SOLID WASTE MANAGEMENT AND UTILIZATION OF UNRECYCLED GLASS WASTE

ENVIRONMENTAL SOLID WASTE MANAGEMENT AND UTILIZATION OF UNRECYCLED WASTE GLASS

1.0 INTRODUCTION

As well said by *Nicholas Serota* (2018) that; “cultural organizations are in unique position to challenge, inform and engage audiences in conversation about the environment”. Over the past two years, the IPCC recommendation on climate change and global warming and the continuing argument about how we want to see our country evolve in solid waste management and pollution control have exposed great differences of belief and opportunity in various society. But at a time when the cohesion of society is threatened by visible inequalities in wealth, housing, health and education, the arts provide a place where ideas can be debated, explored and developed and new propositions can be put forward (Nicholas, 2018). The arts are intrinsically a social medium. They are both personal and pubic at same time. However, I am convinced that in years to come there will be an ever-greater recognition of the values, and the need, for the arts in all our lives.

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Although, I try in my opinion to respond to the environmental issue with my proposed work on *Solid Waste Management and Utilisation Unrecycled Waste Glass* at the National Glass Centre University of Sunderland. Perhaps, it takes a lot of imagination and support to prove the needs of arts in area of waste management and pollution control, that may result in global warming and climate change. However, it is very important the role of arts in the public spheres is to be inclusive, not exclusive. The arts must reach more people if they are to help our divided society. Has it is often said that: *The best and most pioneering work often polarises opinion, and a positive response could strengthen an organization* (Nicholas, 2018).

Of course, a lot of work has been done by some people in the area of waste management using waste glass. People like *Soneva Fushi* opens the first Art and Glass Studio in Maldives. The studio which opened in August this year, is a state-of-the-art facility, and includes a small retail boutique and an art gallery which are designed as platforms to display the work of both locals and international artists.

Fig. d. Soneva Gallery in Island.

Fig. e

In an effort to stay eco-friendly, the studio only uses waste glass produced from the resort and other nearby resorts. *Sonu Shivdasani,* Founder and CEO of *Soneva* said: “The idea behind this project is turn the waste glass into something that is much more beautiful and valuable than it was in its previous.”

Maria Sparre Peterson (2016). PhD holder from The School of Design at the Royal Danish Academy of Fine Arts, also carry out a project using a waste glass. Her project includes practical, artistic and Scientific knowledge and insight. The contribution are manifest in a range of epistemic artifacts, i.e. the outcomes of her experimental work with used of recyclable glass involves a lot of collaborative activities with explicit knowledge and insight about sustainability in glass craft and design as shown in the figure below;


Fig. a

Fig. b
Emma Woffenden and Tord Boontje (1997), carry out a research with the use of waste glass. As stated, “The idea behind our Transglass label is to use what we have. We have developed this range from recycled bottles using the relatively simple machines we have in our worshop. We have all taken an empty bottle and turned it into something else: we pop a

candle into the neck and it is a candelabra, we fill with flower and it becomes a vase. A diagonally- cut Soave bottle becomes a jug etc”. However, The first pieces for Transglass were designed in 1997 and were originally produced by Tord bootje and Emma Woffenden in their London Studio.

Fig. c

Since 2005 Transglass is produced in Guatemala City in a newly created workshop where young people learn the skills of glass and many of whom have become experts in cutting and polishing. Moreover, if we are to avoid irreversible global warming that will have devastating economic and social consequences for the world, “rapid, far-reaching and unprecedented changes in all aspects of the society” are required. Recognising that we had to create the conditions for change to happen, the Art Council buttressed these requirements with a programme of support from Julies Bicycle. Together we substantially increased understanding about the role of the sector in addressing environmental issues and associated challenges. I suggest that Arts and cultural companies possess significant purchasing power and can be instrumental in persuading suppliers to make ethical decisions and developgreener products and services that are more environmentally sustainable and friendly in nature.

