Utilization Of Crushed Glass Waste As Aggregates

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Abstract: As the population of the world is increasing by leaps and bounds, there is an increase in the demand of shelters resulting in the excessive rise in demand of the concrete. As a consequence the production of portland cement, i.e., binding agent in concrete, leads to the release of significant amount of CO₂, i.e. a green house gas. One tone of portland cement clinker production emits approximately one tone of CO₂ and other greenhouse gases (GHGs). These gases are leading to various environmental issues such as air pollution causing various diseases to all the living beings. Hence in order to deal with this problem there is a dire need to replace a portion of cement by certain pozzolanic material so that the consumption of the cement can be reduced and the environmental impact can also be controlled up to certain extent [⁴]. Some of the industrial wastes like fly ash, silica fume, blast furnace slag etc are already in trend of being used in concrete. After using these wastes new research has been made so that the waste glass can be effectively added in concrete either as coarse aggregate or as pozzolona. Waste glass if grounded to very fine powder pozzolanic properties because of presence of silica [¹]. Hence the glass powder to some extent can replace the cement and can also contribute to the development of the strength as well as durability of the concrete strength. [³] One of the major factor leading for this innovation was that the demand for recycled glass has considerably decreased in recent years, and also it is economical to store glass than to recycle, as conditioners needs expenses for the process of recycling. In order to provide a sustainable solution to glass storage, as well as preserving environment the solution would be to reuse this type of glass in concrete. This paper present literature review on replacement of cement by waste of glass powder which consists of current and future trends of research on the use of crushed glass powder in Portland cement concrete. The increasing awareness of recycling glass is speeding up the inspections on the use of waste glass with different forms in various fields. The use of waste glass as aggregate in concrete develops high architectural level besides its high performances.

Keywords: glass pozzolona, glass aggregates, recycled glass, CO₂ emission, green house gases, ASR, aesthetic look.

I. INTRODUCTION

Due to advancement in manufacturing industries there is also an increase in the waste and it has become difficult to dispose of this surplus amount of waste, with the increase in awareness about the environment there is also an increase in the concern related to the disposal of the waste products. In fact solid waste management is one of the major environmental concerns worldwide. Utilization of waste has become an ultimate alternative to disposal because of the scarcity of space available for land filling and due to the increasing cost. The utilization of waste products in concrete not only makes it economical, but it also helps in reducing the disposal problems. For instance plastic waste, this could be used in various applications such as making bottle bricks. According to the World Commission on Environment and Development sustainable development means “making development without compromising with the needs of the future generation”. Human civilization is continuously becoming more industrialized with time. Factories and vehicles are continuously growing in number, and buildings have been constructed all around. Consequently, our natural environment has permanently changed from what it was 20 years ago. Sociologists have examined that people have become more concerned about the environment now a days. Furthermore, individual attitudes toward the environment affect recycling behavior in the community. Individual concern about the environment enhances the effect of the recycling program, but it does not
overcome the barriers presented due to the lack of access. The human population is continuously growing in number; as a result there is a great demand of constructing more structures to facilitate the needs of the community. Need of sand and gravel has lead to the quarry operations. As a result massive destruction of mountains is made which is one of the major causes of landslides, and flashfloods during earthquakes resulting in loss of thousands or even millions of lives. In order to avoid such environmental issues there is a need of using the recycled products so that construction can be made without affecting the environment adversely for further production of materials. Since aggregates constitute approximately 70% of the total concrete volume, the utilization of waste glass as recycled aggregate can yield significant environmental impact. Studies about recycled glass bottles shows that, a very small proportion of the glass has been recycled and reused, a significant proportion, which is about 84% of the waste glass, is sent to landfill. Glass is a 100% recyclable material which provides high performances along with unique aesthetic properties which can be used as an alternative for fine aggregate for concrete mix. This study of use of recycled glass as aggregates will be knowledgeable that junk materials can be used as construction material at the same time preserving the environment. Glass can be found in numerous forms, including container glass, flat glass such as windows and bulb glass. The drawback of using glass as aggregate is the presence of excessive amount of silica leading to ASR (aggregate silica reaction).

II. MATERIALS USED

Cement:
Ordinary Portland cement of 43 grades can be used as a binding agent.[6]

Aggregates:
Coarse aggregates free from salts and should be inert can be used.[7]

Water:
Potable water that is fit for drinking should be used.

Crushed glass:

a) Course aggregates:
Coarse aggregates of different colors can be used which provides soundness as well as good appearance.[2]

b) Fine aggregates:
Use of crushed glass as binding material reduces the proportion of the cement in the concrete.

