Experimental Investigation On Light Weight Cellular Concrete By Using Glass And Plastic Waste—A Review

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Abstract— Cellular Lightweight Concrete (CLC) also known as Foamed concrete is one of the most significant type of concrete used for construction purposes due to its various advantages and usages over traditionally produced concrete. The rapid urbanization has led to the enormous increase in wastes being disposed of. This paper aims at identifying the possibility of using recycled materials such as crushed glass and plastic wastes in foam concrete as substitute filler for fine river sand. A protein based foaming agent is adopt for this study. The workability and strength of different mixes, made using performed foam, at varying densities using powdered glass and plastic wastes will be investigate. In this project foam concrete blocks are prepared according to the designed proportions to attain the maximum strength of 1900kg/m³. In this project, the mixing of recycled glass wastes 5%, 10%, 15% and recycled plastic wastes 1%, 3%, 5% will add as a filler in foam concrete. The 7days, 14, 28days compressive strength, flexural strength, split tensile strength and hardened densities of each batch will be study and compare with obtained nominal mix strength. The Scanning electron microscope (SEM) test will be conduct to know the air void distribution in the concrete.

Index Terms— Cellular light weight concrete, Compressive strength, Flexural strength, Foam concrete, Glass waste, Protein foaming agent, Plastic waste, SEM, Tensile strength.

1 INTRODUCTION

Foam concrete is a type of porous concrete. According to its feature and uses it is similar to aerated concrete. The synonyms are aerated concrete, lightweight concrete or porous concrete. The term foam concrete is containing no aggregates only sand, cement, water and stable foam to perform the concrete. This action incorporates small enclosed air bubbles within the mortar there by making the concrete lighter. Basically, there are two method of producing foamed concrete such as pre-foam method and inline method. The inline method can divided into wet method and dry method. A foamed concrete is described as having an air content of more than 25% which distinguish it from highly air entrained materials. Foamed concrete may have density from as low 500kg/m³ to 1900 kg/m³ and strength from less than 1N/mm² to 25N/mm²

2 LITERATURE REVIEW

2.1 General

Paul J.Tikalsky et al., (2003) in their paper study investigated the production of foam concrete by identifying few parameters like volume, size & spacing of air void. The influence of these parameters on density & strength of foam concrete also investigated. The results showed that mixes with a narrower air void size distribution gives higher strength. The shape of air voids did not influence the property of foam concrete.

K.Ramamurthy.A et al.,(2009) focused in their study on classification of foamed concrete based on constituent materials, mix proportioning, production methods, fresh and hardened properties. The author Emphasis the important of foam stability. The drying shrinkage strains of foam concrete were high as would be expected in concrete with large paste phase volume. But this could be reduced by adopting autoclave method of curing by using light weight aggregates and by using Portland cement with fine fly ash which reduces the heat of hydration. The study shows that replacement of large volume of cement up to 75% by weight (using flyash) will need a longer time to reach their maximum strength which was observed to be higher than that achieved (only by cement).

Dmitriy oreshkin et al.,(2003).The results proved that the extrusion reduces the water requirement of the concrete mixture. The microspheres promotes compaction of the concrete structure significantly increases the strength of concrete, crack resistance reduces water vapor permeability and heat conductivity. The results revealed that the crack resistance, compressive and flexural strength values of extruded concrete increases by 30% to 40% compared with the material produced from a non-extruded light weight concrete mixture with HGMS with the same mobility value.

E.K.Kunhanandan et al.,(2009) studied the air void structure of foam concrete by identifying few parameters like volume, size & spacing of air void. The influence of these parameters on density & strength of foam concrete also investigated. The results showed that mixes with a narrower air void size distribution gives higher strength. The shape of air voids did not influence the property of foam concrete.

Yakovlev et al., (2006) in their paper investigated about cement based foam concrete reinforced by carbon nanotubes. The results showed that the use of carbon nanotubes (0.05% by mass) in production of these concrete allows to decrease its heat conductivity up to (12-20%) and increase its compressive strength up to 70%.

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microscope test and optical microscopy results showed that the manufactured foam glass is characterized by a large porosity in the majority.

Fahrizal Zulkarnain et al., (2011) proposed a methodology to design the rational mix proportion for foam concrete. In this paper the 10% of silica fume is added to the foam concrete as replacement of cement. The silica fume is used to increase the compressive strength. The results revealed that replacing high proportions of cement with silica fume does not significantly affect the long term compressive strength of foam concrete.

