ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

REPLACEMENT OF FINE AGGREGATES BY WASTE GLASS AND COARSE AGGREGATES BY WASTE PLASTIC

D. Hari Krishna[1a], M. Laxman[1b], MD. Hareef[1c], L. Tharun[1d], A. Shiva Krishna[2]

[1]Undergraduates in Civil Engineering

[2]Assistant Professor, Dept of Civil,

SVS GROUP OF INSTITUTION

Bheemaram, Hanamkonda, T. S., India

ABSTRACT

The ever-growing mountains of solid waste pose a significant environmental challenge. In the construction industry, researchers are exploring innovative techniques to address this issue, one of which involves the utilization of waste materials in concrete production. Previous studies have successfully incorporated varying percentages of recycled materials as replacements for conventional aggregates in concrete. This research delves into the potential of partially replacing fine aggregate with waste glass and coarse aggregate with high-density polyethylene (HDPE) plastic. This approach holds a promising future for sustainable construction. By incorporating these waste products, concrete production can contribute to waste diversion, reducing the burden on landfills. Additionally, the use of waste plastic offers the potential to create lightweight concrete, a desirable property for specific applications. However, striking a balance between incorporating recycled materials and maintaining concrete strength is crucial.

To achieve this balance, the research will involve conducting a series of tests to identify the optimal replacement percentages for waste glass and plastic. The pozzolanic activity of waste glass is expected to contribute to increased concrete strength, while the lightweight properties of plastic offer a complementary benefit. This investigation will not only evaluate the impact of these replacements on strength but also assess other key properties like workability and durability. By exploring the potential of waste glass and plastic in concrete production, this research aims to contribute to the development of more sustainable construction practices. Through careful optimization and testing, the goal is to achieve a balance between incorporating recycled materials and maintaining the essential properties of concrete, paving the way for a more environmentally friendly future for this ubiquitous building material.

Keywords: concrete, waste glass, waste plastic (HDPE), concrete strength, lightweight concrete, pozzolanic activity.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

INTRODUCTION

General:

Concrete is a fundamental building block of our civilization, forming the foundation of countless structures from towering skyscrapers to intricate bridges. This ubiquitous material is a composite, meaning it's not a single substance but rather a combination of elements working together. At its core, concrete consists of coarse aggregate, like crushed rock or gravel, bonded together by a paste of cement and water. Over time, this paste undergoes a chemical reaction called hydration, transforming it into a strong, stone-like material.

Traditionally, most concrete uses Portland cement, a hydraulic cement that sets and hardens when mixed with water. However, advancements have led to the exploration of other cement types like hydraulic cement concrete or even asphalt concrete, commonly used for road surfaces.

The beauty of concrete lies in its versatility. When mixed, cement, water, and aggregate form a workable slurry that can be easily moulded into various shapes. This allows concrete to be poured into intricate forms, creating structures with complex geometries. Once the chemical reaction between the water and cement sets in, the concrete hardens, forming a durable and long-lasting material.

Recognizing the environmental impact of traditional concrete production, researchers have delved into utilizing waste materials as replacements for conventional aggregates and cement. For example, studies have shown that replacing fine aggregate with waste glass and coarse aggregate with waste plastic can be successful under specific conditions. This approach not only reduces reliance on virgin resources but also diverts waste from landfills, contributing to a more sustainable construction industry. Finding optimal replacement percentages is crucial, ensuring the resulting concrete retains its fresh and hardened properties while incorporating these recycled materials.

By continuously exploring innovative uses of waste materials and alternative cements, we can make concrete production more environmentally responsible. This ensures that this essential building material continues to serve us for generations to come, while minimizing its footprint on our planet.

Waste Glass

Waste glass, a ubiquitous byproduct of our daily lives, presents a unique opportunity for the construction industry. Locally sourced from discarded bottles, broken glassware, and shop waste, it offers a readily available and sustainable alternative to conventional fine aggregate in concrete. The key advantage of waste glass lies in its composition. Rich in silica, a major component of sand, it possesses the potential to contribute to the strength and structure of concrete.

Table 1 Crushed waste Glass

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

However, the story of waste glass in concrete is not a simple one. Glass exists in an amorphous state, lacking the crystalline structure of natural sand. This characteristic can lead to a detrimental reaction known as alkali-silica reaction (ASR) when used in concrete. ASR occurs when the highly alkaline environment of cement interacts with reactive silica in the glass, causing internal expansion and cracking.

