LABORATORY STUDY ON "COMPRESSIVE STRENGTH OF CONCRETE WITH GLASS POWDER AS PARTIAL REPLCEMENT OF CEMENT"

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***ABSTRACT*----The sheet glass cutting industries producing waste glass material, which are not recycled at present and usually delivered to landfills for disposal. Using glass powder in concrete is an interesting possibility for economy on waste disposal sites and conservation of natural resources. Glass is unstable in the alkaline environment of concrete and could cause deleterious alkali-silica reaction problems.**

This property has been used to advantage by grinding it into a fine glass powder (GLP) for incorporation into concrete as a pozzolanic material. In laboratory experiments it can suppress the alkali-reactivity of coarser glass particles, as well as that of natural reactive aggregates. It undergoes beneficial pozzolonic reactions in the concrete and could replace up to 20% of cement in some concrete mixes with satisfactory strength development. Waste glass powder in appropriate proportion could be used to resist chemical attack.

The aim of the project work is to use glass powder in the range of 2% to 20% as replacement of cement and concrete cube strength compared with conventional concrete cubes. In these work waste glasses is to be used so the cost will be comparatively low when compared with normal concrete

I. INTRODUCTION

Most of the glass 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 equipment's, 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.

Many researchers have thus come forward and have investigated usage of this waste glass into something of productive value. One such group of research scholars has highlighted the usage of glass in powdered form as a partial replacement of cement in concrete. In relation, the recycling of waste glass as a component in concrete gives waste glass a sustainable alternative to land filling and therefore makes it economically viable. A variety of public and private research was investigated to understand the limitations of glass concrete and its properties. Results found were promising as strength tests showed the glass concrete mixtures in question to have moderate to high strengths which shows that a concrete derived from recycled glass could be effectively applied to a multitude of services including structural applications. There is considerable interest in the use of recycled glass with port land cement in making a variety of different types of cement products. This interest has been motivated by the large quantity of recycled glass available through municipal recycling programs--which far exceeds the demand for such glass from conventional markets like container manufacturers. If glass could be incorporated in cement products, it would greatly reduce the disposal of recycled glass and/or its use in lower valued markets such as fill and road base material. 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 equipment's, 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. Many researchers have thus come forward and have investigated usage of this waste glass into something of productive value. One such group of research scholars has highlighted the usage of glass in powdered form as a partial replacement of cement in fiber reinforced concrete. Glass Fiber Reinforced Concrete (GFRC) is a type of fiber reinforced concrete. Glass fiber concretes are mainly used in exterior building façade panels and as architectural precast concrete. Somewhat similar materials are fiber cement siding and cement boards. Composition Glass fiber reinforced concrete (GFRC) consists of high strength glass fiber embedded in a cementations matrix. In this form, both fibers and matrix retain their physical and chemical identities, while offering a synergism: a combination of properties that cannot be achieved with either of the components acting alone. In general, fibers are the principal load- carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between them, and protects them from environmental damage. In fact, the fibers provide reinforcement for the matrix and other useful functions in fiber-reinforced composite materials. Glass fibers can be incorporated into a matrix either in continuous lengths or in discontinuous (chopped) lengths. Laminates a widely used application for fiber-reinforced concrete is structural laminate, obtained by adhering and consolidating thin layers of fibers and matrix into the desired thickness. The fiber orientation in each layer as well as the stacking sequence of various layers can be controlled to generate a wide range of physical and mechanical properties for the composite laminate. However, GFRC cast without steel framing is commonly used for purely decorative applications such as window trims, decorative columns, exterior friezes, or limestone like wall panels. The potential for using a glass fiber reinforced concrete system was recognized by Russians in the 1940s. The early work on glass fiber reinforced concrete went through major modifications over the next few decades. Properties the design of GFRC panels proceeds from a knowledge of its basic properties under tensile, compressive, bending and shear forces, coupled with estimates of behavior under secondary loading effects such as creep, thermal and moisture movement.

