A Technical Review on Concrete Replacing Cement by Glass Powder

Akhilesh Kumar Maurya, M.Tech Scholar, Department of Civil Engineering, Lucknow Institute of Technology, Lucknow, India.
Maaz Allah Khan, Assistant Professor, Department of Civil Engineering, Dr. Shakuntala Misra National Rehabilitation University, Lucknow, India

Abstract— **In a growing country like India a huge amount of industrial waste are polluting the environmental. With a view to the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder was tested with concrete and mortar. Cement was replaced by the glass powder in the proportion of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55% and 60% for M25 grade and M30 grade of concrete with 0.5 and 0.44 water-cement ratios respectively. This paper showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.**

Index Terms—**Concrete, Cement, Glass Powder**

I. INTRODUCTION

The modern building is a multi-billion dollar industry, and the production and getting of raw materials [1] for constructing building purposes is on a worldwide scale. Often being an initial governmental and trade key point between nations, environmental factors are also becoming a dominating world topic concerning the availability and sustainability of particular materials and the extraction of bulk of these are needed for the human habitat. In respect of minimizing the use of natural resources as construction materials, alternate construction materials are developed by the construction society globally to safeguard the natural resources and to utilize the waste and industrial byproducts.

Much of the glass [2] produced in the World is discarded, stockpiled or land filled. This pattern has influenced environmental organizations to pressure the professional community to lower the amount of glass being discarded as well as find use to the non-recycled glass in new applications. The waste glass is one of the issues of environmental problem. Glass is used in a variety of applications right from construction, automobiles, nose-diving submarines, doors and windows, utensils, waste containers, windscreen, medicinal bottles, soft-drink bottles, tube lights, bulbs, electronic equipments, etc. Hence, the usage of glass has increased considerably, which has in essence, contributed to the increase of waste disposal. In addition, glass waste is considered as non-decaying material that pollutes the surrounding environment.

Concrete is one of the world's most used construction material due to its versatility, durability and economy. India uses about 7.3 million cubic meters of ready-mixed concrete each year. It finds application in highways, streets, bridges, high-rise buildings, dams etc. Green house gas like CO2 leads to global warming and it contributes to about 65% of global warming. The global cement industry emits about 7% of green-house gas to the atmosphere. To reduce this environmental impact alternative binders are introduced to make concrete. Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required.

In this paper, the aim is to study the usage of glass in powdered form as a partial replacement of cement in fiber reinforced concrete.

II. LITERATURE REVIEW

Purpose of literature survey is to collect the published information through the various research papers. Filter useful information for research work by doing literature survey.

Shilpa Raju, Dr. P. R. Kumar presented the global warming is caused by the emission of green house gases, such as CO2, to the atmosphere. Among the greenhouse gases, CO2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. Consequently efforts have been made in the concrete industry to use waste materials as partial replacement of coarse or fine aggregates and cement. Waste glass is one materials when ground to a very fine powder shows pozzolanic properties which can be used as a partial replacement for cement

in concrete. In this paper, an attempt has been made to find out the strength of concrete containing waste glass powder as a partial replacement of cement for concrete. Cement replacement by glass powder in the range 5% to 40% increment of 5% has been studied. It was tested for compressive strength and flexural strength at the age of 7, 28 and 90 days and compared with those of conventional concrete. Results showed that replacement of 20% cement by glass powder was found to have higher strength. Also alkalinity test was done to find out resistance to corrosion.

J.M. Khatib, E.M. Negim, H.S. Sohl and N. Chileshe were presented in this paper investigates the performance of concrete containing glass powderas partial substitution of cement. Portland cement (PC) was partially replaced with 0-40% glass powder.

Testing included ultrasonic pulse velocity, compressive strength and absorption. Specimens were cured in water at 20°C. The results indicate that the maximum strength of concrete occurs at around 10% glass powder. Beyond 10% glass powder the strength of concrete reduces and is lower than that of the control. Using ground glass powder can reduce the use of cement and the associated energy demend and impact on air pollution and CO2 emission. The slump of concrete seems to increase with the increase in glass powder in the concrete mix. At 10% glass powder content the compressive strength of concrete is higher than that of substantially decreases.

Gunalaan Vasudevan, Seri Ganis Kanapathy pillay were presented in this study was conducted to investigate the effect of using waste glass powder in concrete. Laboratory work was conducted to determine the performance of control sample and concrete with used waste glass powder. The performance of these types of concrete was determined by the workability test, density test and compressive strength test. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. For each type of concrete, a total of six 150mm x 150mm x 150mm cubes were cast. The cubes were tested at the ages of 7, 14 and 28 days to study the development of compressive strength. The results indicate that the concrete with using waste glass powder were able to increase the workability of concrete and also the compressive strength. However, the density is reduced compare to standard mixture of concrete.

