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EFFECT OF GLASS POWDER ON MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT

Concrete is the most widely used construction material developed by man. Because of its superior specialty of being cast in any desirable shape, it has replaced stone and brick masonry. Inspite of all this, it has some serious deficiencies which, but for its, remarkable qualities of flexibility, resistance and ability to redistribute stress, would have prevented its use as a building material. Prediction of mechanical behaviour of concrete is an important issue in the concrete industry, since the traditional laboratory approach to determine the strength of concrete attracts some drawbacks such as manual involvement, time consumption and chances of creeping of human error. An attempt is made to evaluate the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength. Experimental program was carried out on concrete specimens to evaluate various parameters involved. This study looked at the feasibility of waste glass inclusion as partial cement replacement. The study includes by incorporating waste glass as partial substitution for Portland cement in amounts of 10%, 20%, 30% and 40% were investigated. The workability increased with the increase of glass powder. The optimum dosage of glass powder is found to be at 20%.

Keywords: glass powder, workability, compressive strength, split tensile strength and flexural strength.

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing of fine aggregates, coarse aggregates and cement with water and sometimes admixtures in required proportions. Cement manufacturing industry is one of the biggest carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. Consequently extensive research is on-going into the use of cement replacements, using many waste materials and industrial by products. Concrete is a blend of cement, sand, coarse aggregate and water.

The benefits of developing alternative or supplementary cementing materials as partial substitution for ordinary Portland cement are divided into ecological, economic, and engineering categories. Ecological or environmental benefits of alternative materials include (1) the diversion of non-recycled waste from landfills for useful applications, (2) the reduction in the negative effects of producing cement powder, namely the consumption of non-renewable natural resources,(3) the reduction in the use of energy for cement production and (4) the corresponding emission of greenhouse gasses. The economic benefits of using alternative materials are best realized in situations where the cost of the alternative materials less than that of cement powder while providing comparable performance. The engineering or technical benefits of alternative materials are realized when a specialized use for such material may be developed, such that the use of the alternative material is more desirable than use of concrete made with OPC alone.

The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction. Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75μm.Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various attempts and research have been made to use ground glass as a replacement in conventional ingredients in concrete production as a part of green house management. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between the silca – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. ASR can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are pulverized fuel ash (PFA), silica fume (SF) and metakaolin (MK).A number of studies have proven the suppressing ability of these materials on ASR.A high amount of waste glass as aggregate is known to decrease the concrete unit weight. The fact that glass has high silica content has led to laboratory studies on its feasibility as a raw material in cement manufacture. The use of finely divided glass powder as a cement replacement material has yielded positive results. Waste glass when ground to a very fine powder, SiO2 react chemically with alkalis in cement and form cementitious product that help contribute to the strength development. Also it may be due to the glass powder effectively filling the voids and giving rise to a dense concrete microstructure as a result waste glass powder offers resistance against expansive forces caused by sulphates and penetration of sulphates ion into the concrete mass.

II. LITERATURE REVIEW

Vasudevan Gunalaan and Kanapathy pillay Seri Ganis [2013] studied slump property in his research and resulted that compared to control mix, by using waste glass powder will give another benefit which is the workability of concrete which is much higher. They investigated the test results at 7, 14, 28 days of curing of specimens containing waste glass powder as partial replacement of cement and his results showed that the 20% glass powder mix amount shows a positive value of compressive strength at 28 days compare to other ratio which 10% and 15% is not achievable even though have slight increment from 14 days results. R.Vandhiyan et al[2013] investigated that the workability was reduced due to the replacement and it reduced with increase in replacement, this is due to the increase in the surface area of the glass powder and also the angular shape of the glass particles. They studied the replacement of cement by waste glass powder and concluded that the considerable increase in the early strength gain particularly at Specimen 15% GP gave a 29% increase in the strength at 7th day more than control specimen. At 28th day this difference in strength reduces to 23 %. The strength increment is optimal at 10% replacement. Kumarappan N. [2013] presented that there is a systematic increases in the slump as the glass powder in the mix increases. The slump ranged from around 40mm for the reference mix (i.e. 0% glass powder) to 160mm at 40% glass powder. Khatib J.M. et al [2012] showed that there was a systematic increase in the slump as the glass powder content in the mix increases. Jangid Jitendra B. and Saoji A.C. [2012] resulted that the workability decreases as the percentage glass powder in the mix increases. They concluded that the upto 40% replacement of cement, compressive strength increase upto 20% and cement replaced beyond which decreases compressive strength. Chikhalikar S.M. and Tande S.N. [2012] studied the properties of SFRC(Steel Fibre Reinforced Concrete) containing waste glass as pozzolona and concluded that the 20% replacement of cement by waste glass powder gives better workability to SFRC. Nassar Roz-Ud-Din and Soroushian Parviz [2012]utilized milled waste glass in his experimentation and resulted that slump is observed to slightly increase with the introduction of milled waste glass. This could be attributed to the low water absorption of glass. The slump of recycled aggregate concrete mixes (at