2.0 BACKGROUND

In a contemporary context, Glass is an inert material that does not contribute to pollution in landfills or incinerators. It is produced domestically from plentiful raw materials, primarily silica. Glass is in the background of daily lives of most people. It is manufactured from plentiful raw materials and can readily be re-used as feedstock in glass production. However, the potential for glass recycling comes largely from the container and flat glass sectors, because of their dominance in terms of mass and their relatively uniform chemical composition, with soda lime-silica glass accounting for virtually all the container and the flat glass produced. Hence, the need to focus on environmental issues of how to conserve the remains unrecycled glass, rather than going into the landfill. New bottles and product such as tiles, bricks and concretes with filtration materials can be produced with substitution of up to 30 percent clean, crushed, colour sorted unrecycled glass for virgins' inputs. Such mix saves some energy and reduces some emissions into the environment with huge amount energy used during recycling process (Serota, 2018). However, the main environmental impacts in glass making are the high energy use in batch melting, and the resultant gaseous emission from fuel combustion and the heat reaction of components of the batch mix. Within the waste management hierarchy, reuse is considered before moving to the next option down, recycling. Moreover, mixed coloured unrecycled glass may also be used as substitution for sand and gravel in road building and house hold materials, such uses are less costly but yield even more marginal environmental benefits. Although, the recycling of a waste glass poses a major problem worldwide, since glass is believed to be a unique inert material that can be recycled many times without changing its chemical properties. Recycled glass has traditionally been used in glass manufacture. This practice brings about environmental advantages such as reducing energy and raw materials consumption, related to air and water pollution. However, not all glass can be recycled into new glass because of impurities and cost of colours.

A case study by Thomas (2014), reveals that the use of glass aggregate in concrete is also possible, although concerns regarding damaging alkali-silica reaction have limited this. Due to the fact that the reaction that occur between the aggregates contains reactive silica and hydroxide ions associated with alkali-metal ions from cement. The reaction leads to the disruption of the glass structural network, leading to the formation of an open gel. Which undergoes hydration, leading to swelling, the development of stress and, eventually cracking.

The intending technique for my research work is to carry out experimental testing of combining cement and plaster from ceramics materials with the waste unrecycled glass waste to produce environmental friendly and sustainable household products. However, my visual research is to learn from the previous work that has been done by some previous environmental researchers as a case study, such as Thomas (2014), Elizabeth and Manzanares, (2014) with research work titled Creative *Recycling of Waste Glass as a Tool for Teaching and Learning*. Also learning from other techniques that are available. Moreover, my research would be to focus on Solid Waste Management and Utilization of Unrecycled Glass Waste Glass.

Furthermore, I want to propose and carry out a research of using the same unrecycled glass aggregates with a new technique in combination with cement and plaster from ceramics product as a means of avoiding cracking during analysis on my new design of propose produce that can be considered as environmentally friendly household product, with much economic values for the benefit of the present and future generation.

Main Objective:

1) To reduce the amount of energy used during the batch process during recycling.
2) To produce an environmental friendly product from the unrecycled waste glass.
3) To propose a new research method of waste reduction rather than going into landfill.

3.0 LITERATURE REVIEW

Success in waste management, as in any technical enterprise, depends on three factors: awareness, decision making and action (Trevor *et al.,* 2011). However, glass is in the background of the daily lives of most people. It is manufactured from plentiful raw materials and can be readily reused as feed-stock in glass production. Being aware of the nature of waste and how it has been controlled through times is the first step in sound management. Good decision making depends on knowing what has happened and what has worked and failed in the past. From this knowledge flows the actions needed to solve waste problems (Trevor *et al.,* 2011), such as unrecycled glass waste and its utilisation.

Glass materials: Virgin glass, is one of the oldest synthetic materials (Ernst *et al.,* 2014), with evidence of its production in ancient Egypt dating back to at least 3000 BC. Its Optical clarity, hardness and strength mean that it has made its way into every aspect of human activity, with significant roles in glazing, packaging, vehicles, house-wares, electrical equipment and fibers in insulation products and composite materials (Ernst *et al.,* 2014). Moreover, the materials have played an instrumental role in many advances in arts, sciences and technology. Perhaps despite its important roles. Glass is a problem. Glass is heavy. Glass markets are more and more just a second use as opposed to closed loop. Glass is inert in the landfill. According to prime minister of Inia *Narender Modi* who acknowledge the role of waste management in development, ask people to reduce, reuse and recycle waste from glass. He also stated that, adherence to the principles of reducing, reusing and recycling is the key to manage waste properly and subsequently leading to sustainable development (Narender, 2018).