Prinya chindaprasirt et al.,(2011) in their paper studied the shrinkage behaviour of structural foam concrete containing glycol compounds and fly ash.In this paper Propylene Glycol(PG),Triethylene glycol(TEG) and Dipropylene glycol Terbutyl ether(DPTE) were selected for testing of drying shrinkage. The result shows that PG,TEG and DPTE were effective in reducing the shrinkage of light weight concrete through reduction of surface tension of water. The results also revealed that the partial replacement of cement and sand with fly ash could also reduce the shrinkage of the lightweight concrete.

Rayhatate Atul et al., (2012) studied the behavior of plastic bag in concrete. The compressive strength results shows that addition of 1% of plastic in concrete causes about 20% reduction of strength. The split tensile results shows that up to 0.8% of plastic improved the strength of concrete ,after that the addition of plastic decrease the tensile strength value.

D.K Panser et al., (2013) compared the properties of foamed concrete by using synthetic &protein based foaming agent. The air content range varies from 6% to 35%.The Author had experimented the fresh properties test like slump ,plastic air content and Plastic density ,compressive strength static elastic modulus, sorptivity, hardened air void distribution & thermal resistance. The results revealed that protein foam resulted in smaller isolated spherical air bubbles compared to air voids produced With synthetic foam. The results shows that concrete thermal conductivity was less sensitive to change in air content produced by synthetic foam when compared to protein foam. The compressive strength corresponding to 7 day concrete specimen ranges from 0.9MPA to 47.1 MPA for concrete with air content ranging from 6% to 35%.In 28days the compressive strength value increased from 1.1mpa to 57.6mpa.

M.Iqbal Malik et al., (2013) in their paper studied the concrete involving use of waste glass as partial replacement of fine aggregate. The results showed that 20% replacement of fine aggregate by waste glass showed 15% increase in compressive strength at 7days and 25% increase in compressive strength at 28days. The replacement of fine aggregate by waste glass up to 30% by weight showing 9.8% increase in compressive strength at 28days. The increase of waste glass content reduce the water absorption Siong kang lim et al., (2014) conducts a systematic study to ascertain the influence of filler type like sand and flyash. The author studied the particle size of sand on the properties of moist curved foam concrete. The results shows that the reduction in particle size of sand caused an improvement in strength of foam concrete and the flow behaviour mainly depends on the foam volume. The compressive strength test revealed that the mix with fine sand resulted in higher strength than the mix with coarse sand. The fine sand results in uniform distribution of bubbles and hence results in higher than coarse sand.

T.S Serniabat et al., (2014) focused in their study by using glass as coarse aggregate in concrete instead of stone chips (or) brick chips. The different ratio of glass crushed to 5mm-20mm maximum size and glass marble of 20mm size used as coarse aggregate. The results shows that maximum compressive strength 3889 psi achieved for several mix. Yahya Jani et al., (2014) studied that different uses of waste glass in cement and concrete and the effect of the glass properties on the performance and durability of the produce cement and concrete. The results shows that the waste glass can be used in cement and concrete but the particle size of the glass waste plays a vital role in the alkali silica reaction and the performance of concrete. The pozzolanic properties of glass increased with decreasing its particle sizes under 100um. The author verified that increasing the percentage of waste glass aggregate reduces the maintenance of concrete.

B.Karthikeyan et al., (2015) in their paper studied the properties of lightweight foam concrete with addition of various binders/fillers such as flyash, Micro silica, clay and rice husk. The results revealed that the mix incorporating fly ash gives better results than other mixes. It can be concluded that these is no significance strength loss between 10% to 30% foam volumes.

Sameer Shaikh et al., (2015) studied the behaviour of concrete by replacing waste glass. The author partially replace the cement as well as sand by waste glass powder and crushed glass particles with equal combination by 5% interval up to 20% replacement. The results shows that replacement of glass powder in cement as well as crushed glass particles in sand by 5%,10%,15%,20% increase the compressive strength. Replacement of glass powder in cement and crushed glass particles in sand by 15% increase the split tensile strength after 28days by 5%,10%,15% increases the flexural strength after 28days. Replacement of glass powder in cement and crushed by 5.88%,30% and 44.85% respectively.

Vikram Kathe et al., (2015) in their paper studied the behaviour of conventional concrete by using plastic waste. The authors replace the fine aggregate by plastic waste such as Polyvinyl Chloride (PVC),Polypropylene Polyetheyene. The results shows that natural sand can be replaced with the plastic waste by 10% to 20% to achieve green concrete. The sand can also replaced up to 30% in the members of building which do not carry high load.

