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Comparative study on recycled iron filings and glass particles as a potential fine aggregate in concrete

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ABSTRACT

This study comparatively investigated the strength characteristics and workability performance of partial replacement of natural fine aggregate with waste glass particles and iron filings in concrete production. Fine aggregate was replaced with 0%, 5%, 10%, 15%, 20%, and 25% of waste glass particles and iron filings respectively at a water-cement ratio of 0.55. The result indicated that an increase in percentage replacement of iron filings reduced the slump value and workability of the concrete, while the increase in the percentage content of glass particles increased its slump value and workability. The result showed that concrete with 20% replacement of sand by iron filing and waste glass particles attained the optimum strength. Furthermore, concrete samples containing glass particles exhibited a steady increase in flexural strength at all replacement levels. The use of iron filings and glass particles in the production of concrete will enhance preservation of natural resources and waste management

Introduction

Continuous exploration of natural resources in the production of concrete has negatively affected the environment. This is caused by the over-dependent on reinforced concrete as the leading material in the construction industry. The large-scale production of concrete has led to the scarcity of its constituent materials; especially aggregates that occur naturally. Research has shown that aggregates (fine and coarse) constitute about 70-75% of the concrete volume (Murugan et al., 2020) and the proportioning of these aggregates can influence the workability, durability, and mechanical properties of the concrete. Aggregates can be classified based on their sources, density, particle size, and shape. Alternative and sustainable sources of aggregates are in high demand globally due to the shortage of conventional aggregates (Hossain et al., 2016).

The new global transformation trend in the construction industry is geared towards not only exploring sustainable measures in curtailing the high demands on natural resources but the mitigation of waste by reclaiming and reuse of materials. All waste materials should become food (fuel) for another process; either as a by-product or recovered resources for another industrial process or as regenerative resources. This regenerative approach can lead to material conservation in the construction industry. One of the main goals of sustainable waste management is to maximize the reuse and recycling of materials. Reuse and recycling are logical options for materials that are not suitable for composting (Taiwo, 2011). Metals, plastics, and glass are the most common of these materials. For instance, in the United States, of the 12.3 million tonnes generated municipal solid waste in 2018, landfills received approximately 7.6 million tonnes, which represents about 62%. Also, of the 19.2 million tonnes of ferrous metals generated, landfills received 10.5 million tonnes (United States Environmental Protection, 2018). Furthermore, the total volume of packaging waste generated in Europe in 2018 was estimated at 77.7 million tonnes. Out of this quantity, glass constituted 14.5 million tonnes while metals constituted 3.9 million tonnes (Eurostat Statistics, 2018). Australia generated over 1 million tonnes of waste glass in all waste streams between 2016 and 2017 (Maqsood et al., 2019). On a daily basis, substantial amounts of these waste materials are generated by different industries globally, and these pose serious problems to the environment because they can remain in the ground for years without decomposing. Glass waste for instance takes 1 million years to break down naturally (Suez 2017). This is because they are non-biodegradable materials.

Glass is said to be an inert material that can be recycled without any chemical reaction. Reclamation of recycled glass materials remains a