In New Delhi; sustainable development of mankind is not possible without following the three golden *Rs.* Of waste, management, namely reduce, reuse and recycle. This was Prime Minister *Narender Modis* Message to participants in the Eight Regional 3R Forum in Asia and the Pacific, being held in April 9 to 12 at Indore (Narender, 2018). The forum will see waste management experts from India and abroad discuss how waste management patterns have change globally and the growing importance of international cooperation I waste management. Addressing participants of the forum, the Prime Minister said that the development was only possible when waste manage properly.

All stakeholders-producers, consumers and the state likes-must adhere to this golden principle which can contribute significantly in solving the twin challenges of waste management as well as sustainable development, said by Prime Minister *Narender Modi.*

Although, for most of the twentieth century, wastes were viewed predominantly as inevitable by-products of modern times. Waste generation was a necessary reality associated with economic development. Thus, addressing waste was often a matter of reacting to problems as they arose individually in a situationally dependent way. However, the processes that lead to waste can be viewed much more proactively and systematically. It is best to prevent the generation of wastes in the first place. Perhaps, waste streams should not only be rendered less occupation in landfill, but, also reusable.

Systematically, engineers and other waste managers have begun to embrace waste minimization, pollution prevention, and other approach, albeit incrementally. However, green design and sustainable approaches to waste apply scientific principles to develop objective oriented, function-based processes (MacBride, 2011). They consider every element of a products life cycle in a way that mutually benefits the client, the public, and the environment. Waste from plastics, glass and papers products can decrease in volume and mass as green designs replace traditional methods of landfill waste disposal methods. Moreover, the critical path from product conception to completion has changed very little over the thousands of years. The actual view of the process of design from both artwork and science, varies substantially, even within the waste management community.

A substantial growth in the consumption of plastic and glass is observed all over the world in recent years (Harshad *et al.*, 2016), which also increases the production of plastic and glass related waste. Since glass waste is a non-biodegradable material, it has become a serious environmental threat to modern civilization. Industries have realised that it is a wiser practice to recycle it. In construction practices, recycling of this waste by converting it to fine aggregate, not only saves landfill space but also reduces the demand for extraction of natural raw material. The plastic waste and unrecycled glass waste have been successfully replaced by fine aggregates in self-compacting concretes respectively (Harshad *et al.*, 2016).

Glass, in single stream programs, contaminates other materials (MacBride, 2011). It's no wonder many recycling collection operations are considering removing it from the recycling stream, especially when faced with tough financial choices (Ernst *et al.,* 2014).
Waste management and recycling are neither new concepts nor new activities (Trevor *et al.,* 2011). In fact, glass materials had been recycled long before the term was coined in the twentieth century. People have always seen value in the items cast-off by others. (Especially, a person like me). Witness the aphorism that one's trash is another man's treasure (Trevor *et al.,* 2011). Historically, waste management has been inextricably linked with the evolution of human communities, population growth and the emergences and development of commerce. Contemporary policies of reuse and recycling instead reflect political will to do something better with waste glass than dumping it in the landfill. This political will began to emerge in 1970, when a nascent ecology movement first cast waste prevention, reuse, recycling, and composting as environmentally beneficial methods of handling waste (MacBride, 2011). Demand for reclamation of materials from municipal solid waste was rooted first and foremost in goals of pollution reduction, resource conservation, and beautification of the surroundings (MacBride, 2011). Although, as recycling has emerged as an environmental "success story" so has a common understanding of what is a solid-waste "problem" in relation to unrecycled glass waste and what desirable "solution". In this common understanding, unrecycled waste glass is a problem. Their excavation is not without impacts,

but these pale in contrast to those produced by other types of materials extraction (MacBride, 2011).
Unlike other commodities, glass is not generally traded globally; it is fabricated and used in its country of origin (an exception involves trade in glass for certain beverage containers-the United States and United Kingdom import continental beers and wines and with them foreign glass). Transportation pollution from the glass trade, at least on global scale, is therefore not as pronounced as for other commodities. Nor is the glassmaking Industry a major polluter (MacBride, 2011). The glassmaking process is somewhat energy intensive, but it generates far fewer air or water impacts than do paper, plastic, and metal manufacturing process (MacBride, 2011).