Chien chung-chen et al., (2015) conducted experiments on a conventional concrete. Replacing of fine aggregate by recycled plastic of 0%, 10%,20%,30%,40%,50% and 100%. The results showed that the 10% replacement level decrease the 15% loss of compressive strength. The tensile strength test showed that the 10%, 20% and 30% replacements of plastic waste increase the tensile strength value than conventional concrete. So as per the result paper percentage of fine aggregate replaced by the HDPE plastic may be beneficial aggregate replaced by the HDPE plastic may be beneficial to tensile strength development. The 10%,20%,30% replacement mixes showed a significant decrease in heat absorption and a minor decrease in heat transfer through the test slab.

Paweł Walczak et al., (2015) Conducted experiments on Autoclaved aerated concrete using sub grain packaging glass cullet, CRT(Cathode Ray tube) panel glass waste & calci glass as a replacement of sand. The result shows that higher content of glass cullet between 3-10% caused an average
decrease of compressive strength of the samples by 8%. The specimen with 20% waste glass replacement in place of quartz showed compressive strength decrease by 33% in comparison to reference mix.

Mohammad Akbur Rasheed et al., (2015) in their paper discuss the mechanical behaviour of CLC cylinders under pure compression and CLC blocks under flexure with and without polyethylene structural fiber reinforcement. The results revealed that the addition of structural fibers improved the compressive strength up to 66.8% for 0.55% volume fraction. The result shows that the compressive strength increased with addition of macro-fibers dosage. The addition of macro-fibers, the flexural strength increased up to 11.7% for 0.22% & up to 46.7% for 0.44% volume fraction.

Ameer.A et al., (2015) in their paper discuss about an enhancement of pre-formed foamed concrete, 1300-1900kg/ m³ by utilizing two types of additives silica fume & Fly ash to Portland cement & silica fume. The author focused on consistency, mechanical & Thermal properties. The author compared the conventional foam concrete with foamed concrete mixes with high flow ability & strength. The 10% of silica fume replace the cement content. The results revealed that adding silica fume or fly ash individually improve the 28day compressive strength to 10% & 60% respectively.

Y.H.Mugahed Amran et al., (2015) in their paper discussed about the foamed concrete constituents, fabrication techniques and properties of foamed concrete. The paper discussed about the fresh properties of foamed concrete like consistency, stability, workability & compatibility. The physical properties like density, drying shrinkage, porosity, sorptivity also addressed. In this paper the author recommended that to produce foamed concrete with high consistency & stability, the volume of foaming agent should be reduce using partial replacement of cement either by fly ash or silica fume

Eva Namsone et al., (2016) in their paper discussed about the possibilities for creating durable high performance foamed concrete by applying intensive mixing technology and modified micro admixtures. The author discussed about the strenght, density, water absorption ,carbonization and frost resistance. The result revealed that low density and high open porosity of material accelerates carbonation processes. The use of pozzolanic admixtures and turbulence mixing technology makes possible to produce more water resistant and durable foamed concrete.

Nursyami et al., (2017) in their paper discuss about utilization of poly ethylene Terephthalate(PET) plastic waste as a coarse aggregate. The results shows that the maximum compressive strength is achieved on sample using the maximum fineness modulus of PET Plastic waste aggregate. The author presented a methodology to convert the PET Waste to coarse aggregate. The results shows that maximum compressive strength is 16.57Mpa. The study determines the gradation of coarse aggregate of PET plastic waste can affect the compressive strength of structural light concrete.

Claudia Aciu et al., (2017) studied the optimal recipes for the manufacture of Ecological mortars by PVC waste recycling were established. This study result shows that 25% sand in the standard recipe replaced with PVC. The compressive strength results of 28days shows that this mortar falls into masonry mortar class M20 & also having the best adhesion to the substrate. The 100% of replacement of sand with PVC waste classifies this masonry mortar as class of M12.5. The flexural Strength of the materials containing PVC waste decreases significantly compared to standard mortar, with the increasing proportion of plastic material. The 25% replacement of sand with plastic waste, the thermal conductivity coefficient of the mortar decreases by 65% compared to that of the standard mortar specimen.

N.Vinith kumar et al., (2017) conducts experiments on a foamed concrete by using sodium lauryl ether sulphate as a foaming agent. The properties like thermal resistance and compressive strength are much higher than that of plant surfactants and surfactants are much higher than that of plant surfactants and surfactants. The compressive strength of foamed concrete with synthetic surfactants is 11% and 43% higher than that of foamed concrete with animal surfactants and plant surfactants. The results revealed that fooded concrete with surface surfactants showed narrower pore size distribution and fewer connected pores compared with the plant surfactants and animal surfactants.