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difficult and expensive procedure amidst complex technological approaches, yet its reuse as the concrete aggregate is justifiable (Adekomaya and Majozi, 2021, Drzymała et al., 2020). Several studies have proposed the use of recycled waste glass as a filler for the production of polymer concrete (Kou and Poon, 2013, Zegardło et al., 2018, Szeląg et al., 2019). Finely ground waste glass used as partial cement replacement lowered expansion in a mortar (Shao et al., 2000), as a partial replacement for fine aggregate, it also reduced expansion of mortars subjected to alkali-silica reaction (Idir et al., 2010), as well as improvements in microstructural properties and mechanical performance (Corinaldesi et al., 2005). The chemical constituents of glass are: 52.89% silicon oxide, 3.75% magnesium oxide, 11.60% sodium oxide, 8.14% aluminum oxide, 11.62% potassium oxide, 0.08% ferric oxide, 6.69% calcium oxide, 7.17% boric oxide, 1.33% zinc oxide and 22.30% lead oxide (Otunyo and Okechukwu, 2017). Research has shown that glass waste has some impacts on the climate when compared to fine aggregate. For instance, (Hossain et al., 2016) reported a low climate change impact of 27% for glass waste as fine aggregate as against 100% for crushed stone and 70% for river sand. In addition, they evaluated the environmental impact sensitivity analysis generated in the production of fine aggregates as 3.2 milli-points (mPt) for glass waste and 7.88 mPt for river sand. (Jani and Hogland, 2014) review on waste glass in the production of cement and concrete highlighted that increase in waste glass aggregate reduces the maintenance of concrete from the different tests evaluated. When waste glass is milled down to micron size particles, it undergoes pozzolanic reactions with cement hydrates, forming secondary Calcium Silicate Hydrate (C–S–H), which plays a vital role in the strength and durability performance of the concrete (Islam et al., 2017, Zadeh and Bobko, 2013). Some experimental results on the effect of waste glass aggregate on the mechanical properties of concrete have shown that compressive strength increased with an increase in the percentages of waste glass aggregate up to 20% (Batayneh et al., 2007, Ismail and Al-Hashmi, 2009, Mageswari and Vidivelli, 2010, Degirmenci et al., 2011, Tan and Du, 2013). Beyond this limit, compressive strength reduces with an increase in glass content. This reduction may be attributed to the smooth surface and sharper edges of glass particles that resulted in the weaker bond between glass particles and cement paste matrix (Rashad, 2014, Topçu and Canbaz, 2004, de Castro and de Brito, 2013, Park et al., 2004). Flexural strength which offers the ability to resist bending stresses, increases with an increase in the percentage of waste glass aggregate up to 20% (Batayneh et al., 2007, Ismail and Al-Hashmi, 2009, Mageswari and Vidivelli, 2010), whereas others reported a decrease with an increase of the fine waste glass aggregate due to the decline in adhesive intensity between the glass particle surfaces (Degirmenci et al., 2011, Tan and Du, 2013, Topçu and Canbaz, 2004, Park et al., 2004). The strength properties of concrete with the addition of waste glass as a partial replacement for fine aggregate is also influenced by parameters, such as the percentage of replacement, particle size, and shape of the glass (Abdelli et al., 2020). In the enhancement of durability characteristics (adsorption, resistance to chloride-ion permeability, and resistance to the freeze-thaw cycles), the glass powder reduces the chloride-ion penetrability of concrete to approximately one-third due to the improved characteristics of the pore network, the filling effect of glass particles, and the conversion of CH to C–S–H, thereby reducing the risk of chloride-induced corrosion of steel reinforcement (Omran and Tagnit-Hamou, 2016). Furthermore, the inclusion of fine glass particles in the concrete matrix increased its sulfate and its sulphuric acid resistance (Rashad, 2014). (Poutos et al., 2008) reported thermal stability of concrete made with waste glass waste concrete at both high and low temperatures (-20°c to 60°c) due to glass lower specific heat compared to that of natural sand. A full study is crucial to find the optimum percentage of waste glass (as aggregate replacement) and particle size effect (Jani and Hogland, 2014). (Mohajerani et al., 2017) review of the practical recycling application of crushed waste glass as construction materials recommended an additional investigation to clarify the contradictions regarding the properties of concrete containing crushed waste glass as a replacement for fine aggregate, especially the effect of fine glass aggregates on the water absorption. Furthermore, there are still contradictory results clearly showing that the optimal mix design of recycled glass waste has still not been found (Harrison et al., 2020).

The emerging concept of circular economy has driven the steel industry to save natural resources and to reduce its environmental impact, by reusing and recycling by-products to reach its "zero waste" goal (Branca et al., 2020). Iron filing is another waste material obtained from iron workshops and steel mills abundantly available worldwide due to rapid urbanization. The chemical constituents of iron filing are: 3.53% carbon, 2.67% silicon, 0.05% magnesium, 0.01% sulfur, 0.03% phosphorus, 0.31% manganese and 93.40% iron (Olutoge et al., 2016). (Kim et al., 2018) quantified the beneficial effects of using slag waste in concrete by determining associated CO_2 emissions. They concluded that slag incorporation in concrete significantly reduces the CO_2 emissions, (up to 68%), thus promoting green construction and sustainable development. Some experimental studies have shown that the mechanical properties of the concrete cast with aggregates of up to 20% waste iron content displayed some significant compressive and flexural strengths. (Ismail and Al-Hashmi, 2008) reported a 17.4% and 27.86% increase in compressive and flexural strengths over the reference specimen at 28 days curing age. On durability, for 30% replacement level, 15% decrease in chloride ion penetration and 3% carbonation resistance were reported, which further encourages its use in precast concrete incorporating high early strength cement (HESC) (Kim et al., 2018). The influence of the addition of recycled iron particles on the mechanical properties of concrete remains an open issue due to contradictory trends reported in some literature (Miah et al., 2020). Hence, (Satyaprakash et al., 2019) proposed a further investigation on water absorption and flexural strength to ascertain its durability and suitability in the beams. To address these identified issues. The objectives of this comparative study include the following;

- study their environmental impact.
- To evaluate the strength properties of iron filings and glass particles aggregate concrete.
- To investigate their effect on water absorption and optimum replacement levels.

Experimental Program

This section enumerates the experimental tests conducted to evaluate the quality and suitability of the materials used in this present study.