both levels of w/cm ratio) is higher than that of corresponding control mixes. In their experimentation on strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement concluded that water absorption of concrete is observed to be significantly reduced with introduction of milled waste glass as partial replacement for cement in both low and high w/c ratio mixes.

III. SCOPE AND OBJECTIVE OF THE INVESTIGATION

The investigation is aimed to study the mechanical properties of Glass powered concrete for various grades of concrete such as M20, M30 and M40. In each grade of concrete the cement is partially replaced with the glass powder at various percentages of replacement such as 0%, 10%, 20%, 30%, 40% and 50%. The following parameters are aimed to study the mechanical properties of glass powered concrete.

a. Compressive Strength
b. Split tensile Strength
c. Flexural Strength

IV. EXPERIMENTAL PROGRAMME

To meet the objective of the investigation the glass powered concrete for various grades of concrete such as M20, M30 and M40 is adopted. In each grade of concrete the cement is partially replaced with the glass powder at various percentages of replacement such as 0%, 10%, 20%, 30%, 40% and 50%.

The materials used in this investigation are
- 53 Grade Ordinary Portland cement.
- Fine Aggregate.
- Coarse Aggregate
- Water.
- Glass Powder

Cement
Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS12269. The cement was obtained from a single consignment and of the same grade and source.

Table 4.1: Properties of cement

Sl.No	Property	Value
1	Fineness	8%
2	Specific gravity	3.09
3	Standard consistency	32%
4	Initial setting time	80 min
5	Final setting time	290 min

Aggregates
Crushed granite was used as Coarse aggregate. The coarse aggregate was obtained from a local crushing unit with 20mm well graded aggregate according to IS 383. The Fine aggregate conforming to Zone-II according to IS 383 was used. The fine aggregate used was obtained from a nearby river source.

Table 4.2: Properties of Aggregate

Sl.No	Property	20 mm	12 mm	Fine aggregate
1	Bulk Density	1.44	1.42	1.49
2	% of voids ratio	50.22	51.47	34.23
3	Voids Ratio	1.01	1.06	0.58
4	Specific Gravity	2.89	2.93	2.88

Water
Potable water was used in the experimental work for both mixing and curing.

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 to be very uniform, with an even consistency. Costs vary, depending on the level of grind and the applications. Some companies use recycled glass to make their glass powders, while others may use specially made glass. The process can involve dry or wet grinding to achieve particles of the desired size. Pigments can be added to make colored glass powders, and companies can also work with colored glass if they want to make powders of a particular color, like blue.

Test program
To achieve the objective of investigation the following specimens were cast in the test program

Table 4.3: Scheme of testing

% replacement of cement with glass power	Compressive strength and Young's modulus			Split tensile strength			Flexural strength		
	M20	M30	M40	M20	M30	M40	M20	M30	M40
	Cubes	Cubes	Cubes	Cylinders	Cylinders	Cylinders	prisms	prisms	prisms
0%	3	3	3	3	3	3	3	3	3
10 %	3	3	3	3	3	3	3	3	3
20 %	3	3	3	3	3	3	3	3	3
30 %	3	3	3	3	3	3	3	3	3
40 %	3	3	3	3	3	3	3	3	3
50 %	3	3	3	3	3	3	3	3	3

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. Three grades such as M20, M30 and M40 mix were designed and the proportions arrived for different grades of concrete are given in the table 4.4

Table 4.4 Mix proportions of concrete per m^3

Grade	Cement (kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water(lts)
M20	320	650	1320	175
M30	370	610	1290	165
M40	410	580	1250	172