Table 2 Partial Replacement of Sand with Waste Glass in Concrete

The key to harnessing the benefits of waste glass lies in size control. By grinding the glass into a fine powder, we can significantly reduce the risk of ASR. This finer particle size also unlocks another crucial property: pozzolanic activity. Pozzolans are materials that react with calcium hydroxide, a byproduct of cement hydration, to form additional cementitious compounds. This reaction strengthens the concrete matrix and enhances its overall durability.

Waste Plastic

Concrete, the backbone of modern infrastructure, traditionally relies on natural aggregates like sand and gravel. However, with growing concerns about resource depletion and waste management, researchers are exploring innovative ways to incorporate recycled materials. Waste plastic emerges as a promising candidate, offering a potential solution to both challenges.

Several plastic types hold promise for concrete production, including low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET). Each type possesses unique characteristics that can influence the resulting concrete properties.

The key lies in finding the optimal replacement percentage for these plastic aggregates. Complete replacement is not feasible, but strategic partial substitutions can yield significant benefits. Researchers are investigating the impact of varying replacement percentages on different concrete properties. For instance, some plastics may enhance workability, the ease with which fresh concrete can be molded, while others might affect strength or weight.

The success of this approach hinges on understanding the interplay between plastic type, replacement level, and the desired concrete properties. For example, LDPE, known for its flexibility, might improve workability at lower replacement levels but could negatively impact strength at higher percentages. Conversely, HDPE, with its superior strength, might offer benefits for specific applications requiring lightweight yet sturdy concrete.

Table 3 Waste Plastic

This exploration requires a systematic approach. Researchers will conduct a series of tests to determine the optimal replacement percentages for each plastic type. These tests will evaluate not just strength and workability but also other crucial properties like durability, fire resistance, and shrinkage. By carefully analysing the data, researchers can establish clear guidelines for incorporating waste plastic in concrete production.

The potential benefits of utilizing waste plastic in concrete are multifaceted. Firstly, it diverts plastic waste from landfills, contributing to a more sustainable construction industry. Secondly, it reduces reliance on virgin resources like sand and gravel, which are becoming increasingly scarce in some regions. Finally, depending on the plastic type and replacement level, concrete properties like workability or weight can be tailored for specific applications.

Solid waste management is one of the biggest problems faced by the world. We should find ways to recycle waste materials into some usable products. The concept of utilizing waste materials for building purposes has been done in the past. Different waste materials like fly ash, rice husk, silica fume etc has been successfully incorporated into construction use.

Similarly, we can use waste glass and waste plastic as partial replacement of fine aggregate and coarse aggregate respectively.

Table 4 waste plastic shredding

Different percentage of these waste materials have been used in concrete and tested for their strength. Successful incorporation of these waste materials (glass and plastic) has provided alternate means of solid waste management. Glass and Plastic as waste materials is being produced in large quantities around the globe. Reusing of these waste materials has decreased the burden of dumping them in soil. Different tests have been carried out on concrete at different percentages by waste glass and plastic with good results.

Utilization of these waste materials will decrease the cost of concrete as well as help in producing light weight concrete. There is need to recycle the glass to avoid environmental threats and by using waste glass in concrete makes it more valuable material.

OBJECTIVE OF THE STUDY

Reduce Environmental Impact:

- Divert waste glass and waste plastic from landfills, promoting sustainable waste management practices.

- Reduce reliance on virgin resources like sand and gravel for concrete production, minimizing environmental footprint.

Enhance Concrete Properties:

- Investigate the potential for waste glass to improve concrete strength through pozzolanic activity.
- Explore the use of waste plastic to create lightweight concrete, desirable for specific applications.
- Evaluate the impact of these replacements on other key concrete properties like workability, durability, and fire resistance.

Optimize Replacement Levels:

- Identify the optimal replacement percentages for waste glass and different plastic types within the concrete mix.
- Balance the benefits of waste utilization with maintaining or improving desired concrete properties.

Develop Sustainable Construction Practices:

- Establish guidelines for incorporating waste glass and plastic into concrete production for practical applications.
- Promote the development of more sustainable and resource-efficient construction materials and techniques.

Economic Feasibility:

- Evaluate the economic viability of using waste materials compared to conventional aggregates.
- Consider potential cost savings or benefits associated with reduced reliance on virgin resources and waste disposal costs.

LITERATURE REVIEW

The use of waste material represents a means of relief to some of the solid waste management. Various researchers have worked on the replacement of fine aggregate and coarse aggregate in concrete and to see the effect of replacement on different properties of concrete.