There are number differences between structural metal and fiber-reinforced composites. For example, metals in general exhibit yielding and plastic deformation whereas most fiber-reinforced composites are elastic in their tensile stress-strain characteristics. However, the dissimilar nature of these materials provides mechanisms for high-energy absorption on a microscopic scale comparable to the yielding process. Depending on the type and severity of external loads, a composite laminate may exhibit gradual deterioration in properties but usually would not fail in catastrophic manner. Mechanisms of damage development and growth in metal and composite structure are also quite different. Other important characteristics of many fiber-reinforced composites are their non-corroding behavior, high damping capacity and low coefficients of thermal expansion.

Glass fiber reinforced concrete architectural panels have general appearance of pre-cast concrete panels, but are different in several significant ways. For example, GFRC panels will, on the average, weigh substantially less than pre-cast concrete panels due to their reduced thickness. The low weight of GFRC panels decrease superimposed loads on the building's structural components. The building frame becomes more economical. Sandwich panels A sandwich panel is a composite of three or more materials bonded together to form a structural panel. It takes advantage of the shear strength of a low density core material and the high compressive and tensile strengths of the GFRC facing to obtain high strength to weight ratios. The theory of sandwich panels and functions of the individual components may be described by making an analogy to an I - beam. Core in a sandwich panel is comparable to the web of an I -beam, which supports the flanges and allows them to act as a unit. The web of the I -beam and the core of the sandwich panels carry the beam shear stresses. The core in a sandwich panel differs from the web of an I -beam in that it maintains a continuous support for the facings, allowing the facings to be worked up to or above their yield strength without crimping or buckling. Obviously, the bonds between the core and facings must be capable of transmitting shear loads between these two components thus making the entire structure an integral unit. The load carrying capacity of a sandwich panel can be increased dramatically by introducing light steel framing.

The light steel stud framing will be similar to conventional steel stud framing for walls, except, that the frame is encased in a concrete product. Here, sides of the steel frame are covered with two or more layers of GFRC, depending on the type and magnitude of external loads. The strong and rigid GFRC provides full lateral support on both sides of the studs, preventing studs from twisting and buckling laterally. The resulting panel is light weight in comparison with traditionally reinforced concrete, yet is strong and durable and can be easily handled

In this research, the aim is to study the usage of glass in powdered form as a partial replacement of cement in fiber reinforced concrete and its impact on compressive strength of concrete. A considerable amount of research work is carried around the world on fiber reinforced concrete. However, most of the studies are related predominantly to the investigation of basic properties of fibrous concrete. Use of waste and by- product as cement in fiber reinforced concrete (FRC) is of great practical significance; because of about 20% of concrete comprises cement. There are various types of waste materials that can be considered for use as cement. The experimental study for preparing nine cubes of seven different mixes using cement partially replaced by waste glass powder at varying percentage of 2%, 4%, 8%, 16%, 20%,and to study

2 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 object 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 With the help of techniques developed in the glass industry the glass industry, the glass of any type and quality can be produced to suit the requirement of different industries. Just to stress the importance of glass in the engineering field of today, few of the recent development that have taken place in the glass industry The glass is a mixture of a number of metallic silicates, one of which is usually that of an alkali metal. It is an amorphous, transparent or translucent. It may also be considered as a solidified super cooled solution of various metallic silicates having infinite viscosity. For the purpose of classification the glass may be grouped into the following three categories:

1) Soda lime glass
2) Potash lime glass
3) Potash lead glass

One more category of glass may be formed and it may be called the common glass. The property and uses of different categories are mentioned later on this chapter

3 EXPERIMENTAL PROGRAMMES

CONSTITUENT MATERIALS

The ingredients of concrete consist of cement, fine aggregate and coarse aggregates, water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. In this project work we used waste glass powder as a partial replacement of cement. The ingredients are used in proper proportion. Also the cement is replaced at 15%, 20%, and 25% by glass powder. They are described in details with their properties are as follows

CEMENT

The Ordinary Portland Cement (OPC) 53 grade used in the project work. This is used as main binder in the mixes.

FINE AGGREGATE AND COARSE AGGREGATE

Fine and coarse aggregate make up the bulk of concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose. For fine aggregates natural sand is provided with maximum size of 4.75 mm. coarse aggregates are used with size between 20mm-4.75mm.