Glass is manufactured by melting a suitable combination of raw materials in a furnace and using various processes to form it before it is cooled (Ernst *et al*., 2014). A wide variety of raw materials are used, but in soda-lime—silicate glass, the most commonly encountered materials are silica (Sio_2), soda ash (sodium carbonate, Na_2Co_2) and calcium carbonate ($CaCo_3$) (Ernst *et al*., 2014). Although pure silica can be made into high-quality glass, this requires the batch to be heated to a temperature of around 2300 ºC, at which point its viscosity is reduced to a liquid state suitable for the subsequent formulation stage, the melting point (Trevor *et al*., 2011).
However, a wide variety of techniques are available for glass reuse and recycling, since glass is a material that, in many of its forms, is reusable (Ernst *et al*., 2014). This is particularly true of bottles and other glass vessels, which are still able to satisfy their role as a container long after their original use is over. This has led to manufacturer and governments recognizing that savings in terms of energy and resources could be achieved through the recovery and reuse or recycling of glass.

4.0 STATE OF THE ART OF UNRECYCLED GLASS WASTE RESEARCH

As glass is sifted out of mixing mix, it emerges crushed, mixed with other residues and bits of label as waste glass. In this form, known as "dirty mixed cullet", It is not good for much (MacBride, 2011). At best, it can used as lower grade fill or as what is Known as "alternative daily cover", a substitute for the earthen layer that must cover each day's load of trash at the landfill. If it is going on become anything more (MacBride, 2011), it must be shipped to a beneficiation facility to get cleaned and colour sorted.
Waste glass has been investigated by Sadiqul *et al*., (2016) for use as an aggregate for cement concrete to provide additional option for communities targeting glass disposal and concrete production. Result of their study indicate glass aggregate to be satisfactory substitutes for natural fine aggregate at replacement levels up to 20% of the total aggregate and at a glass gradation between mortar and concrete compressive strength of 2% at 90days. In addition, production of every six-ton glass powder concrete results in reduction of each CO_2 emission from cement production and save the environment significantly by reducing green-house gas and particulate production.
Shao *et al.,* (2000) study on concrete containing ground waste glass. Compared to fly ash concrete, glass concrete had a higher early strength as well as higher late strength. The high

early strength could have attributed to the high alkali content in soda-lime lamp glass. Nevertheless, the high alkali content in mixture did not deteriorate the strength of the concrete at a late age.

Topcu and Canbaz (2204) carry out research about the properties of concrete containing waste glass. When hardened concrete specimen properties were analysed, compressive flexural and indirect tensile strengths as well as Schmidt hardness values were determined to decrease in proportion to an increase in waste glass. The compressive strength decreased as much as 49% with a 60% of waste glass addition. They conclude that using waste glass in preference to fine aggregate would produce better results if its geometry be more proper and almost spherical.

Ismail and Enas (2009) research on the recycling of waste glass as partial replacement for fine aggregate in concrete. The optimum percentage of waste glass that gives the maximum values of compressive and flexural strength is 20%. Using finely ground waste glass in preference to fine aggregate could produce promising results, if the geometry will be heterogenous.

Recent studies which have focused on the suitability of using waste glass as a partial replacement for fine aggregate have found promising results. One crucial finding I discovered from all past research work has been that glass colour has no influence on concrete properties. Thus, eliminating the need to sort post-consumer glass by colour, and thus making this an attractive form of recycling.

With no clear consensus currently available in literature, my research study will seek to clarify the new discovery of glass waste utilization with other new waste materials from the National Glass Centre at the University of Sunderland St Peters Campus (such as waste gahnite and fired ceramics malachite and plaster waste known as *Ludo* in placement of sand or gravel. However, Glass waste mix with other known and scarce materials (such as waste gahnite and fired ceramics malachite and plaster waste known as *Ludo* will be determine and may be handled, spread and compacted with conventional construction equipment.

5.0 Testing

5.1 Methodology

Materials Used and Tests Carried Out On Materials:

MATERIALS USED

- Cement and Aggregates

Ordinary Portland cement of good grade with fine aggregate of sands gravels was bought from B and Q building materials sales shop close to Sunderland city centre. Noth Easth England.