They have discussed about the effects on different properties of concrete. Here are some of the details of their outcomes which come from their papers in the shape of literature.

Yixin Shao et al. (1999) in this research paper study was carried out to find the possibility of using waste glass as fine aggregate replacement. Different tests were conducted to check the possibility of replacement. Some of these tests include Lime glass test, Mortar bar test and compressive strength test. Lime glass test was done to check the pozzolanic activity due to presence of waste glass. Compressive strength test was conducted at 30% replacement of fine aggregate by WG and mortar bar test was used to study the effect on expansion. It was confirmed from the tests that WG having size less than 38 microns did possess some pozzolanic behaviour. The specimen passed the compressive strength test by surpassing 4.11 MPa. The strength activity index was 91, 84, 96, and 108% at 3,7,28 and 90 days respectively exceeding 75% at all stage. The reduction in expansion was more than 50% as confirmed by mortar bar test. It was confirmed than smaller sized particles have higher strength and lower expansion due to their interaction with the lime.

ISSN2454-9940
www.ijasem.org
Vol 18, Issue 2, 2024

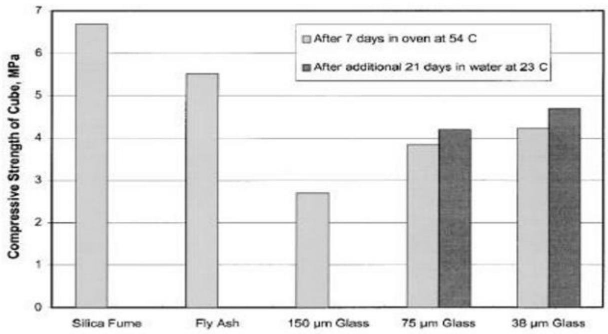

Figure 1 Compressive strength of additive mixtures

Mehmet Canbaz et al. (2003) this research was done to study the effects of WG as coarse aggregate replacement. WG having size 4-16 mm was used in the experiment. The study was carried out on the fresh and hardened properties of concrete. It was found out from the test results that WG does not have much effect on workability and strength is slightly reduced due to replacement of coarse aggregate. ASR properties were also taken into consideration during the testing process. It also decreased the cost of concrete production because of usage of waste materials instead of natural coarse aggregates. WG replacement declined the slump, air content and fresh unit weight. However VeBe values were increased. These were the effects on fresh properties of concrete. On examining the hardened properties, the test results suggested that compressive strength, flexural and indirect tensile strength show a declining pattern with increase in WG. With 60% replacement of coarse aggregate by WG, the compressive strength values decreased by 49%. Due to high amount of silica (SiO2) alkali silica reaction can be the reason for decrease in strength.

Seung Bum Park et al (2004) this work was aimed at finding out the possibility of using recycled glass as fine aggregate replacement. Test results showed that slump and compacting factors decrease due to angular size of waste glass and air content was also increased due presence of so many small sized particles in the waste glass. It was also found out that compressive strength, flexural strength, and split tensile strength decreases with increase in percentage of waste glass. As per the test results it was predicted that use of waste glass in the concrete is possible practically and percentage should be under 30 %. Increasing the percentage would decrease the strength drastically and concrete won't be of use. So the different replacements under 30% were tested and favourable results were found out.

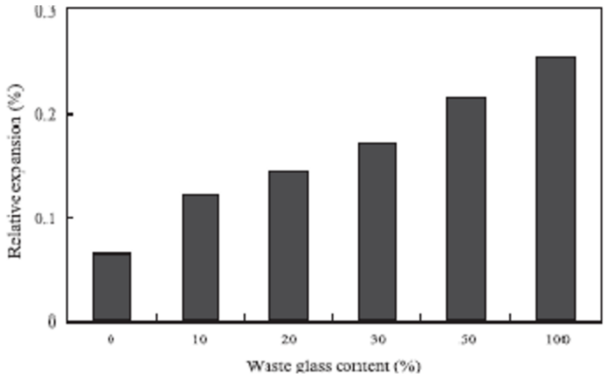

Figure 2 Expansion versus waste glass percentage

Zainab Z. Ismail et al. (2007) the study was done on the use of plastic as sand replacement. Different replacements of 0%, 10%, 15% and 20% as fine aggregate were carried out. Different concrete mixtures were tested at room temperature and tests include slump, fresh density, dry density, compressive strength, flexural strength, and toughness indices and curing was done at 3, 7, 14 and 28 days. The results showed decrease in micro crack propagation due to inclusion of plastic. The results showed decrease in slump with increase in plastic ratio. The fresh and dry density showed a declining pattern and the reason was attributed towards lower density of plastic than sand. The compressive strength and flexural strength also decreased at each stage and this was due to decrease in adhesive strength between waste plastic and cement paste.