Samples collection and preparation

The materials used in this study were; fine glass particles, iron filings, granite, sharp sand, Portland cement, and water. Iron filings were obtained from the iron mill in Uyo metropolis, southern Nigeria, while crushed glass particles were obtained from the Coca-Cola bottling agency in Uyo metropolis, southern Nigeria, see profile in Fig. 1. The sharp sand and granite were collected from the building department workshop, at the University of Uyo. In the control mix, sharp sand was used as fine aggregate while iron filings and glass particles were used to replace sharp sand partially in the production of concrete specimens. Ordinary Portland cement conforming to (BS EN 197-1 2009) also adopted in (Olutoge et al., 2016) and(Limbachiya et al., 2012) was used in this study. Portable water conforming to (BS EN 1008 2002) used in this study was obtained from the concrete laboratory. The sharp sand was first dried at room temperature for 48 hours before use while the granite was washed and allowed to dry before using. Preliminary tests were carried out to determine the quality and suitability of the materials for use in the experiment and also to identify the physical properties of iron filings and glass particles.

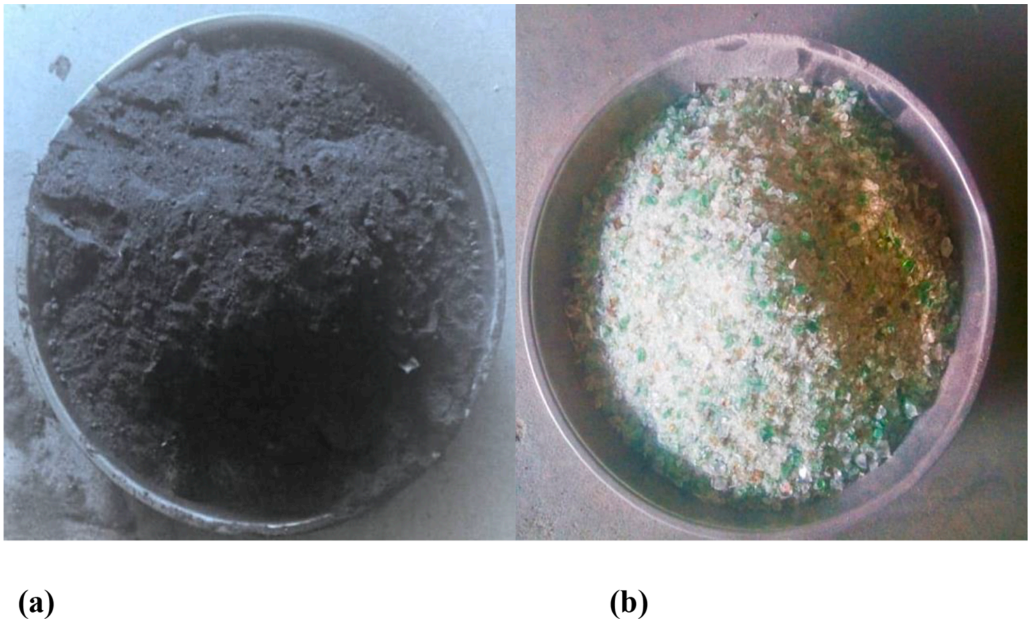

Fig. 1. profile of (a) iron filings (b) glass particles.

Particle size distribution

The purpose of this test was to determine the size distribution of aggregates (sharp sand, granite, iron filings, and glass particles). This grading of aggregates would measure adequate proportioning that guarantees homogeneity and workable concrete. The apparatus was set up in accordance with (BS EN 12620 –1 2002) specification also adopted in (Olutoge et al., 2016).

Specific gravity test

The specific gravity of iron filings and glass particles was determined in accordance with (ASTM D854 2014) specification also adopted in (Miah et al., 2020).

Bulk density test

Bulk density measures the ratio of the mass of an untapped material and its volume including the contribution of the inter-particle void volume. It depends on the density of material particles and the spatial arrangement of particles. Aggregate bulk density is usually specified as loose or compacted. The bulk density was determined based on a saturated dry surface to determine the bulk density of iron filings and glass particles in accordance with (BS EN ISO 11272 2017) specification.

Concrete mix specification and proportion

The concrete mixture proportioned by weight for a targeted strength of 25 MPa is shown in Table 1 for different percentages of replacement of iron filings and glass particles. The water to cement ratio of 0.55 was adopted after a series of trial workability mixes. In the first batch, fine aggregate in the mix was partially replaced with iron filings at 5%, 10%, 15% 20%, and 25% and in the second batch, fine aggregate in the mix was partially replaced with glass particles at 5%, 10%, 15% 20%, and 25% while the control samples in each batch consisted of sharp sand as fine aggregate. A total of 132 specimens were produced, consisting of 99 cubes for compressive strength test at 7, 14, and 28 days curing age, and 33 beams for flexural strength test at 28 days curing age. Specimens produced from iron filings were 45 cubes and 15 beams, while specimens from glass particles were 45 cubes and 15 beams. The control specimens were 9 cubes and 3 beams.

Table 1
Concrete mix proportions used in the study (all quantities in kg/m3). For Iron Filings and Glass particles specimens.