Dhanaraj mohan patil , Dr. Keshav , K.Sangle were explained the concrete is a construction material composed of cement, aggregates (fine and coarse aggregates) water and admixtures. Today many researches are ongoing into the use of Portland cement replacements, using many waste materials like pulverized fly ash (PFA) and ground granulated blast furnace slag (GGBS). Like PFA and GGBS a waste glass powder (GLP) is also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also it is act as a filler material. In this study, waste glass powders have been used as replacements to the concrete ingredient i.e. cement and the mechanical properties like compressive strength are measured. Also we were studied the size effect of glass powder on strength of concrete. For checking strength effect of replacement of cement by glass powder, the cement is replaced at 10%, 20% and 30%. For study of size effect of glass powder the powder is divided in to two grades one is glass powder having size less than 90 micron and another is glass powder having particle size ranges from 90 micron to 150 micron. It is found from study, Initial strength gain is very less due to addition of GLP on 7th day but it increases on the 28th day. It is found that 20% addition of GLP gives higher strength. And also GLP size less than 90 micron is very effective in enhancement of strength.

Brown et al (2002) studied the concept of fiber reinforcement of concrete structures.The objective of this research was to explore the properties of polypropylene fibers in specific environments to which the commercial FRCs (Fiber Reinforced Concretes) are exposed. The analysis of the experimental results for the various environments under which the polypropylene fiber was subjected, indicated that at high temperature and low temperature including during the presence of salt water and in a salt spray environment, the service conditions of the polypropylene fiber does not change and remains constant within the normal range.

Shasavandi (2012) carried out a literature review of the investigations that had contributed to the eco-efficiency of concrete, namely, partial replacement of cement with pozzolanos and replacement of natural aggregates by non-reactive wastes such as fly ash, silica fume, rice husk ash, sewage sludge ash, Waste ceramics and tungsten mine wastes, Recycled glass, Fluidized bed cracking catalyst (FBCC), non-reactive wastes as aggregate replacement, vegetable wastes and tyre rubber wastes. She recommended that new investigations were needed to maximize the volume of pozzolanas used by the construction industry.

Karim et al. (2011) made a significant review on the significance and utilizing of waste materials - slag, rice husk ash (RHA), palm oil fuel ash (POFA), and fly ash (FA) - as a addition of cement for the production of sustainable concrete as well as sustainable improvement. They have listed the benefits of the additional use of waste materials in cement and concrete.

However, based on the information from the published literature, they concluded that proper utilization of waste materials as a substitute for cement and constituent of concrete would be a valuable and useful way for the production of sustainable concrete as well as sustainable development for comfortable and continued existence of present and future generation on the planet.

III. EXPERIMENTAL MATERIALS

Basically concrete is a versatile engineering material which can be mould in to wide verities of shapes when in wet condition. Concrete is a mixture of cement, fine aggregates, coarse aggregates, water, and admixture (if any). The red mud concrete is a mixture of cement, fine aggregates, coarse aggregates, water.

A) Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement (OPC) conforming to ([17] IS: 8112-1989). Table 1 gives the properties of cement used.

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water. [5]

- Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting.
- The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack.

Table 1: Properties of Portland Pozzolona Cement [9]

Parameter	Value
Specific gravity	2.92
Bulk density	1400kg/m^3
Loss on ignition	4.2%
Magnesium oxide (MgO)	5.1%
Sulphuric anhydride	2.2%
Insoluble material	25.12%

Figure 1: Raw Cement

B) Fine Aggregates

It is the aggregate [6] most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

1. **Natural Sand**– it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies
2. **Crushed Stone Sand**– it is the fine aggregate produced by crushing hard stone.
3. **Crushed Gravel Sand**– it is the fine aggregate produced by crushing natural gravel.

According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4.

The four grading zones Crushed aggregate is a maximum size of 20 mm and normal grading. The specific gravity of the coarse aggregates of 2.73 was used. The sieve analysis of coarse and fine aggregates is confirmed to IS10262.

Become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Figure 2: Fine Aggregates

C) Coarse Aggregate

It is the aggregate [22] most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

1. **Uncrushed Gravel or Stone**– it results from natural disintegration of rock
2. **Crushed Gravel or Stone**– it results from crushing of gravel or hard stone.
3. **Partially Crushed Gravel or Stone**– it is a product of the blending of the above two aggregate.

According to size coarse aggregate is described as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm and 12.5 mm etc. for example a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm IS sieve.