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

Zainab Z. Ismail et al. (2008) Recycled waste glass was used as partial replacement of fine aggregate. The properties of concretes containing waste glass as fine aggregate were investigated in this study. The strength and ASR properties were investigated in terms of waste glass. The waste glass was used as partial replacement at 10%, 15%, and 20%. The result showed 80% pozzolanic activity after 28 days. The compressive and flexural strength was found out to be higher than normal concrete after 28 days. The tests verified that finely ground waste glass reduce expansion by 66%. The optimum percentage of waste glass was 20% based on the test results.

S.P. Gautam et al. (2012) Ground waste glass was used as a fine aggregate replacement and no reaction was detected with fine particle size. This shows the viability of using it as fine aggregate replacement. The effect on workability and compressive strength was carried out in this research. After testing the samples it was found out there is 20% increase in strength after 28 days. There is little decrease in strength when replacement was done between 30 % to 40 % and optimum percentage was found out to be 10%.

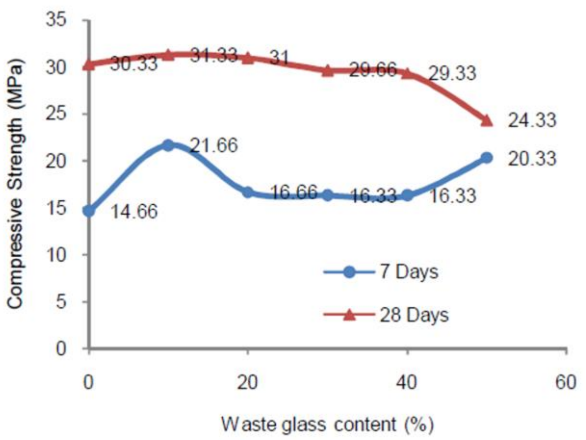

Figure 3 Variation of compressive strength of glass concrete

S. Vanitha et al. (2014), this paper deals with the use of plastic aggregates as coarse aggregate replacement. The percentage replacement was done at 0%, 2%, 4%, 6%, 8%, and 10% in M20 concrete. Based on the test results it was found out that plastic can be used as replacement of coarse aggregate and plastic concrete can be used in pavement construction successfully. The optimum percentage was found out to be 4% for paver blocks and 2% for solid blocks.

T.Subramani et al. (2015) Experimental study of using plastic waste as coarse aggregate replacement was carried out. The percentage replacement which gave highest compressive strength was used to determine other properties of concrete like modulus of elasticity, split tensile strength and flexural strength. Maximum compressive strength was found at 20% replacement.

Tanveer Asif et al. (2016), this research is intended at the use of waste plastic (HDPE) in concrete as a partial replacement of coarse aggregate to obtain light weight concrete. In this research, M20 grade of concrete was used for test analyses because M20 concrete is mostly used for construction work. The percentage of waste plastic used in concrete was 0%, 10%, 20%, and 30% to replace the coarse aggregate. Different cubes of concrete were casted and tested after 3, 7, 14, 28 days of curing for compressive strength test. The compressive strength of modified concrete was then matched with the conventional concrete to study the effects of replacement by HDPE. It was observed that compressive strength of 79.55%, 85.61%, 76.47% was achieved for 10%, 20%, and 30% respectively. The test results showed that HDPE as coarse aggregate replacement can be used in concrete up to 30%, if only compressive strength was taken in to consideration. It also resulted in production of light weight concrete due to low density of HDPE than natural coarse aggregates.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

However, percentages more than 30% of HDPE were not acceptable as strength gets reduced below the threshold value.

Tanveer Asif et al. (2016), the study was carried out on the compressive strength of concrete by replacing coarse aggregates by plastic granules (HDPE). M20 concrete was used and plastic replacements were done at 0%, 10%, 20%, 30%. The test results showed that maximum compressive strength was achieved at 20% replacement but was less than the normal concrete mix. And also increasing the plastic percentage further decreases the compressive strength. It was observed that the compressive strength in comparison to normal concrete was 79.55%, 85.61%, 76.47% for mix of waste plastic of 10%, 20%, and 30% respectively.

