A Review On Utilization Of Waste Glass In Construction Field

A REVIEW ON UTILIZATION OF WASTE GLASS IN CONSTRUCTION FIELD

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ABSTRACT:

The concrete production has a huge demand in aggregate and clay (bricks) source. In the year 2015, 48.3 billion tonnes of aggregates are utilized as construction material globally per year in which 2.2 billion tonnes of aggregates were used in India. To overcome the demand of aggregate glass waste materials can be used as alternate construction material. In the year 2019, 21 billion tonnes of glass waste has been produced in India out of which only 45% is recycled, which shows that there is a need for proper procurement and management of waste glass. This review illustrate about utilization of waste glass in construction material such as blocks. The main aim of the study is to gain knowledge about the mechanical properties and physical properties of the blocks and other products produced with waste glass, to reduce the waste glass in landfill by producing sustainable construction material and to overcome the demand of aggregates and clay.

KEYWORDS: Waste glass, blocks, sustainable materials, construction materials

1.INTRODUCTION

The fast urbanization is making a shortage of ordinary building construction materials due to restricted accessibility of normal resources. On the other hand energy used through for the creation of regular building construction materials pollutes air, water and land. To meet the ever expanding demand for the energy efficient building construction materials there is a need to adopt practical, environmentally appropriate technologies and update traditional techniques with accessible nearby materials. Million tons of controlled waste from family unit, business and modern are discarded in landfill sites in the most developing and developed nations causing a raise in landfill costs and ecological issues. Reusing of waste helps saving the landfill space and spare garbage removal costs. The energy needed to reuse the recyclable material is less than that of virgin materials [26]. In the year 2020 it is predicted that 2880 million metric tonnes of sand and gravel will be used [41]. Glass is also plays a major role in increasing landfill. Glass is an unavoidable part of the Indian economy, where it represents in excess of 21 million metric tonnes of consumer products every year yet there is no appropriate management of waste glass created by consumers. Out of the total glass manufactured in India just 45% is reused which shows that there is a requirement for appropriate acquirement and management of waste glass [27]. A huge volume of post-buyer refreshment glass bottles is being disposed every day around the world, just a little extent is either washed for reuse or re-melted to manufacture new glass. In Hong Kong, the dominant part of waste glass is utilized once or a couple of times before being disposed of into landfills. As indicated by government reviews, as it were 1–2% of the waste glass in Hong Kong is reused. The utilization of reused glass as total for the creation of concrete blocks has received significant application interest [28].

In 1994, United States produced 9.2 million metric tonnes of glass waste in landfills [29].As indicated by 2010 information, the global generation of municipal solid waste was 1.3 billion tons, out of which glass represented 5 % of the wastes. In India, which lies in South Asian region, 1 % of complete metropolitan waste produced contains glass wastes [30].

Figure 1

General outcomes indicated that the reused glass cullet can be utilized as a substitution for common total in the creation of concrete blocks without trading off its mechanical properties [32] . By the by, the waste glass is largely utilized in concrete. It is important to make reference to here, that majority of the available research considers only washed glass, which unfortunately requests an extra mechanical advance in the concrete production process. Waste glass is accessible in various size portions, from a few micrometres (powder) up to a couple of centimetres, which makes it conceivable to replace ordinary, mineral concrete aggregates, fillers1 in concrete such as sand, gravel, etc. [31].Besides, glass aggregate has been likewise utilized for the creation of decorative and aesthetic concrete because the uncovered glass particles in cleaned surfaces are alluring for certain decorative and architectural applications. [33]. Not with standing the use of glass totals in traditional concrete, research has been performed on the improvement of architectural self-compacting concrete (SCC) utilizing fine and coarse glass aggregate [32].

At first, the employments of glass were restricted to jars, beads and bowls [34], but, because of advances in innovation, the quantity of utilizations of glass has soar to incorporate windows, racks/shelves, lighting, appliances, fibre optic cables and solar panels, and so forth. The increase in number of utilizations of glass is generally because of the disclosure of various kinds of glass with shifting properties. The initial phases in the glass fabricating process are the mining, transporting and preparing of materials that become glass inputs [35]. After the information sources are moved to a glass fabricating manufacturing facility, the main process in glass producing are batch preparation, melting and refining, forming and post forming [36]. For each ton of glass recycled, roughly 560 kg of sand, 190 kg of soda ash, 176 kg of limestone and 64 kg of feldspar are preserved Glass Packaging [37]. As indicated by the U.S. Environmental Protection Agency, in 2013, Americans created 10.37 million tons of glass in the municipal solid waste stream, most of which were food and drink containers. Out of the glass discarded, 2.78 tonnes of glass (27%) were recovered for recycling, which brought about 7.59 million tons of waste glass being disposed of in landfills [35]. In expansion, in 2013, the European Union created 1.5 million tons of glass waste from destruction and remodel [38], and roughly 15.9 million tons of glass packing waste [39]. Moreover, in 2007 it was assessed that 130 million tons of glass were created around the world [40].

