ISSN: 2455 – 4200
International Journal of Engineering Research and Modern Education
Impact Factor 6.525, Special Issue, April - 2017
6th National Conference on Innovative Practices in Construction and Waste Management
On 25th April 2017 Organized By
Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu

INVESTIGATION ON RECYCLED GLASS AS A REPLACEMENT FOR FINE AGGREGATE IN CONCRETE

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Cite This Article: S. Dinesh, R. Preetha & M. Subhi "Investigation on Recycled Glass as a Replacement for Fine Aggregate in Concrete", Special Issue, April, Page Number 105-108, 2017.

Abstract:

Waste management is becoming a major issue for communities worldwide. Glass, being non-biodegradable, is not suitable for addition to landfill and such recycling opportunities need to investigate. Continuous use of natural resources since ages has been depleting them at an alarming rate. Natural sand is the best form of the fine aggregate used in concrete till now. But continuous sand mining results in impure water in river which leads to an environment disaster. In the search for the replacement of sand, construction material waste and environmental waste materials got the focus of research people. Among these materials like waste glass can be an effective replacement for fine aggregate. This project studies the suitability of crushed glass as a possible substitute for conventional fine aggregate. Experimental investigation was carried out to evaluate the properties of concrete mixture in which the fine aggregate was replaced with the crushed glass in 20%, 40%, 60%, 80% & 100% by weight. Mechanical properties like compressive strength and tensile strength were determined at an age of 28 days. The test results indicate when crushed glass used as fine aggregate enhances the strength properties of concrete. It is found that 60% fine glass and 40% natural is the optimum proportion.

Key Words: Waste Management, Concrete, Compressive Strength & Waste Glass

1. Introduction:

Waste management has become a significant issue in today's growing society. Population levels around the globe are increasing rapidly, resulting in unprecedented levels of waste materials. New and innovative methods of recycling need to be established in order to ensure that we do not run out of room for storage. Glass, being non-biodegradable, is not suitable for addition to landfill. Fortunately, glass can be recycled indefinitely without any loss in quality, but first need to be sorted by colour. This is an expansive process subsequently waste glass formation can be deduced by using the recycled glass as a replacement for fine aggregate. Concrete is a construction material consists of cement, coarse aggregate such as gravel, limestone or granite, fine aggregate such as sand, water and chemical admixtures. Each constituent in concrete has its own importance and affects the strength and quality of concrete in all aspects. Fine and coarse aggregate make upbulk of concrete mixture sand; natural gravel and crushed stone are mainly used for this purpose. Recycled aggregates(from construction, demolition or excavation waste) are increasingly used as partial replacements of natural aggregates like glass, ceramics and quarry dust are giving beneficial results in terms of strength and durability. Natural sand is the best form of fine aggregate used in concrete till now. But sand which is mined from river bed has vital impact on purifying capacity of the river. Continuous sand mining leads to flow of impure water through river as the ability of the river to purify decreases with decrease in sand content. This is an indication of huge environmental disaster leading to scarcity of drinking water. Hence an effective replacement for fine aggregate has to be invented soon to save the environment. In the search for the replacement of glass is wasted and dumped without recycling. It is estimated that a sum of 953000 tons of waste glass is dumped on earth every year. This waste glass can be recycled and collected. This recycled glass can be used as a fine aggregate and it can replace a huge amount of river sand. By using recycled glass as a fine aggregate we can reduce the amount of river sand mining every year and also prevent the land from getting degraded by dumping waste glass on earth. The use of recycled glass as aggregate in concrete has become popular in modern times, with large scale research being carried out to find effective replacement for fine aggregate. In recent researches it is found that the concrete made with the recycled glass aggregate have shown a good strength and better thermal properties than the conventional concrete. The major requirements for glass used as fine aggregate are grading and constituents which alter the rate of setting and hardening of concrete. The effect of constituents which alter the rate of setting and hardening of concrete is required to be assessed in terms of stiffening and compressive strength. The grading of aggregate is limited to particle size not more than 4.75mm, a limit set primarily to avoid problems which may be encountered with high flakiness indicates a large particle sizes. In the case of fine aggregate, it is stated that the glass may be used as part or all of the fine aggregate in a mix. Concrete containing crushed glass has not displayed harmfully expansive. Taking into the consideration the above mentioned points, this research work poses to use the recycled glass as a replacement for the fine aggregate in varying percentage (0%, 20%, 40%, 60%, 80% and 100%) which would be efficient in conserving the waste management if adopted in the construction sector throughout the country and world.