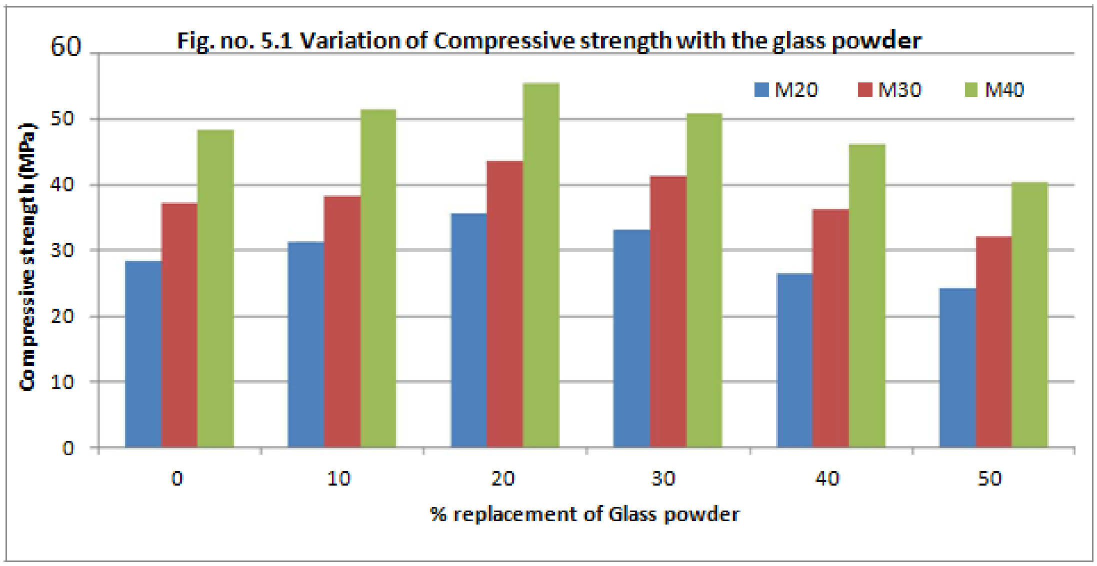
To evaluate the compressive strength, cubes of standard size 150 x 150 x 150 mm were cast. Standard cast iron moulds of size 300 x 150mm were used for casting of cylinders to study the Split tensile strength. The flexural strength is obtained by casting prisms of size 400 x 100 x 100 mm.

V. RESULTS AND DISCUSSION

Compressive Strength
The concrete cubes which were cast are tested for its compressive strength. The results are shown in table no. 5.1. It is found that the compressive strength increases with the increase in the dosage of glass powder. The optimum dosage of glass powder is found to be at 20%. The graphical variation of compressive strength is shown in Fig. no. 5.1

Table no. 5.1

Compressive strength			
% of replacement of Glass powder	M20	M30	M40
0	28.34	37.21	48.25
10	31.25	38.23	51.45
20	35.64	43.61	55.35
30	33.12	41.25	50.76
40	26.52	36.23	46.15
50	24.25	32.15	40.35



Split Tensile Strength:
The concrete cylinders which were cast are tested for its Split Tensile strength. The results are shown in table no. 5.2. It is found that the Split Tensile strength increases with the increase in the dosage of glass powder. The optimum dosage of glass powder is found to be at 20%. The graphical variation of Split Tensile strength is shown in Fig. no. 5.2.

Table no. 5.2

Split Tensile strength			
% of replacement of Glass powder	M20	M30	M40
0	4.20	5.48	7.12
10	4.61	5.70	7.62
20	5.30	6.50	8.25
30	4.90	6.19	7.58
40	3.98	5.40	6,84
50	3.60	4.82	6.05