Figure 3: Coarse Aggregates

A coarse aggregate which has the sizes of particles mainly belonging to a single sieve size is known as single size aggregate. For example 20 mm single size aggregate mean an aggregate most of which passes 20 mm IS sieve and its major portion is retained on 10 mm IS sieve.

D) Glass

The glass has been used as an engineering material since ancient times. But because of the rapid progress made in glass industry in recent times the glass has come out as the most versatile engineering material of the modern times. The first glass objects made by man were of natural glass such as obsidian and rock crystal. The manufactured glass dates from per historic times in the far east, India and Egypt but its exact place and date of the origin are unknown .it is however believed that the ancient Hindus knew the method of glass making long before the Christian era.[9]

Glass is a non-crystalline, often transparent amorphous solid, that has widespread practical, technological, and decorative uses in, for example, window panes, tableware, optics, and optoelectronics.

The most familiar, and historically the oldest, types of manufactured [10] glass are "silicate glasses" based on the chemical compound silica (silicon dioxide, or quartz), the primary constituent of sand. The term glass, in popular usage, is often used to refer only to this type of material, which is familiar from use as window glass and in glass bottles. Of the many silica-based [13] glasses that exist, ordinary glazing and container glass is formed from a specific type called soda-lime glass, composed of approximately 75% silicon dioxide (SiO_2), sodium oxide (Na_2O) from sodium carbonate (Na_2CO_3), calcium oxide (CaO), also called lime, and several minor additives.[12]

Many applications of silicate glasses derive from their optical transparency, giving rise to their primary use as window panes. Glass will transmit, reflect and refract light; these qualities can be enhanced by cutting and polishing to make optical lenses, prisms, fine glassware, and optical fibers for high speed data transmission by light. Glass can be coloured by adding metal salts, and can also be painted and printed with vitreous enamels. These qualities have led to the extensive use of glass in the manufacture of art objects and in particular, stained glass windows. Although brittle, silicate glass is extremely durable, and many examples of glass fragments exist from early glass-making cultures. Because glass can be formed or moulded [14] into any shape, it has been traditionally used for vessels: bowls, vases, bottles, jars and drinking glasses. In its most solid forms it has also been used for paperweights, marbles, and beads. When extruded as glass fiber and matted as glass wool so as to trap air, it becomes a thermal insulating material, and when glass fibers are embedded into an organic polymer plastic, they are a key structural reinforcement part of the composite material fiberglass. Some objects, such as drinking glasses and eyeglasses, are so commonly made of silicate glass that they are simply called by the name of the material.

E) Glass Power

Glass is an amorphous & transparent material, which are super-cooled liquid and not a solid. Glass can be made verity of forms and sizes from small fiber to meter-sizes pieces. Primarily glass is produced by melting a mixture of materials such as silica, $CaCO_3$, and soda ash at high temperature followed by cooling during which solidification occurs without crystallization. Glass has been used as aggregates in road construction, masonry and building materials. Before adding glass powder in the concrete it has to be powdered to wanted size. Glass powder is obtained from Crushing of glass Pieces. A Glass powder [13] can be used as cement replacement material upto particle size less than 90μm.

Figure 4: Glass Powder

Glass powder is an extremely fine powder made from ground glass. It can be used in a number of industrial and craft applications and is often available through supplier of glass and industrial supplies. High precision machining equipment is necessary to prepare it, as it needs to be very uniform, with an even consistency. Costs vary, depending on the level of grind and the applications.

IV. Concrete Specimens Making

A) Preparation of Materials

All the materials were proportioned by weight to give the required ratios of water to cement (w/c).

Figure 5: Coarse Aggregate Weighting

Figure 6: Coarse Aggregate Weighting

Figure 7: Materials mixing process

B) Mixing Process

The mixing process was done using an electrically operated concrete mixer of 0.04 m^3 capacity. The concrete making and mixing in the laboratory was done with accordance to ASTMC-192. The batching procedure was as follows:

- Add coarse, fine aggregate mixing for about 2-3 minutes.
- Add cement than mixing for about 1-2 minutes.
- Add approximately two-thirds of water slowly and mix for 2-3minutes.
- Add fiber with water than mixing for 2-3 minutes.

V. CONCLUSION

In this Based on experimental observations, the following conclusions are drawn.

- The material properties of the cement, coarse aggregates, and fine aggregates are within the acceptable limits hence theses materials are suitable for the research.
- The slump of concrete increases monotonically as the replacement cement with glass powder increases. The workability decreases when cement is replaced partially with glass powder.
- The present study shows that there is a great potential for the utilization of glass powdering concrete as partial replacement of cement.

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