Figure 2

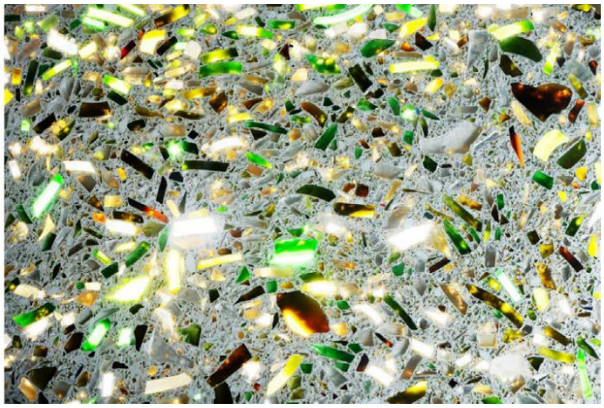

Figure 3

2.LITERATURE REVIEW

Tung-chai Ling, Chi- Sun Poon ,et al., (2012) had studied the " Management and recycling of waste glass in concrete products: Current situation in Hong Kong" .This paper tells about the management and recycling of waste glass and the involvement of using waste glass in the manufacturing of concrete products. It has been found that nearly 300 tonnes of waste glass needs landfill disposal everyday. To overcome this state and private sectors has taken many action. Since the outcome of action was not up to expectation different process to recycle and to promote a trust worthy market for waste glass. The study which was carried out in Hong Kong polytechnic university is to evaluate the utility of recycled waste glass in manufacturing various concrete products such as concrete blocks, etc from which expected outcome has been achieved and they have concluded that to enhance the recycling rate of waste glass (Hong Kong) more schemes has to introduced.

T O Ogundario, D D Adegoke , et.al., (2019) has reviewed on "Sustainable use of recycled waste glass as an alternative material for building construction- A review". This paper explores the recycled waste glass, standard and sustainable uses of waste glass in production of construction material. According to this study to minimize the impact on environment by waste glass, it is discovered that glass can be used as an sustainable building component. When compared to the convention concrete the mechanical properties of the concrete made up of recycled waste glass is high. To reduce the utilization of cement which emits CO2 into the environment it can be replaced with waste glass. The motive of the construction industry is to improve the profit, increase the lifespan of the building structures at the same safeguarding the environment is also be considered which can be fulfilled by replacing the cement and aggregates with wastes (glass). Attempt of using waste glass in construction needs more research and improvement . It is concluded that there are few factors bothering the perfoprmanvce of the building structure which are constructed using recycled waste glass and also few condition has to followed while using with recycled waste glass.

R.Saraswathy, Jijo James, et al., (2019) carried out a experiment on " Valorization of crushed glass as potential replacement for sand in cement stabilized fly ash bricks". This study ellabrates the use of crushed glass as an additive in production of cement stabilized fly ash bricks. In this the fine aggregate is replaced with crushed glass and the brick were produced. With different mix proportion the bricked were moulded and cured for 21 days. Then the flowing tests were conducted compressive strength, water absorption and efflorescence test are carried out. This research results that when compared to stabilized block and burnt brick the strength of the brick which is made with crushed glass is higher and the cost of the brick with crushed glass was less than the conventional brick.

Omoniyi T.E, Akinyemi B.A, et al., (2014) examined the "Effects of waste glass powder as pozzolanic material in saw dust cement brick" . This project analyze the chance of utilizing the waste glass powder as limited replacement of cement in saw dust composite brick to evaluate its pozzolanic

activity and effects on the3 properties of the composite brick. Cubes were casted with various percentage of waste glass powder and were checked for compressive strength, water absorption, capillary water absorption and volume porosity. From the outcome, it is noted that no negative effect is found in the non load bearing concrete blocks manufactured with 30% replacement of waste glass powder.