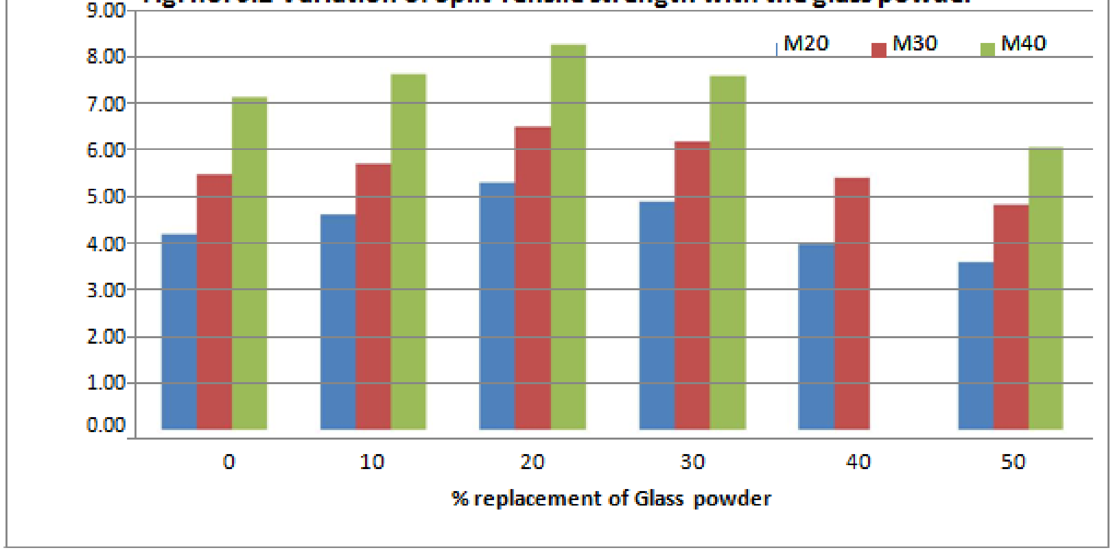


Fig. no. 5.2 Variation of Split Tensile strength with the glass powder

Flexural Strength

The concrete cylinders which were cast are tested for its Flexural strength. The results are shown in table no. 5.3. It is found that the Flexural strength increases with the increase in the dosage of glass powder. The optimum dosage of glass powder is found to be at 20%. The graphical variation of Flexural strength is shown in Fig. no. 5.3.

Table no. 5.3

Flexural strength			
% of replacement of Glass powder	M20	M30	M40
0	3.69	4.30	4.78
10	3.80	4.40	4.98
20	4.15	4.68	5.14
30	3.90	4.50	4.80
40	3.62	4.15	4.66
50	3.55	3.90	4.45

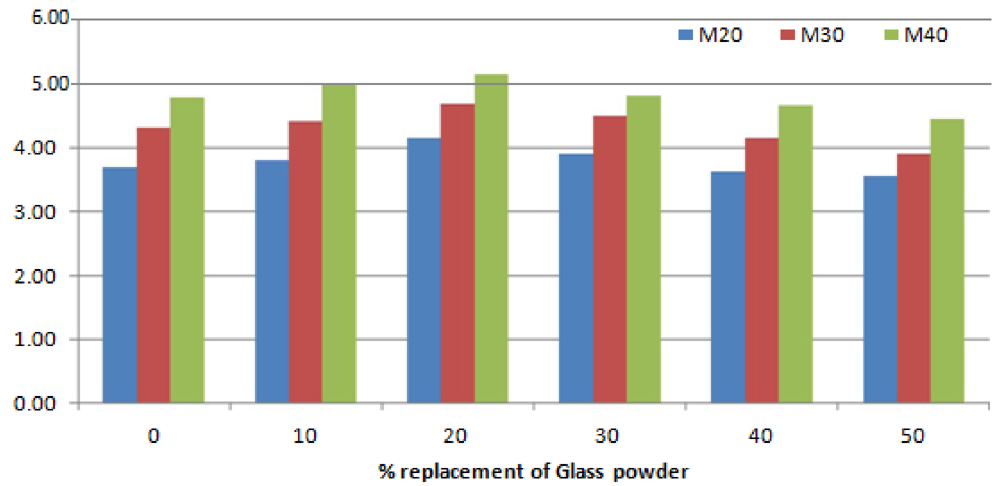


Fig No. 5.3 Variation of Flexural strength with the glass powder

VI. CONCLUSION

1. The workability increased with the increase of glass powder.
2. It is found that the compressive strength increases with the increase in the dosage of glass powder.
3. It is found that the Split Tensile strength increases with the increase in the dosage of glass powder.
4. It is found that the Flexural strength increases with the increase in the dosage of glass powder.
5. The optimum dosage of glass powder is found to be at 20%.