Materials	0%	5%	10%	15%	20%	25%
Cement	420	420	420	420	420	420
Fine Aggregate	685	651	616	582	548	514
Glass Particles or Iron Filings	0	34	69	103	137	171
Coarse Aggregate	1115	1115	1115	1115	1115	1115
Water Content	231	231	231	231	231	231

Slump test

This was carried out to determine the workability of fresh concrete produced with iron filings and glass particles as fine aggregate. The test was conducted in accordance with (BS EN 12350 -2 2009) also adopted in (Drzymała et al., 2020, Mohajerani et al., 2017, Jurczak et al., 2021).

Water absorption test

This was carried out to determine the rate at which moisture penetrates the concrete cubes produced. The water absorption test was carried out in accordance with (BS 1881- 122 2011) also adopted in (Alzaed, 2014).

Compressive strength test

The compressive strength of concrete was determined by crushing the cubes in accordance with (BS EN 12390-3 2009) specification also adopted in (Drzymała et al., 2020, Mohajerani et al., 2017, Jurczak et al., 2021). The weights of concrete cubes were recorded before compressive strength was conducted. Three concrete cubes from each replacement level (5%, 10%, 15%, 20%, and 25%), for glass and iron filings respectively, were crushed each at 7, 14, and 28 days using Avery-Dennison Universal Testing Machine.

Flexural strength test

The flexural strength Test on 750mm x 150mm x 150mm concrete beams was done in accordance with (BS EN 12390-5 2009) specification also adopted in (Drzymała et al., 2020, Mohajerani et al., 2017, Jurczak et al., 2021). The tested beam specimens were placed in the machine properly centered with the longitudinal axis of the specimen at right angles to the rollers.

Results and discussion

This section discusses the results obtained from the experimental tests and compared it with existing studies in the literature.

Particle size distribution

Fig. 2 shows the results of particle size distribution which was used to determine the fineness modulus of iron filings and glass particles. The higher the value of fineness modulus, the higher the coarseness of the aggregate while a lower value of fineness modulus indicates that the aggregate is finer. (Jurczak et al., 2021) suggested that lower particle size distribution is mandatory for the successful use of recycled glass particles at higher replacement levels without compromising the strength. Iron filings had a fineness modulus of 2.37 greater than 2.24 but less than 2.65 reported by (Olutoge et al., 2016), and (Kim et al., 2018), glass particles had a fineness modulus of 3.26 less than 4.25 reported by (Miah et al., 2020) but greater than 2.36 recorded by (Ismail and Al-Hashmi, 2009). The fineness modulus of the two aggregates fell within the range of 2.0-3.5 which satisfies the requirements of (BS EN 12620 –1 2002) and (ASTM C 33 2003) for fine aggregates used in concrete production. The percentage of fine aggregate passing through the sieve 300μm was 18% for iron filings and 12.1% for glass particles which indicates that the aggregates fall under Zone-III grading, which is suitable for concrete work, and this is in good agreement with (Satyaprakash et al., 2019). This validation further supports the need to close the material cycle loop regarding resources recovery, reuse, and recycling by using iron filings and glass particles in concrete production.

Specific gravity and bulk density

The values recorded for specific gravity and bulk density of sand, iron filings, and glass particles were 2.68, 3.33, 2.47, and 1589, 2883, 1540 respectively. A low specific gravity may indicate high porosity and therefore poor durability. Also, the density of concrete depends greatly on the specific gravity. Iron filings had a specific gravity of 3.33 which was the highest among the three aggregates, sand and glass particles had a specific gravity of 2.68 and 2.47 respectively, adequate for normal-weight aggregates. The value obtained for iron filings was lower than the 3.66 reported by (Satyaprakash et al., 2019). The value obtained for glass was close to 2.40 reported by (Shao et al., 2000) but greater than 2.19 recorded by (Ismail and Al-Hashmi, 2009). The values of the specific gravity for both specimens were also not less than 2.4 - 2.9 proposed by (Neville, 2000) for normal-weight aggregates. The bulk density of aggregates shows how dense the aggregates are packed. Bulk density depends on the aggregate shape and particle size. Iron filings had a bulk density of 2883kg/m^3, sand and glass particles had 1589kg/m^3 and 1540kg/m^3 respectively which satisfied the standard requirements for lightweight structural concrete aggregates. In the context of materials sustainability, using these recycled waste materials as a potential fine aggregate in concrete minimizes the high exploitation of virgin materials.

Slump

A slump test was used to evaluate the workability of concrete. Fig. 3 shows the result of the slump test. The slump decreased with an increase in iron filings content but increased with an increase in glass particles content. This may be due to the higher specific gravity of iron filings compared to glass particles. Hence, the higher the percentage of iron filings, the lower the slump. This trend supports the observation by (Kim et al., 2018), (Ismail and Al-Hashmi, 2008) that a decrease in slump value corresponds to an increase in waste iron filings content as a fine aggregate in the concrete mix. This characteristic could also be attributed to the shape of the iron filings grains. Conversely, glass particles have a lower specific gravity which leads to a higher slump as the percentage of particles increases. The workability in concrete samples incorporating iron filing as fine aggregate could be enhanced by the introduction of superplasticizers.