Hathaichanok Warnphen, Nuta supa kata et al., (2019) investigated on "The reuse of waste glass as aggregate replacement for producing concrete bricks as an alternative for waste glass management on Koh sichang".The motive of the research is to control the waste glass in Koh sichang, Chonburi by replacing the fine aggregate in manufacturing of concrete bricks.Specimens were casted with various percentage of waste glass aggregates. Tests like compressive strength, scanning electron microscope and xray diffractometry was conducted. From the test results it is found that compressive strength was enhanced by the replacement of 20% of waste glass in the concrete (48.49 Mpa at 28 days) with low water absorption. It is concluded that waste glass can be used in the making of concrete bricks and can be an substituted for managing waste glass.

P.Turgut and E.S.Yahlizade (2009) has done the "Research into concrete blocks with waste glass". In this research the parametric experiments were studied for the paving blocks casted with fine waste glass and coarse waste glass. Compressive strength, flexural strength, split tensile strength, and abrasion resistance test were examined for the paving block. Comparison was done between the paving blocks casted with fine glass and control samples. From the experiment it is found that fine glass replacement of 20% are 69%, 9%, 47% and 15% are high in compressive strength, flexural strength, split tensile strength, and abrasion resistance. It is found that 20% of fine glass good choice for manufacturing the paving blocks when compared with coarse glass

Marcin Malek, Waldemar Lasica et al., (2010) explores the "Effect to waste glass addition as replacement for fine aggregate on properties of mortar". The motive of the research is to appraise feasibility of utilizing the glass sand aggregate manufacture by post consumer waste glass. Fresh mix tests (slump cone, air content and ph values) and hardened sample tests (Bulk density, compressive strength, flexural strength, tensile strength, elasticity of modulus and poisson co-efficient) were conducted. For the tests it is obtained that more recycled glass sand aggregate reduced the mortar density.

Linqiang Mao, Huijuan Guo et al., (2017) tells about "Addition of waste glass for improving the immobilization of heavy metals during the use of electroplating sludge in the production clay bricks". In this study glass powder was collected from the broken glass bottles with ball crushers. X-ray were conducted on the materials to find the chemical composition. Different dosage of glass waste powder are added (5, 10, 15, 20, 25 and 30%). Samples were prepared with the size of 50x35x10 mm. Water absorption capacity, open porosity, compressive strength and scanning electron microscopy, X-ray diffraction were conducted From the study it is concluded that the bricks made with waste glass has lower water absorption and high compressive strength.

Hariharan.S and Jebaraj.G (2018) tells about the "Manufacturing of bricks with partial replacement of clay with waste glass powder". The main motive of the study is to produce brick made of clay and waste glass, to explore the compressive strength and physical properties of the clay bricks. The aim of the study is partial replacement of the waste glass powder. Waste glass powder was replaced 25%, 30%, 35%, 40%, 45% up to 50%. The mixture was made with correct proportions and consistency, then the bricks were made in the size of 190x90x90 mm. The drying process is carried out. From the result of the tests conducted it is concluded that more percentage of waste glass powder can be replaced in the clay bricks and the compressive strength and other properties are equal in both clay bricks and normal fired clay bricks.

Koli Nishikant, Aiwale Nachiket et al., (2016) carried out a study on "Manufacturing of concrete paving block by using waste glass material". The aim of the study is to see the feasibility of the waste glass in fine aggregate replacement process. Tests like compression and flexure was carried out and the results of ordinary paving blocks and waste glass replaced paving blocks (15%, 30% and 45%). The test results tells that the waste glass improves the compressive strength of the concrete and glass can be replaced up to 45% which does not give any change in strength of the concrete.

Paki turgut (2007) has studied on the "Properties of masonry blocks produced with waste limestone sawdust and glass powder". The main objective of the research is to estimate the usage feasibility of waste limestone and waste glass powder in masonry blocks water absorption, unit weight compressive strength and flexural strength test were conducted on the masonry blocks. The speciens were made in two type. First type with waste limestone with Portland cement and waste glaSs powder which were subjected to the above mentioned test. From the results it is concluded that the blocks made with WLS and WGP is high in compressive and flexure strength. Both the blocks WLS with and without WGP can be used for manufacturing of blocks.

Chi Sing Lam,Chi Sun Poon et al.,(2007) explores about " Enhancing the performance of the precast concrete blocks by incorporating waste glass ASR Consideration".This research is composed into two parts.The first part is to measure extent of ASR expansion and in the second part concrete paving blocks were made using the optimal mix portion and the mechanical properties are found.From the study it fund that the optimal mix formulation for using the waste glass in concrete mix should have minimum of 10% PFA by the total aggregate weight used.