2. Materials and Methods:

A. Materials:

Cement: Ordinary Portland cement (53 Grade) was used. The cement was kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to moisture. The specific gravity of cement is found to be 3.15. The physical and chemical properties of the cement are presented in Table 1

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Table 1: Physical and Chemical Properties of Cement

Properties	Cement
Physical Properties	
Specific gravity	3.15
Surface area,m^2/kg	320
Initial setting time (min)	45
Final setting time (min)	375
Chemical Properties	
SiO_2	90-96
Al_2O_3	0.5-0.8
MgO	0.5-1.5
Fe_2O_3	0.2-0.8
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1
Loss of Ignition	0.7-2.5

Fine Aggregate: Locally available river sand having bulk density 1726 kg/m^3 was used and the specific gravity is 2.77. The fineness modulus of river sand is 3.26. The properties of fine aggregate is given in Table 2

Coarse Aggregate: Locally available crushed coarse aggregate having maximum size of 12.5 mm was used. It was confirming as per Indian standard (IS 383-1970)[21] and satisfied its requirement. Coarse aggregate passing through 12.5mm sieve is taken. The specific gravity of coarse aggregate is 2.75. The properties of coarse aggregate is given in Table 2

Table 2: Properties of Coarse and Fine Aggregate

S.No	Properties	Coarse Aggregate	Fine Aggregate
1	Specific Gravity	2.77	2.75
2	Fineness Modulus	3.26	2.34
3	Water Absorption	1.00%	0.5%
4	Surface Moisture	4.77%	0.13%

Waste Glass: Waste glass for this experiment was sourced from a glass recycling company. The company collects mixed colour post-consumer con-trainer glass, before subjecting the material to a crushing and milling process in order to create a fine aggregate. Glass conforming to zone II as per (IS 383-1970) has to be selected. The properties of the waste glass is given in the Table 3

Table 3: Properties of Waste Glass

S.No	Material Property	Crushed Glass
1	Specific Gravity	2.67
2	Fineness Modulus	2.76
3	Water Absorption	Nill

Water: Fresh portable water, which is free from acid and organic substance, was used for mixing the concrete.

B. Methods:

Mix Design And Sample Preparation: Concrete mix design adopted throughout this study was undertaken in accordance with the procedure specified in ACI 211.1 (American Concrete Institute 2009). All mixes were proportional in order to achieve a design compressive strength of 40 MPa after 28 days. Corresponding water cement ratio is calculated as 0.42. A control mix was produced containing only natural aggregate with a five resulting mixes incorporating waste glass as a partial replacement for fine aggregate in a proportion of 20%, 25%, 30% & 40%. As the crushed glass exhibited a lower fineness modulus the aggregate so an minor adjustment was done to the each mix design to ensure the strength and workability design parameters remained constant. The adjustment was made by increasing the bulk modulus of the coarse aggregate to compensate for the reduced fineness modulus and therefore a subsequent reduction in fine aggregate volume. These changes ensured a design compressive strength of 40 M Pa was achieved for all batches.

Testing of Specimen: Compressive strength test was conducted at the age of 28 days accordance with IS 1881: Part 116 using a loading rate of 140 kg/cm^2 per minute till the specimens fails. The test was conducted using Compression Testing Machine (CTM) of capacity 2000KN. Flexural strength of concrete was carried out conforming to IS: 516-1959[19],prisms was tested using Flexural Strength of Concrete (FTM) of capacity 100 KN. In this the mix with the proper proportion are batched. Then the concrete was thoroughly mixed until it achieves the homogeneous and uniform consistency. Then the fresh concrete was casted and it was compacted by needle vibrator. All freshly cast specimens were left in the moulds for 24 hours before being de moulded. The beams were de moulded after 24 h and were cured with water for 28 days.

3. Result and Discussion:

A. Compressive Strength & Split Tensile Strength: The results of compressive strength and flexural strength of concrete at the age of 28 days are shown in the Table 4.The comparison of the compressive strength and the flexural strength of the concrete is shown in fig 1

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Table 4: Compressive Strength and Split Tensile Strength at 28 Days

Mix Details	Compressive Strength N/mm^2	Split Tensile Strength N/mm^2
M1	23.56	2.31
M2	24.77	2.41
M3	26.31	2.52
M4	27.63	2.57
M5	25.24	2.46
M6	23.64	2.38