Density of concrete with iron filings and glass particles content

Fig. 4 shows the variations of densities of iron filings and glass particles. The density of normal concrete (with sand as fine aggregate) varies between 2400kg/m^3 and 2500kg/m^3. To understand how the

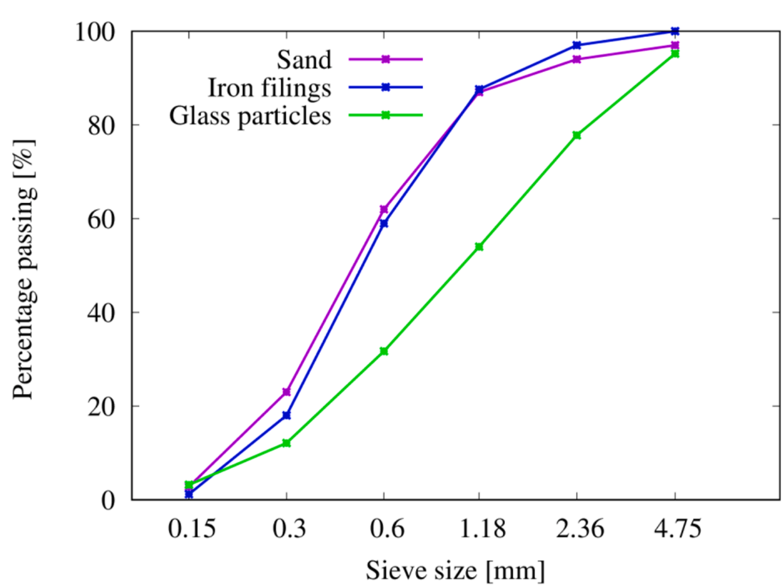

Fig. 2. Particle size distribution curve for fine sand, iron filings, and glass particles.

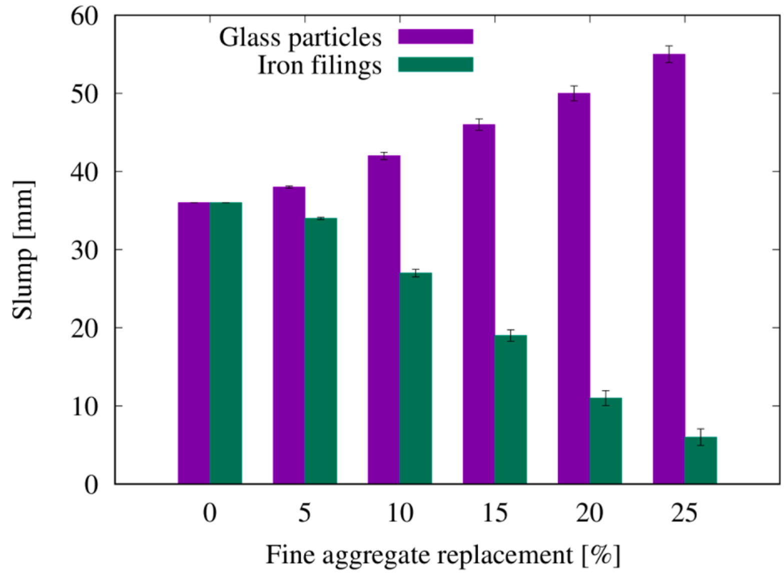

Fig. 3. Slump variation for different percentages of fine aggregate replacement

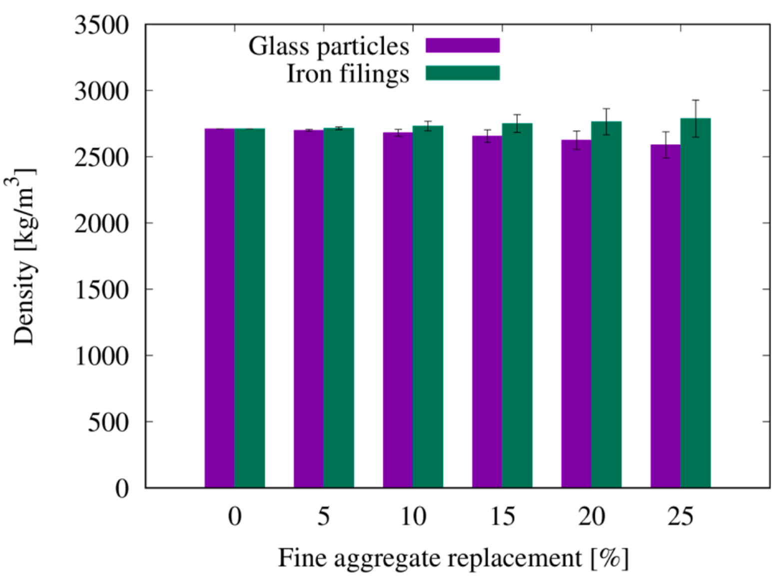

Fig. 4. Variation of density with different percentages of fine aggregate replacement