Nonthaphong Phonphuak, Prinya Chindaprasirt et al.,(2015) has researched on "utilization of waste glass to enhance physical and mechanical properties of fired clay brick"objective of the study is to examine the improvement of physical mechanical of the fired clay rick by integrated waste glass to minimize the firing temperature.The samples were prepared with three dfferent dosage and for firing the bricks three different temperatures were conducted on compressive strength, water absorption, density and porosity of the clay bricks.The results of the test tells that upto 10% weight of the waste glass added to the clay bricks and fired in the temperature of 900-1000^{o} C improves the properties of the bricks.And it was concluded that waste glass can be used in the production of bricks to improve the physical-mechaniacl properties of thr clay bricks.

S.E Chidiac, S.N. Mihaljevic (2011) studies the "performance of dry cast concrete blocks containing waste glass powder or polyethylene aggregates". The motive of the study is to enhance the economic and environmental sustainability of the construction industry, it is based on the natural aggregate and Portland cement utilization to be minimized. To carry out this study blocks were produced with 25% of cement replaced by glass waste powder or 15% of sand replaced with high density polyethylene or low density polyethylene. The Blocks made with WGP, HDPE, LDPE were tested. From the test results it is concluded that the blocks produced with 10% waste glass powder is equivalent to the controlled blocks. The physical, mechanical and durability properties were low and water absorption was high in polyethylene blocks.

Syed Minhaj Saleem Kazmi, Muhammad Junaid Munir et al., (2017) researched the "Thermal performance evaluation of eco-friendly bricks incorporating waste glass sludge". The main motive of this study is to analyze the thermal properties of bricks which are fused with waste glass sludge. Waste glass sludge were collected from the glass cutting and polishing industries. Various dosage of waste glass sludge was used for production of clay bricks (5%, 10%, 15%, 20%, 25%). Physical, mechanical and thermal properties were examined. From the result it is found that compressive strength of the clay bricks was enhanced when waste glass sludge is used, porosity and water absorption was minimized when the waste glass sludge percentage is high in the bricks. The result obtained from microscopic images gives the dense and uniformity of the structure with low porosity by incorporating waste glass sludge in the bricks which enhances the thermal conductivity of the clay

bricks. In the manufacturing of clay bricks with waste glass sludge minimize the landfill and environmental problems of waste glass sludge.

J.O.Akinyele, U.T.Igba et al., (2020) examined on "Structural efficiency of burnt clay brick containing waste crushed glass and polypropylene granules". This project inspected on the utilization of crushed glass and polypropylene granules in two batch of clay bricks. The bricks where produced using waste glass and waste plastic separately with various proportions from 1%-5%. Scanning electron microscopy, Water absorption, shrinkage, mechanical properties tests were carried out on bricks produced with waste glass, brick produced with waste plastic and also in ordinary bricks. Compressive strength comparison was done from the result obtained. It is concluded that waste glass infused brick has high structural efficiency than ordinary brick and plastic infused brick.

Patricia Ponce Pena, Maria Azucena Gonzalez Lozano et al., (2016) explores "Effect of crushed glass cullet sizes on physical and mechanical properties of red clay bricks. In this study the composition of bricks are partially replaced by 20, 25 and 30% of recycled glass with different particle size. The bricks were moulded and dried at the room temperature for 72 hours. The tests conducted in the bricks are total shrinkage, water absorption, compressive strength, micro structure and space composition based on the particle size and dosage. It is concluded that water absorption and compressive strength can be enhanced by increasing the glass content and reducing the particle size. By reducing the particle size the properties of brick are improved with less porosity.

Hisham Hussein Abdeen (2016) has done the research on "Properties of fired clay bricks mixed with waste glass. The main motive of the study is to concentrate in the capability of producing fired clay brick as the replacement masonry units by concrete blocks which also improves the property by utilizing the waste glass. The physical and mechanical properties were examines for the clay brick. From the test result it is found that increased quantity of waste glass enhances the firing shrinkage, bulk density and compressive strength. The uniform and finest particle size of the waste glass powder plays a major role which give high compressive strength to the clay brick.