- Glass Waste

The waste glass used in this study was obtained from various units at the National Glass Centre (such as the Architectural glass studio, water jets operation workshop and the hot glassblowing workshop). Glass waste is very hard materials, it must be powdered grain of desired size, before it can be used with the mixture of the concrete. The glass waste was broken into smaller proportion of powdered grain with the use of proper PPE (Personal Protective Equipment) and harmer, at the glass and ceramics workshop section National Glass Centre University of Sunderland.

Fig.1 shows how the glass is being hammered into smaller proportion and Fig. 2 shows the smaller proportion of the broken glass.

Fig. 1a.

Fig. 1b.

Fig. 2a.

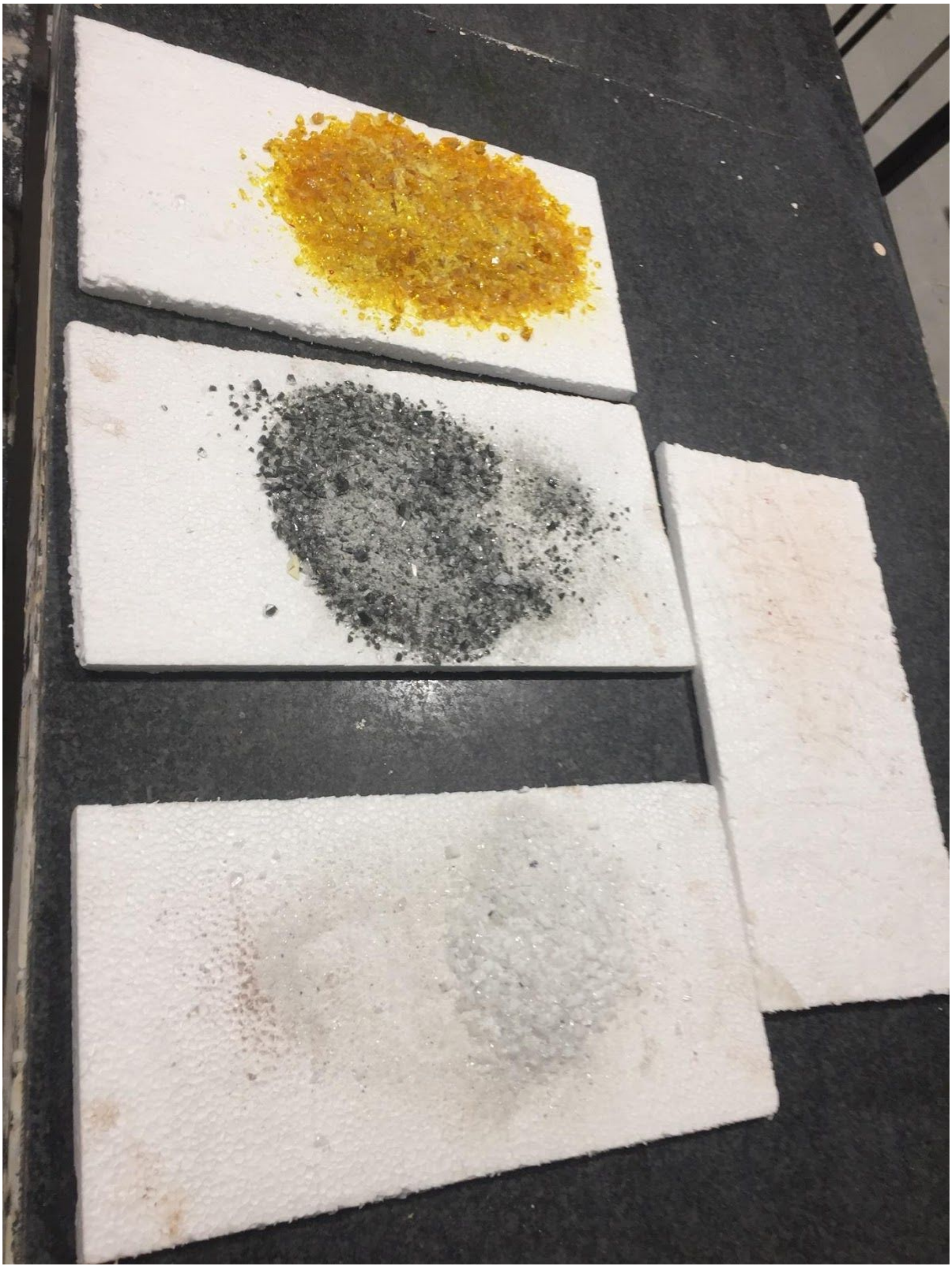


Fig. 2b.