EQUIPMENT AND MATERIALS

The equipment that has been used till now for testing of materials are as follows:

a) IS Sieves: - To determine the gradation, sieve analysis according to IS383 of fine and coarse aggregate.
b) Pycnometer: - To determine the specific gravity values of aggregates as per IS 2386.
c) Impact Testing Machine: - To determine the impact value of coarse aggregates against impact loading.
d) LOS Angeles Abrasion Testing Machine: - To determine the LOS Angeles Abrasion value of coarse aggregate against wear and tear.

The equipment's that will be used for further testing of the specimens are as follows: -

a) Compression Testing Machine: - To determine the compressive strength of concrete.
b) Universal Testing Machine: - To determine the split tensile strength band flexural strength of concrete.

Materials

The materials that will be used for testing are: -

a) Cement
b) Natural Sand and Waste Glass
c) Coarse Aggregate and Waste Plastic

Research Methodology

Waste glass, due to its pozzolanic activity leads to increase in compressive strength of concrete and due to low specific density of waste plastic; it helps in formation of light weight concrete. These both can be used in concrete as replacement of fine aggregate and coarse aggregate respectively to form high strength light weight concrete. Different tests will be conducted on concrete at regular intervals of time to find the effect of replacements which include compressive strength test, flexural test, Split tensile test etc. Different percentages replacements of waste glass and waste plastic will be carried out to find the optimum percentage of both the waste materials.

Percentage	No. of beams	No. of cylinder	No. of cubes
0%WG + 0%WP	3	3	3
10%WG + 0%WP	3	3	3
10%WG + 5%WP	3	3	3
10%WG + 15%WP	3	3	3
10%WG + 20%WP	3	3	3
10%WG + 25%WP	3	3	3

Table 5 Proportions of Materials

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

Keeping the waste glass percentage constant at 10% and replacing the waste glass percentage to find the optimum percentage. This will be followed by regular testing to find out the maximum strength of concrete.

Mix Design

Design steps of M25 mix design as per IS-10262-2009 are as follows

Strength Calculation:-

- fck' = fck + 1.65s
- Where fck' = Target compressive strength at 28 days in N/mm2
- fck = Characteristic compressive strength at 28 days in N/mm2 s = Standard deviation
- fck' = 25 + 1.65*4 = 31.6 N/mm2
- Where s = 4 for M25 Concrete

Selection of water-cement ratio as per IS-456 Table-1

- So select w/c ratio as 0.5.

Selection of water content

- As maximum size of coarse aggregate is 20mm, so maximum water content will be 186 Kg.

Calculating cementious material content

- Cement amount = Water amount/wc ratio
- Cement quantity = 186/0.5 = 372 Kg
- From IS 10262 minimum cement content for M25 is 300 Kg

Finding out volume proportions of coarse aggregate and fine aggregate

- As per Table-3 IS-10262, coarse aggregates fall in zone 2 and size of coarse aggregate is 20mm Hence coarse aggregate = 62% of total aggregate

Mix calculations

- Volume of concrete = 1 m3
- Volume of cement = 372/(3.15*1000) = 0.118 m3 where 3.15 is specific gravity of cement Volume of water = 186/(1*1000) = 0.186 m3
- Total volume except aggregates = 0118 + 0.186 = 0.304 m3 Therefore volume of aggregates = 1 – 0.304 = 0.696 m3
- Volume of coarse aggregate = 0.696 * 0.62 = 0.4315 m3 Volume of fine aggregate 0.696 – 0.413 = 0.2645 m3
- In terms of weight
- Weight of coarse aggregate = 0.413*2.84*1000 = 1225.46 Kg/m3 Weight of fine aggregate = 0.2645*2.64*1000 = 698.28 Kg/m3 Therefore cement: fine aggregate: coarse aggregate

Results

Different tests were done separately on waste glass, natural sand, cement and coarse aggregate. The results of different tests are given below: -

Natural Sand

1. Sieve Analysis: -

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

IS Sieve No.	Weight Retained (gm)	% of weight Retained	Cumulative % Retained
4.75	5	0.5	0.5
2.36	15	1.5	2.0
1.18	125	12.5	14.5
600	210	21.0	35.5
425	20	2.0	37.5
300	520	52.0	89.5
150	70	7.0	96.5
75	15	1.5	98
pan	20	2.0	100
Total	1000 gm	100%	Cumulative % Retained = 474%

Table 6 Sieve Analysis of Natural Sand

2. Specific Gravity: - The specific gravity of natural sand has been determined by pycnometer method. The results showed that specific gravity of natural sand is 2.65.
3. Water Absorption: - By the experiments, the water absorption of natural sand is 2.26%.