density varies with partial replacement of fine aggregate, the density of the specimens was determined after curing for 28 days. The values obtained for iron filings and glass particles at 20% replacement level were 2764kg/m^3 and 2625kg/m^3, respectively. These values were greater than 2476 kg/m^3 and 2382.9kg/m^3 reported by (Kim et al., 2018), (Ismail and Al-Hashmi, 2009) for waste iron and waste glass concrete, respectively. The variation for different percentages of fine aggregate replacement indicates that density increased as the percentage of iron filings increased and decreased as the percentage of glass particles increased. This could also be linked to the specific gravity of the fine aggregates determined to be 3.33 and 2.47 for iron filings and glass particles, respectively.

Water absorption

Fig. 5 shows the result of the water absorption test. From the standpoint of water absorbed, an increase in the percentage of iron filings leads to an increase in the percentage of water absorbed whereas an increase in glass particles leads to a reduction in the percentage of water absorbed. This trend supports (Mohajerani et al., 2017) for waste glass. The maximum water absorption at 25% replacement was 7.0% for samples with iron filings, and the minimum water absorption of 4.9% occurred at 25% replacement for samples with glass particles both falling within the acceptable range of 5-7% specified by (ASTM C140 /C140M-20a 2020). The low water permeability in concrete samples incorporating glass particles will improve the service life of the structure against deterioration.

Compressive strength

Aside from the properties of freshly mixed concrete, hardened properties of concrete are also very important in the characterization of concrete. Consequently, the hardening test on concrete was also considered to ascertain the influence of partial replacement of iron filings and glass particles as fine aggregates on the behavior of concrete, these included compressive strength and flexural strength test. The compressive strength for a particular curing age was taken as the average of three tests. The plot of the variation of compressive strength

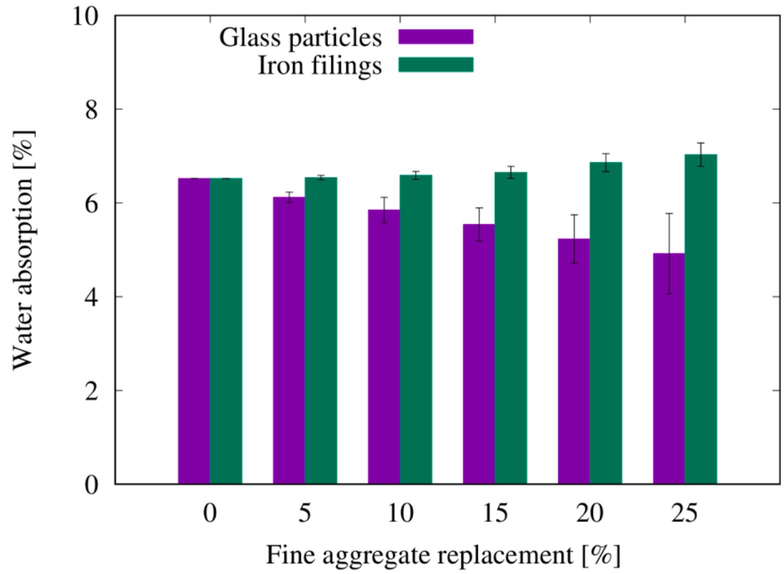

Fig. 5. Water absorption for different percentages of fine aggregate replacement

of concrete with curing age for different percentages replacement of iron filings and glass particles are shown in Fig.s 6 and 7 respectively. It can be observed in both cases that the compressive strength of concrete increased with an increase in the percentage of iron filings in samples up to 20%, these characteristics support (Batayneh et al., 2007, Ismail and Al-Hashmi, 2009, Mageswari and Vidivelli, 2010, Degirmenci et al., 2011, Tan and Du, 2013), for waste glass and Kim et al. (Kim et al., 2018) for waste iron. The compressive strength also decreased slightly at 25% percent replacement. The compressive strength of 22.68 MPa at 20% was less than 30.81 MPa and 45.9 MPa reported at 28days by (Alzaed, 2014, Ismail and Al-Hashmi, 2008) respectively. A maximum strength value of 21.5 MPa and 22.7 MPa at 28 days strength was recorded for samples containing 20% of iron filings and glass particles, respectively. This compressive strength could be suitable for lightweight concrete with targeted strength between 15 and 20 MPa. At 20% replacement, the compressive strength development for all samples when compared to the compressive strength of the controlled samples at 7, 14, and 28 days attained 112%, 107%, and 93% for iron filings and 118%, 113%, and 99% for glass particles respectively. In both samples, the compressive strength at 28days satisfied the minimum strength requirement for structural lightweight concrete (Neville and Brooks., 2005, ASTM, 2006). The construction industry could harness these recycled wastes as fine aggregate for the production of lightweight concrete, hence reducing environmental degradation and enhancing material sustainability in the built environment.