H.Suleyman Gokce et al., (2018) in their paper discuss about the foam concrete by replacing cement by silica fume(0%,10%,20%) and the content of foam varies 0%,31%,47% by volume by weight. The result showed that at a constant foam content, silica fume increased the density of the concrete up to 55%. For the same foam content, silica fume incorporation reduced the water absorption value of foam concrete up to 67%. The mixture containing 10% silica fume and cured in water produced the closest density to the optimum value.

Elango et al., (2018) studied the conventional concrete by replacing plastic waste as a fine aggregate. The mix were cast for 0%,10%,20%,30% sand being replaced by pulverized plastic material. The author suggested the replacement of sand by plastic up to 20% is give positive results. The 20% replacement of plastic reduce the compressive strength from 3.2N/mm² to 3N/mm² in 28days. The results also shows that...
the water cement ratio was also found to increase with increasing proportion of plastic.

Ali-Reza Mohammadinia et al., (2018) In their paper discussed about replacement of Recycled plastic waste(RPW) and Recycled crushed glass(RCG) as coarse aggregate in conventional concrete. The coarse aggregate in concrete were replaced by RPW and RCG aggregates in proportions of 0%, 10%, 20%, 30%, 40% & 50% was investigated. The author experimented uniaxial strength, tensile strength & Capillary water intake. The results shows that decreasing the compressive & split tensile strength value. The 5% of RPW & 5% of RCG gives the UCS value 43Mpa. The 10% of RPW & 10% RCG gives 58 Mpa & 38 Mpa respectively. The result shows that 50% use of RCG & RPW in construction footprint is viable.

Awham Mohammed Hameed et al., (2018) investigated the properties of concrete using Recycled Polyethylene terephthalate(PET) flake aggregates. The PET contents varies 1%,3%,5%,7%,10% by the weight of Portland cement. The authors performed compressive strength, flexural strength, splitting tensile strength. The results showed that use of 1% of PET waste increase the compressive strength in 58% compared to the reference batch. Flexural strength results revealed that the use of PET at 1%,3% increases the values flexural strength in 23.11%,25.59% compared to the conventional batch. The split tensile results shows that adding 1% of PET to the reference batch gives the optimum value of split tensile strength with increment ratio 130%. The density values clearly decreased with increasing the percentage of PET content, the decreasing ratio of density close to 14% especially at 10% of PET.

Qusim S Khan et al., (2018) focused in their study to use the recycled glass powder in foam concrete. The paper discuss the effects of cement & recycled glass contents water to cement ratio and volume of foam on the plastic density and dry density. The replacement of cement with recycled glass powder(20%) by mass increased the compressive strength of foam concrete. The results revealed that 20% replacement of cement is better suited than 40% replacement of cement with recycled glass powder. The particle size of recycled glass particles should be smaller than 45um.

D.Kavitha et al., (2018) in their paper performed the design and analysis of foam concrete using Blast furnace slag, Glass powder, Fly ash as a filler material in this study. The author proposed the design proportion to attain the maximum strength of 1900kg/m3 and also the methodology for mix design. The paper reveals that the compressive strength of foamed concrete increases with increase in the density.

T.J Chandni et al., (2018) in their study compared the behaviour of foam concrete using recycled glass and recycled plastic waste. The protein based foaming agent adopted for this study.Poly carboxylate Ether(PCE) and Sulphonated Naphthalene Formaldehyde are added to foam concrete to obtain required density and consistancy. The protein based foaming agent is used to generate stable foam. In this report the compressive strength and air-void distribution on foam concrete is obtained. The results show that compressive strength of GFC(1600kg/ m3) is 10.26N/mm2. For GFC, the volume of foam decreased from 30% to 10% to design density of 1200kg/ m3 to 1600kg/ m3. For PFC foam volume decreased from 40% to 15% to design density of 800 kg/ m3 to 1200kg/ m3. The result shows that GFC showed higher strength than PFC because of the higher design densities & lower water to solids ratio for the former mixes.

Lina et al.,(2019) in their paper discussed about the main aspect that influence the application of cellular concrete like raw materials ,production methods and expected properties based on density. The paper discuss the use of new and alternative raw materials for cellular concrete could permit modifications on the physical and mechanical properties for construction applications.In a fresh concrete state consistency, spreadability, yield stress, pseudo plasticity are the important characteristics for foamed concrete. In the hardened state ,pore internal structure, voids size distribution ,uniformity, geometry, spatial distribution are the important characteristics of foamed concrete.