REFERENCES

1. *Sunny O. Nwaubani and Konstantino Poutos, The Influence of Waste Glass Powder Fineness on the Properties of Cement Mortars, February2013, IJAIEM.*
2. *Dr. G. Vijayakumar, Ms H. Vishaliny, and Dr. D. Govindarajulu, Studies on Glass Powder as Partial Replacement of Cement in Concrete Production.*
3. *Aimin Xu and Ahmad shayam, "Value – added utilization of waste glass in concrete", Cement and concrete research, vol.34, 81- 89, 2004.*
4. *Dhanaraj Mohan Patil and Dr. Keshav K. Sangle, "Experimental Investigation of Waste Glass Powder as Partial Replacement of Cement in Concrete", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 – 5721, Volume-2, Issue-1, 2013.*
5. *Mohan Jiang, Xiaoju Chen, Farshad Rajabipour, and Chris T. Hendrickson (2014). "Comparative Life Cycle Assessment of Conventional, Glass Powder, and Alkali-Activated Slag Concrete and Mortar." J. Infrastruct. Syst., Published: 27 February 2014 ISSN 1076-0342, Publisher: American Society of Civil Engineers.*
6. *Federio.L.M and Chidiac S.E, "Waste glass as a supplementary cementitious material in concrete – Critical review of treatment methods", Cement and Concrtet Composites, vol, 31,606-610,2001.*
7. *Idir.R, Cyr.M and Tagnit – Hamou.A, "Use of waste glass as powder and aggregate in cement based materials",SBEIDCO – 1st international Conference on Sustainable Built Environment Infrastructures in Developing Countries ENSET Oran (Algeria) – October 12-14, 2009.*
8. *Narayanan Neithalath, "An overview of the benefits of using glass powder as a partial cement replacement material in concrete", The Indian concrete journal, 9-18, 2011.*
9. *Narayanan Neithalath and Nathan Schwarz, " Properties of Cast – in – Place Concrete and Precast Concrete*
Blocks Incorporating Waste Glass Powder", The open Construction and Building Technology Journal,

vol:3,42-51, 2009.

10. *Khmiri A, Samet B, Chaabouni M; Assessment of the waste glass powder pozzolanic activity by different methods. IJRRAS, 2012; 10(2): 322-328.*
11. *Meena A, Singh R; Comparative study of waste glass powder as pozzolanic material in concrete. B. Tech Thesis of Department of Civil Engineering, National Institute of Technology Rourkela, 2011.*
12. *University of Dundee. (2005). Recycled Glass. Use of Recycled Materials and Industrial by-Products in Concrete. [Online].Available at: http://www.greenconcrete.dundee.ac.uk/RecycledGlass-t.htm [Accessed 5 October 2008]*
13. *T. T. Le, M. N. Soutsos, S. G. Millard, and S. J. Barnett, "Ultrahigh performance fiber reinforced concrete—*
14. *optimization of mix proportions," in Proceedings of the International Conference Entitled Concrete Platform, pp.339–349, Belfast, UK,2007.*
15. *International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 7, July 2014 Copyright to IJIRSET www.ijirset.com 14822 "Utilisation of Waste Glass Powder in Concrete"*
16. *Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement Gunalaan Vasudevan, Seri Ganis Kanapathy pillay ,Faculty of Engineering and Built Environment, Lecturer,Tunku Abdul Rahman University College ,Malaysia Department Structural & Infra, Engineer JPTM Sdn.Bhd, Malaysia. American Journal of Engineering Research (AJER).*
17. *Shayan, A., Xu, A. (2006). Performance of glass powder as pozzolanic material in concrete: a field trial on concrete slabs. Cement and Concrete Research 36 (3), 457-468.*
18. *University of Dundee. (2005). Recycled Glass. Use of Recycled Materials and Industrial by-Products in Concrete. [Online].Available at: http://www.greenconcrete.dundee.ac.uk/RecycledGlass-t.htm [Accessed 5 October 2008]*
19. *Shayan, A., Xu, A. (2004). Value-added utilization of waste glass in concrete. Cement and Concrete Research 34 (1), 81–89.*

List of Standard Codes Referred

1. **IS 383-1970** (Reaffirmed 2002), Specification for coarse and fine aggregates from natural sources for concrete.
2. **IS 456-2000**, Plain and reinforced concrete – Code of practice.
3. **IS 516-1959** (Reaffirmed 1999), Method of test for strength of concrete.
4. **IS 2386-1963** Part 1(Reaffirmed 2002), Methods of test for aggregates for concrete: Particle size and shape.
5. **IS 12269-1987**, Specifications for 53 grade ordinary Portland cement