Flexural strength

Fig. 8 shows the result of the flexural strength test. The flexural strength of each batch for a particular curing age was taken as the average of three tests. The flexural strength increased with an increase in percentage replacement of iron filings from 5% to 15% but decreased gradually from 20% to 25%, a trend similar to (Kim et al., 2018). The flexural strength increased steadily with an increase in glass particles from 5% to 25% replacement content, a trend also similar to (Ismail and Al-Hashmi, 2009, Batayneh et al., 2007, Mageswari and Vidivelli, 2010). The flexural strength of 7.51 MPa, obtained at 20% was greater than 6.66 MPa reported by (Olutoge et al., 2016) for iron filings at 28days.

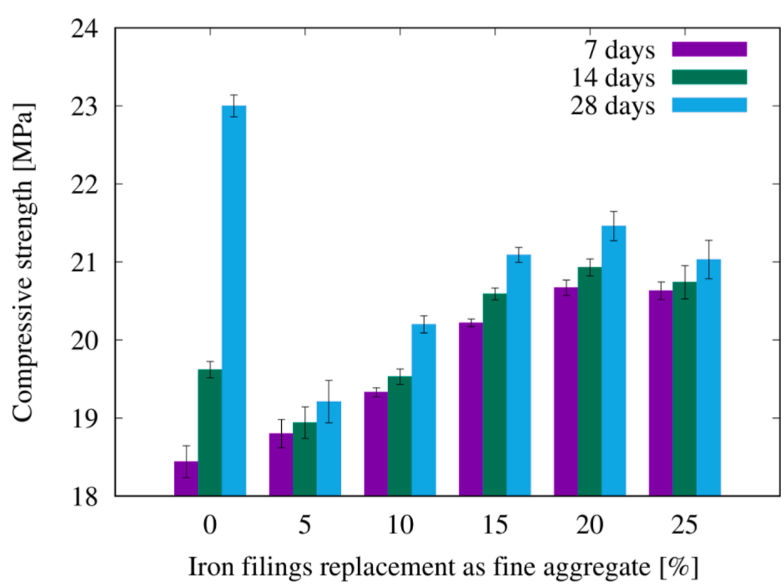

Fig. 6. Variation of compressive strength with curing age in samples partially replaced with iron filings.

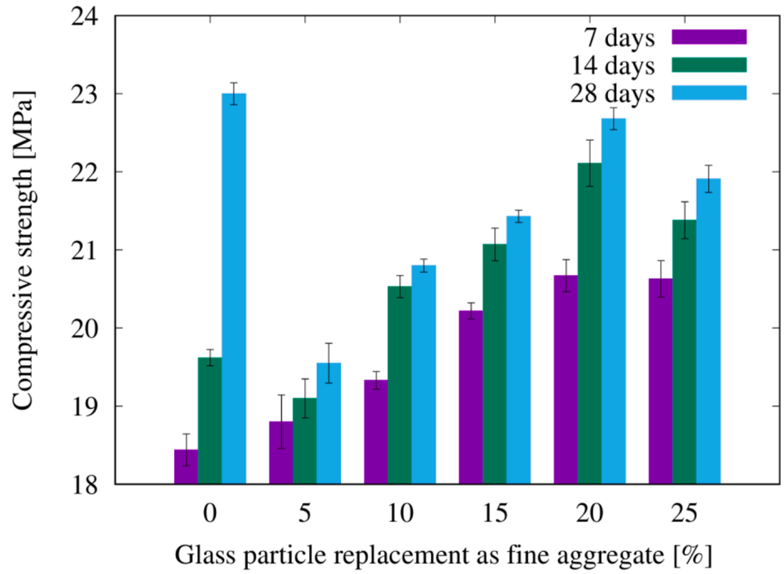

Fig. 7. Variation of compressive strength with curing age in samples partially replaced with glass particles.