Devid Falliano et al., (2019) in their study investigate the fracture behaviour of light weight foamed concrete. The authors studied the foam concrete in two curing condition. One is air and another is water. The results shows that the curing conditions did not affect the compressive strength values at the lower dry densities and the better performance is achieved in air curing conditions. The scanning electron microscope test had conducted to determine the micrographs across the crack surface.

Fernando Antonio da silva fernandes et al., (2019) in their paper discuss about the effect of partial replacement of natural aggregate with glass foam(10-30%) produced with soda lime glass wastes, rice huk, calcium carbonate. The 3,7,28,56,90 days uni axial compression test had conducted. The best results at all ages were obtained with 4.8mm glass foam..

Saeid Ghorbani et al., (2019) in their paper the author studied the stability and microstructure of foam and foam concrete using statistical methods. The result showed that synthetic based foams displayed much higher overall stability than protein based foams. The author evaluate the effect of magnetized water on the stability of foam agents. The results shows that magnetized water enhanced the stability of synthetic based foam concrete. Magnetic water has a sensible positive effect on the stability of synthetic based foams and negative effect on the stability of protein based foams.

Mehran Khan et al., (2019) in their paper discussed about the mechanical properties of fly ash silicafume plain concrete(FA-SPA) and fly ash silica fume coconut fibre reinforced concrete. The compression test, flexure and split tensile test are conducted. The results revealed that FA-SC FRC has generally enhanced properties than that of their respective FA-SPC. The results also shows that, the nutshell FA-SCFRC with 10% fly ash content demonstrates overall best mechanical properties than that of FA-SPC.

Xiao-hua wang et al., (2019) performed the research on cellular concrete with steel fiber. The compressive and split tensile behaviour are investigated. The crimped straight & hooked steel fibers are used. The different volume fraction of steel fibers (i.e 0.5%,1%,1.5% used). The study reveals that the higher volume fraction or aspect ratio of steel fiber increase the compressive and split tensile strength of cellular concrete.

Sheelan Mahmoud Hama et al., (2019) in their paper investigated the effect of waste glass powder as a cement in conventional concrete. The result shows that, the ultimate load of specimens with 10% and 15% WGP demonstrated increasing capacity compared with that of reference beams. The load –deflection relationship shows that 10% of waste glass powder have higher crack resistance capacity than that of reference beams. The results revealed that the usage of...
15% of waste glass powder economize 52.5kg of cement per cubic metre of concrete.

Kenneouche salim et al., (2019) in their study the plaster will be reinforces by fiber from waste plastic and powder glass. By adding 1% and 2% of plastic fiber and 5% and 10% of glass powder to reference specimen. The results shows that increasing of flexural strength of the beams content of 2% of plastic fiber compared to the 1% of plastic fiber. The decreasing of flexural strength observed for the beams content of (2% of plastic fiber+10% of glass powder) and (1% of plastic fiber +10% glass powder) relative to (2% of plastic fiber +5% glass powder) and (1% of plastic fiber+5% of glass powder)

Amritha Raj et al., (2019) in their paper discussed about the fresh state and physical properties like consistency, stability, workability, drying shrinkage, air void system& mechanical properties like compressive strength, flexural strength & Elastic modulus. The result shows that a minimum water/cement ratio 0.30 is preferred for foam concrete. The compressive strength increased with density.

Juan He et al., (2019) studied the behaviour of foam concrete by using Alkali activated cement &three different types of foaming agent like sodium alpha olefin(AOS),Sodium dodecyle sulfate(k12) and sodium alcohol ether sulphate (AES) with the same foam stabilizer of silicone resin polyether emulsion FM-500 (Mps) were used to prepare foam. The results revealed that the foam stability of AES and K12 is better than that of AES. When comparing the three types of foaming agent, the compressive strength of sodium alpha olefin sulfonate gives high result. So AOS foaming agent is mostly preferred for Alkali Activated slag foam concrete.

3 Conclusion

Based on the literature survey it is clear that the performance of cellular light weight concrete depends on the type of foaming agent and fillers. The density of foamed concrete is inversely proportional to the foam content. The protein based foaming agent is used to generate stable foam. In this report the compressive strength and air-void Recycled glass and plastic is suitable material to use as a filler. Glass filler foam concrete showed higher compressive strength compared to plastic filler foam concrete. The use of fly ash in cellular light weight concrete can be greatly improves its properties.

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