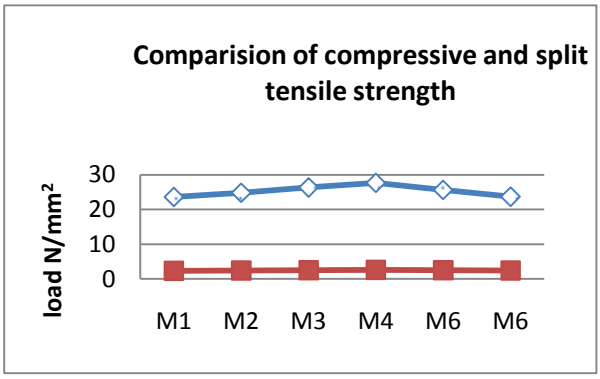

Figure 1: Comparison of compressive strength and split tensile strength at 28 days

Mix Proportions (mm): It could be observed that a concrete mixture made with 60% replacement of the crushed glass with the fine aggregate will give a good strength with comparing to the conventional concrete. There is a significant improvement in the concrete comparing to the conventional concrete.

4. Conclusion:

Based on the investigation the following conclusion can be obtained.

- ✓ Workability of crushed glass concrete is found to be better than conventional concrete.
- ✓ Up to 100% of fine aggregate in cement concrete can be replaced by crushed glass without affecting the compressive strength and tensile strength.
- ✓ Mix proportion of glass 60% and 40% gives the better result which is optimized from various proportions.
- ✓ Glass can be used successfully for making concrete by replacing ordinary river sand.
- ✓ Glass concrete is ideally suited for precast construction, as crushed glass can be directly added in to concrete mixer without human intervention.
- ✓ Glass can be used for road buds, pavement and parking lots as well as for drainage medium, backfill purposes and architectural purposes.

5. References:

1. Zainab Z. Ismail, Enas A. AL-Hashmi, (2009), Recycling of waste glass as a partial replacement for fine aggregate in concrete waste management, 29(2), pp 655-659.
2. Mohamad J. Terro, (2006), Properties of concrete made with recycled crushed glass at elevated temperatures, Building and environment, 41(5), pp 633-639
3. P. Turgut, E. S. Yahlizade, (2009), Research into concrete blocks with waste glass, International Journal of Environment Science and Engineering.
4. Assoc. Prof. Zsuzanna Joza – Rita Nemes, Recycled glass aggregate for light weight concrete.
5. Samari. A use of fine crushed bottle glass and partial cement replacement in concrete proceeding of International Conference of Materials of Construction for Developing Countries, Vol, Bankok, 1978, 363-393.
6. Abrahams J.H (Jr) Recycling Container Glass an Overview "Proceeding Third Mineral Utilization" symposium Chicago 1972, 35-47.
7. Bynum, Jr D. Scrap tire- beer bottle concrete material construction and material structures 5(27), May –June 1972, 151-157.
8. Chen C H, Wu J K & Yang C C, "Waste E-glass particles used in cementitious mixtures", *Cem Conr Res.,* VOL 36, 2006, PP. 449-456.
9. Du, H, Tan, K H., "Concrete with recycled glass as fine aggregates", *ACI Mater.*J, 111- M05, 2014, pp.47-58.
10. Ismail, Z Z & Al-Hashmi, E A., "Recycling of waste glass as a partial replacement for fine aggregate in concrete", *Waste manag*., vol.29,2009,pp.655-659.
11. Johnson C.D., "Waste glass as coarse aggregate for concrete", J. *of Testing and Evaluation,* vol.2 no.5, 1974, pp. 344-350.
12. Jozsa, Z& Nemes, R., " Recycled glass aggregate for light-weight concrete", *concr.struct*.,2002,pp.41-46.
13. Limbachiya, M., " Bulk engineering and durability properties of washed glass sand concrete", Constr. Build, Mater., vol.23, 2009, pp. 1078-1083.

14. 14 Malik, M, Bashir, M, Ahmed, S, Tariq, T &Chowdhary, U., " Study of Concrete involving use of waste glass as partial replacement of fine aggregate", IOSR.J.Eng.,vol. 3, no 7, 2013, pp. 8-13.
15. Oliveria R, de Brito J, Veiga R, "Incorporation of fine aggregates in renderings", Constr Build Mater, vol. 44, 2013, pp. 329-341
16. Park, S B, Lee, B C & Kim, J H., "Studies on mechanical properties of concrete containing waste glass aggregate", Cem. Conc. Res., vol. 34, no. 12, 2004, pp. 2181-2189.
17. Saccani, A & Bignozzi, M C & ASR expansion behaviour of recycled glass fine aggregate in concrete", Cem. Concr. Res., vol. 40, no. 4, 2008, pp. 531-536.
18. Serpa D, Santos Silva A, de Brito J, Pontest J, Soares D.,. "ASR of motars containing glass", Conctr Build Mater, vol.47, 2013, pp. 489-456.