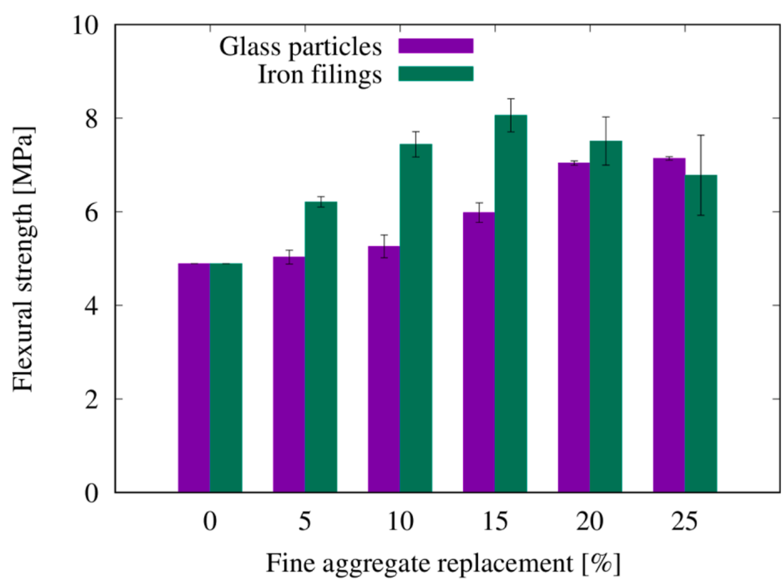

Fig. 8. Flexural strength test result for different percentages of fine aggregate replacement

Similarly, the flexural strength of 7.04 MPa obtained at 20% was also greater than 6.55 MPa reported by (Ismail and Al-Hashmi, 2008) for waste glass at 28days. The increase in flexural strength recorded for iron filings samples may be attributed to the iron filings acting as a micro-reinforcement in the concrete matrix. Similarly, the increment in flexural strength recorded for glass particles samples could be due to the shape and texture of glass particles which allows for better bonding between the aggregate and cement paste. The closest results of the flexural strengths were 7.51 MPa and 7.05 MPa recorded at 28days for concrete samples containing 20% iron filings and glass particles respectively. The ratio of flexural strength to compressive strength was 35% and 31% for concrete samples containing 20% iron filings and glass particles at 28days respectively. This ratio for glass particles was similar to the behavior reported in (Kou and Poon, 2013). The relationship between flexural strength and compressive strength is relevant for structural design. Flexural strength here evaluates the ability of an unreinforced concrete beam to withstand failure in bending. The flexural strength is commonly referred to as more representative of the real-life loading scenario than the compressive strength and can be used to determine the deflections and cracking stresses of a concrete element (Campos et al., 2021). Areas of the practical application of the concrete experimented within this study could include; lintel beams construction, concrete blocks production, and pavement construction.

Conclusion

A circular economy as portrayed in this study emphasizes recycling or reuse of this waste as potential construction materials needed to produce concrete for use in building and pavement. The study comparatively investigated the strength characteristics and workability performance of partial replacement of natural fine aggregate with waste glass particles and iron filings.

The highlight of the major findings indicates that iron filings had a fineness modulus of 2.37 while glass particles had a fineness modulus of 3.26. The fineness modulus of the two specimens used as fine aggregates fell within the range of 2.0 – 3.5 which satisfied the requirement of (BS

EN 12620 –1 2002). Iron filings and glass particles were found to have a bulk density of 2883 kg/m^3 and 1540 kg/m^3, and specific gravity of 3.33 and 2.47 respectively. The increase in the percentage replacement of iron filings increased the density of the concrete, while the increase in the percentage of glass particles decreased the density of the concrete. The increase in percentage replacement of iron filings reduced the slump value, while the increase in the percentage content of glass particles increased the slump value. This may be attributed to the higher specific gravity and shape of the iron filings compared to glass particles. An increase in water absorption with an increase in the percentage replacement was also observed with iron filings. Glass particles had a low water absorption which led to improvement in the workability of the concrete samples containing up to 25% glass particles content as fine aggregate. Iron filings exhibited an optimum flexural strength of 8.06 MPa at 15% replacement then dropped from 20% to 25% whereas glass samples showed a steady increase in flexural strength from 5% to 25% content. The compressive strength of samples containing iron filings was lower than that of glass particles in all replacement levels and curing ages. At 20% replacement, the compressive strength of concrete samples containing iron filings and glass particles increased in each case by 12.95% and 19.37% respectively over the samples with 15% contents at 28 days curing age. Therefore, 20% optimum iron filings and glass particles dosages gave a peak performance in the concrete. In both samples, the compressive strength at 28days satisfied the minimum strength requirement for structural lightweight concrete hence, it could be used for lintel beams construction, concrete blocks production, and pavement construction. The use of iron filings and glass particles in the production of concrete could lead to prudent waste management, profitable utilization of industrial waste, and environmental conservation. The study has demonstrated the potential of optimum 20% of iron filings and glass particles replacement in concrete leads to judicious use of industrial waste and lowering environmental impact while also meeting the needs for sustainable development in construction. A further durability test is proposed to examine their effects in an aggressive environment.

CRediT authorship contribution statement

Ifiok Edem Ekop: Conceptualization, Methodology, Writing – review & editing, Visualization, Supervision. **Chisom Jude Okeke:** Data curation, Formal analysis, Writing – original draft. **Etieno Victor Inyang:** Resources, Investigation.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.rcradv.2022.200093.

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