Fig. 3b.

In this study, the production of concrete for this test was conducted at the glass and ceramics workshop at National Glass Centre University of Sunderland. All preparation of concrete was undertaken in accordance to the specified standard at the National Glass Centre. Four specimens were created for each percentage replacement of glass, with three samples being used for the seven and twenty-eight-day compressive tests, respectively.

5.2 EXPERIMENTAL INVESTIGATION

- Mix Proportion:

The concrete mix design was proposed by using conventional construction equipment and may be used to handled, spread the mixture into a desired compacted shape.

5.3 PRILIMINARY MATERIALS TESTING

Sample A: *Control* (To assess the compability of materials with proposed materials);
Code (A): W.C (Sample Colour: Red and white)

- W.C. Ratio: 8:4

Fig. a

Sample B: *Control* (To assess the compability of materials with proposed materials);
Code (B): W.C.G (Sample Colour: Light Brown with White Patches)

- W.C.G. Ratio: 3:3

Fig. b

Sample C: *Control* (To assess the compability of materials with proposed materials);

- Code (C): W.C (Sample Colour: White)

- W.C. Ratio: 3:2

Fig. c.

Sample D: *Control* (To assess the compability of materials with proposed materials);

· Code (D): W.C.S. (Sample Colour: Black and White) · W.C.S. Ratio: 4:3:2

Fig. d

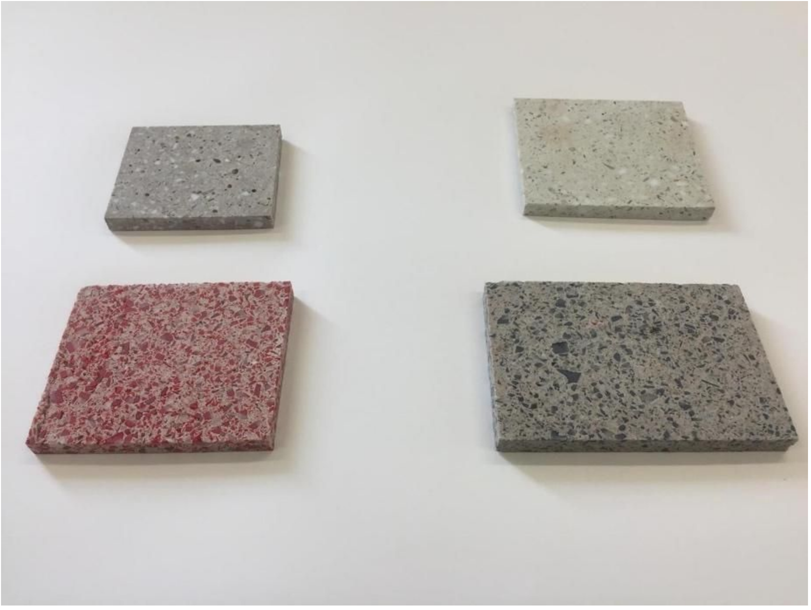


Fig. e

9.0 DEFINITIVE MATERIALS TESTING SAMPLE 2A

- Code (2A): C.W.S + H_20 (Sample Colour: Bright cream with patches colours of R.O.G)

- C.W.S Ratio: 2:2:2 + 130ml of H_20

SAMPLE 2B

Code (2B): C.W.S + H_20 (Sample Colour: Brown with patches colours of G.W.O)