![Fig.1.1 Coarse glass aggregates of various sizes.](image1)

![Fig.1.2 fine glass aggregates.](image2)
How to make glass aggregates:
- Recycle glass bottles.\[^4\]
- Send those bottles to recycle centers that separate bottles by color.
- They break glass to uniform size and sort by size and color.
- Broken glass is mixed with concrete.
- Curing process is done after concreting.
- After 28 days it reaches its full strength.

Crushing of glass bottles:
- For small scale use glass can be crushed using a hammer manually.
- For large scale use glass can be crushed using crushing machines\[^1\]

**Fig.2.1 Glass bottle crusher**

There are a number of measures to avoid ASR or its damaging effects:
- Addition of the mineral admixtures so that they can effectively suppress the reaction.
- Making alkali resistant glass, for instance, by coating it with zirconium solution.
- Preventing the concrete from moisture by sealing it, either because ASR needs three factors to thrive: alkali, silica, and moisture;
- User of low-alkali cement, which is less effective, unless alkalis from the environment can be kept away;
- Making special ASR-resistant cements.

Even after having potential reactivity in an alkaline environment, glass has a numerous properties that make it a very attractive aggregate for a concrete:
- It has zero water absorption; therefore it is one of the most durable materials.
- Excellent hardness of glass gives the concrete an abrasion resistance.
- Glass aggregate enhances the flow properties of fresh concrete so that very high strengths can be gained even without the use of super plasticizers.
- Very finely ground glass comprises of pozzolanic properties and therefore can act both as partial cement replacement and filler.

Recycled glass aggregates can be used for:
- Building façade elements
- Precast wall panels
- Partition walls
- Floor tiles
- Wall tiles and panels
- Elevator paneling
- Table top counters
- Park benches
• Planters
• Trash receptacles
• Ashtrays

Crushed glass can also be used in making pavements:

**Engineering properties:**
Some of the properties of glass when used as fine aggregate in asphalt paving include gradation, specific gravity, and durability.

- **Gradation:**
  Waste glass to be used in asphalt surface pavements should be processed to a fine aggregate size (less than 4.75 mm (No. 4 sieve)) larger top sizes ranging from 9.5 mm to 15.3 mm (3/8 to 5/8 in) are suitable for use in base course mixes.

- **Specific Gravity:**
  Due to a specific gravity approximately 10 to 15 percent below conventional aggregates, waste glass can provide a greater yield.

- **Durability:**
  Glass is a brittle material and coarse particles greater than 4.75 mm in size break down during handling. Consequently, it is preferable to process waste glass into a fine aggregate size, which is minus 4.75 mm (No. 4 sieve), prior to its use in surface course asphalt paving mixes.

**Advantages of recycled glass as aggregates:**
- It can serve both as coarse aggregate as well as filler material.
- It provides greater water tightness.
- It provides high abrasion resistance.
- It provides soundness as glass is a hard material.
- It consists of pozzolonic activities and hence shows cement like properties.
- It provides aesthetic look.
- It is helping in preserving environment by reducing the manufacturing of cement which leads to the emission of green house gases, thus polluting the environment.
- Utilization of waste glass which is otherwise difficult to dispose off.

![Fig.3 Glass used as coarse aggregates in concrete](image)

**Disadvantages of glass as aggregates:**
- ASR (aggregate silica reaction) takes place due to the excessive amount of silica present in the glass.[5]
Inhaling of the glass dust can destroy the lungs and respiratory tract of the workers and may even lead to the death of the workers.[5]

It requires special machinery for the crushing of the glass[1]

Properties of glass concrete:
1. Low coefficients of thermal expansion.
2. High damping capacity
3. Economical
4. Reduced thickness
5. Low weight

Compressive strength of glass concrete:

As the result shows glass concrete attains its maximum compressive strength at 28th day.[2]

Maximum compressive strength can be attained by replacing glass by 20%.[4]

III. CONCLUSION

With the increase in population the demand for housing has also increased in order to deal with that demand without affecting the environment concept of use of crushed glass as aggregates came into existence. These glass aggregates acts as both coarse as well as fine aggregates. These aggregates provide high strength, durability and water tightness along with the aesthetic look. as glass bottles are inert and does not react when added to the concrete. Every year million of tone of glass bottles are produced, all the bottles are not recycles and are filled in the landfills creating mounds of the bottles on the surface of the earth. As the new generation is becoming aware about the environment this new innovation of using of glass bottles as aggregates after crushing them is in trend. Glass bottles of different colors are crushed and are mixed with the concrete the coarse glass particles are coarse aggregates and finely crushed particles are fine aggregates. This construction is environment friendly. The only drawback of this construction is ASR i.e. alkali silica reaction which causes deterioration of the structures. But overall structures made from glass aggregates are sound and durable. Therefore it should be used on large scale in order to protect the environment as well as attain the strength and the durability of the structures.

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