S.P.Gautam, Vikas Srivastvava et al., (2012) investigated the "Use of glass wastes as fine aggregate in concrete". To investigate the effect of waste glass as partial replacement of the cement. 66 cubes were casted with various percentage of waste glass in the mix proportion and specimens were tested. Compressive strength test is carried out for the specimen and sieve analysis, bulk density, specific gravity tests were conducted for the materials used. From the study it is conclude that replacing the fine aggregate by 20% of glass waste enhance the compressive strength at 7 days and 28 test.

Nisha devi.A (2016) has done a "Study of partial replacement by glass powder and crushed spent fire bricks in concrete. The objective of the research is to find out the concrete strength and replaced concrete strength for M30 grade concrete. Samples were produced based on the mix proportion 1:1.452:2774 and also the partial replacement of cement with glass powder and sand with crushed spent fire bricks. Slump cone test, compressive strength, split tensile strength and rupture modulus are tested on the samples. From the test result it is concluded that the compressive strength, split tensile strength increases when 20% of cement is replaced by glass powder and 20% of sand is replaced by crushed spent fire bricks. This research recommends glass powder and crushed spent fire bricks can be utilized as alternative for cement and sand in the concrete.

L.M.Federico, S.E.Chidiac et al., (2005) has reviewed on " The use of waste material I manufacturing of clay brick. In this paper number of literatures were collected and reviewed. From the summary of the literature it is studied that by adding waste glass the strength has been enhanced, Quality of the brick are improved and reduced the emission by lowering hydrogen floride. And other waste materials like sludge and blast furnace slag were also reviewed in this paper.

Ari Rahman, Takeo Uarbe et al., (2015) tells about "Effect of waste glass additions on quality textile sludge-based bricks". The study examine the use of textile sludge as alternate for clay in brick

manufacturing. The specimens were prepared and compressive strength, water absorption, percentage of shrinkage and weight loss, leaching test were tested. From the tests result it is found that incorporating waste glass to textile sludge clay for brick manufacturing can enhance both compressive and water absorption. When the textile sludge and waste glass is fused together in the manufacturing of brick it resolve the issue of textile sludge disposal.

Ahmad Shaker Anna (2013) studied the "Characteristic of concrete building units containing crushed waste glass". The aim of study is to analyze compressive strength and splitting tensile strength of the concrete mixes with various glass aggregate replacement up to 20% by the volume of fine aggregate with and without the admixture. For testing the compressive strength and split tensile strength 144 cubes and 144 cylinders were casted with various admixtures. From the tests it is found that glass replacement from 5- 20% by volume of fine aggregate decreases the compressive strength and split tensile strength examined in contrast with 21 days of controlled mix. By utilizing the mineral admixture the properties can be enhanced.

M.Iqbal Malik, Muzafar Bashir et al., has "Study of concrete involving use of waste glass as partial replacement of fine aggregate". The main motive of this study is to explore the problems of environmental and economic concern which are forwarded by the utilization of waste glass as the replacement of fine aggregate in the concrete. Specimens were produced by replacement of waste glass powder in 10, 20, 30 and 40% by weight of M25 mix. Age of 28 days the specimen were tested for compressive strength, splitting tensile strength, water absorption and density. The test results were compared with normal concrete and concluded that when sand was replaced by waste glass (20%, 25%) enhances the compressive strength (7, 28 days), and the water absorption decreases. By utilizing the waste glass in concrete will save natural resources mainly the river sand and also the concrete construction industry can be sustainable.

N.Sudharsan, T.Palanisamy (2016) has researched on "Feasibility of using waste glass powder in fly ash bricks. The main motive of the is to minimize the waste glass in dumping in the earth to save the environment and to make profit low cost brick in the construction industry to develop the sustainability. The fly ash was replaced by boron glass powder, soda lime glass powder. The samples were casted based on the two types mixtures and were examined under compressive strength, water absorption, efflorescence test, bulk density, initial rate of absorption. From the test result it is found that the price of fly ash bricks containing waste glass powder is lesser than the ordinary fly ash brick. The replacement of boron glass powder and soda lime glass powder (20%) gives optimum compressive strength.

3. CONCLUSION

From the literatures surveyed it is analysed that by using glass as a construction material the utilization of natural resources like gravel, sand, etc can be minimized, the landfill occupied by the waste glass can be reduced, the environmental issues due to waste glass can be sorted out, by adding waste glass with proper mix proportion enhances the compressive strength, flexural strength, tensile strength and durability of the structure. The cost of the construction can be reduced by partially replacing the waste glass with fine and coarse aggregate and it also makes the construction sustainable.

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