C.W.S Ratio: 2:2:2 + 110ml of H_20

SAMPLE 2C

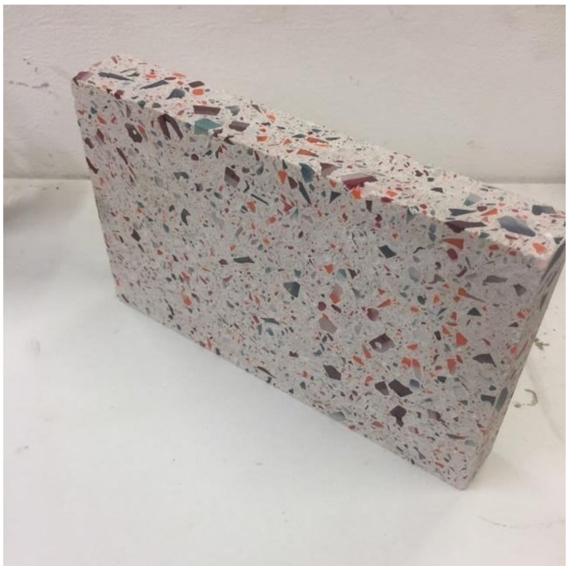
Code (2C): C.W.L + H_20 (Sample Colour: Brown with patches colours of B.W.G.O)

C.W.L Ratio: 3:2:2 + 250ml of H_20

SAMPLE 2D
- Code (2D): C.W. + H_20 (Sample Colour: Brown with patches colours of G.B.O.W)
- G.B.O.W Ratio: 0.5 each + 110ml of H_20

PART 11 WITH USE OF JESMONITE
SAMPLE (X): LUDO TESTS
- Code (X): C.L.W. + H_20 (Sample Colour: Light Cream with patches colours of R.O.G.GR)
- C.L Ratio: 6:6:2+500ml of H_20

SAMPLE (Xa): Garnet
- Code (Xa): Gar.C.W. + H_20 (Sample Colour: Light Brown with patches colours of R.O.G.GR)
- Gar.C.W: Ratio: 6:6:6 + 600 of H_20




Testing C

6.0 DISSCUSION/ EVALUATION

The control concrete was based on cement of 200kg/m^3 with a compatibility tests strength of 48hours. Compaction factor values gradually increase with increase in glass percentage. The first sample testing shows good compatibility with cement. With increase in waste glass content, percentage of water absorption decreases. In the second sample testing of waste glass with Ludo, Garnet and Sand, the workability of concrete mix increases with increase in waste glass content. However, my research work is totally different from the common Terrazzo which is a thin set flooring decorative material, which often, combine solid epoxy resin with Marble, Granite and other approved aggregates in a trawled mortar system for its production. Complicated designs are drawn using divider strips made of Brass, Aluminium, Stainless steel, coloured plastic or water jet cut pattern to aid its quality production. The flooring is then ground and polished to reveal the natural beauty of the aggregates surrounded by high glossy or mat finished epoxy background. With very careful and conscious status of research, my work and tests products does not include or involve the use of high glossy epoxy resin rather than the use of various glass aggregates from various units (such as, Architectural glass studio/workshop, Water jets units and the Hot glass workshop) at the National Glass Centre University of Sunderland St Peters Campus. In combination with other new discovered waste materials such as Ceramics Waste (Ludo) and Water Jets Waste Sediments (Garnett). Although, the baseline properties such as the strength of the materials is yet to be determined. More so, the current manufacturing process for my new pre-cast products is very close to optimal in term of casting pressure and time being used. Moreover, marginal improvements in mechanical properties could be achieved up to the resistance limits of my new casts products with great value added to cost of production. Ultimately, the greatest disappointment, I encountered during my research tests work, was the use of resin called Jesmonite, which has no good compatibility with my waste glass aggregates, neither, act as a binding agent with use of Jesmonite (a resin). Use of waste glass in concrete can prove to be more economical as it is non-useful waste and free of cost. However, use of waste glass in concrete will eradicate the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete reducing climate change and global warming issue. Use of waste glass in new products design will help preserve natural resources particularly landfill, river, sand and thus make construction industry sustainable.

7.0 CONCLUSION

This study intended to find effective ways for utilization of solid waste glass as fine aggregate in new products design for sustainability. The data presented in this paper show that there is a promising potential for the utilisation of waste glass and other ceramics waste products; further investigations may be considered regarding its long-term effect based on its strength and other properties.

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