Cement

IS Sieve No.	Weight Retained (gm)	% of Weight Retained (gm)	Cumulative % Retained
4.75 mm	0	0	0
2.36 mm	20	2	2
1.18 mm	125	12.5	14.5
600 microns	195	19.5	34
425 microns	17	1.7	35.7
300 microns	530	53.0	88.7
150 microns	63	6.3	95
75 microns	25	2.5	97.5
pan	25	2.5	100
Total	1000 gm	100 %	467.4 %

Different grades of cement are available in the market which includes grade 33, 43 and 53. The grade 43 and 53 mainly corresponds to average

compressive strength. The grade used for the test analysis is 43. The test results are below: -

S.No.	Property	Test Results
1	Consistency	29%
2	Specific Gravity	3.097
3	Initial Setting Time	34 minutes
4	Final Setting Time	610 minutes
5	Fineness of Cement	3.5%

Table 7 Properties of Ordinary Portland cement

Coarse Aggregate

1. Sieve Analysis: -

IS Sieve No.	Weight Retained (Kg)	% Retained	Cumulative % Retained
80 mm	0	0	0
40 mm	0	0	0
20 mm	2.7	27	27
10 mm	6.2	62	89
pan	1.1	11	100
Total	10 Kg	100 %	210%

Table 8 Sieve Analysis of Coarse Aggregate

Waste Glass

a. Specific Gravity: - Based on the test results, the specific gravity of waste glass is 2.18.
b. Water Absorption: - By doing experiments on waste glass, it was found out that water absorption of waster glass is 0.43%.
c. Sieve analysis: -

CONCLUSION

As, it has been found by experimental study that replacements by waste glass and waste plastic can lead to increased strength, light weight concrete and low cost of concrete. Based on the different tests that have been done on individual materials of concrete, the following conclusion can be made: -

- The physical analysis of waste glass aggregates gave the values of specific gravity and water absorption which qualify the waste glass as suitable replacement of fine aggregates.

Table 9 Sieve analysis of waste glass

- The testing results of sieve analysis of coarse aggregate and waste plastic makes it appropriate replacement of coarse aggregate.

REFERENCES

1. ***Yixin Shao et al. (1999)*** Department of Civil Engineering and Applied Mechanics, McGill University, Montreal, Quebec H3A 2K6, Canada.
2. ***Mehmet Canbaz et al. (2003)*** Civil Engineering Department, Osmangazi University, Eskisehir 26480, Turkey.
3. ***Seung Bum Park et al (2004)*** Department of Civil Engineering, Chungnam National University, 220 King Dong, Yuseong-Gu, Taejon 305-764, South Korea.
4. ***Zainab Z. Ismail et al. (2007)*** Department of Environmental Engineering, College of Engineering, University of Baghdad, Iraq
5. ***Rafat Siddique (2007)*** Thapar Institute of Engineering and Technology, Deemed University, Patiala – 147 004, India.
6. ***Zainab Z. Ismail et al. (2008)*** Department of Environmental Engineering, College of Engineering, University of Baghdad, Iraq
7. ***S.P. Gautam et al. (2012)*** Centre for Effective Design of Structures, Department of Civil Engineering, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S 4L7
8. ***Praveen Mathew et al. (2013)*** Civil Engg. Dept., SHIATS (formerly AAI-DU), Allahabad-211007, UP, India
9. ***K.Madhangopal et al. (2014***) Assistant Professor in Civil Engineering Department, RGMCET, Nandyal
10. ***S. Vanitha et al. (2014)*** Department of Civil Engineering, Sathyabama University, Chennai, Tamil Nadu,
11. ***T.Subramani et al. (2015)*** 1Professor & Dean, Department of Civil Engineering, VMKV Engg. College, Vinayaka Missions University, Salem, India
12. ***Tanveer Asif et al. (2016)*** Director, Professor & H.O.D Civil Engineering, Dept K.C.T.E.C, C/o Dr Meenaz Hospital H.NO. 5-408/40/1&2, Near KBN Medical College,Roza B, Kalaburgi. Karnataka India
13. ***Tanveer Asif et al. (2016)*** Director, Professor Head of Civil Engg Dept, KCT Engineering college, Gulbarga, Karnataka, India.
14. ***Gaurav Verma et al. (2016)*** Post Graduate Student, BBD University, Uttar Pradesh, India