GLASS POWDER

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. The amount of waste glass is gradually increased over the recent years due to an ever-growing use of glass products. Most waste glasses have been dumped into landfill sites. The Land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly. So we use the waste glass in concrete to become the construction economical as well as eco-friendly. The glass powder used in the 20

Present study is brought from Bharuch market. This material replaces the cement in mix proportion.

GLASS PIECES 300 MICRONS GLASS POWDER 75 MICRONS GLASS POWDER

EXPERIMENTAL WORK

The experimental work was carried out in our college concrete technology laboratory. In this study, total of four groups of concrete mixes were prepared in laboratory. First group was normal cement concrete mix. Second, third fourth fifth sixth and seventh group was cement replacement by fine glass powder (GLP) particle size from 90 micron to 150 micron with replacement from 2%, 4%,8%,16% and 20% respectively

Casting and testing

Six different mixes (**Mix0, Mix1, Mix2, Mix3, Mix4, and Mix5**) were prepared using cement replaced by glass powder at varying percentage of **0%, 2%, 4%, 8%, 16% and 20%**. Thirty six number standard specimens of dimensions 150 × 150 × 150 mm were cast according to the mix proportion and cured in water at room temperature in the laboratory for 3 7 and 28 days. At the end of each curing period, three specimens for each mixes were tested for compressive strength and the average strength was recorded. The size of the specimen is as per the IS code 10086 – 1982. The compressive strength test on both conventional and glass added concrete was performed on standard compression testing machine of 3000kN capacity, as per IS: 516-1959.

4 RESULTS AND DISCUSSION

MIX-0 represents normal concrete of M30 grade. Table-4shows the 3 days compressive strength. For this two samples cube were taken and the average compressive strength is found to be 16.4 N/mm2. Fig shows the graphical representation of compressive strength.

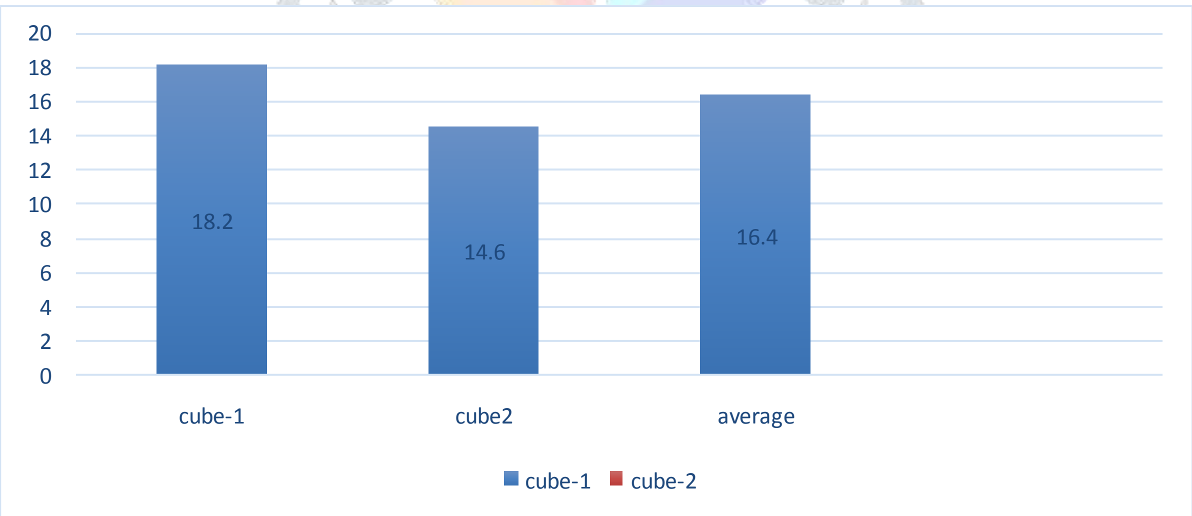
COMPRESSIVE STRENGTH OF M30 NORMAL CONCRETE (3 DAYS)

Sr. No	Mixtures	Compressive strength (N/mm2)		Average compressive strength (N/mm2)
		Cube-1	cube-2	
1	mix-0	18.2	14.6	16.4

- **MIX-1 MIX-2 MIX-3 MIX-4 and MIX-5 represent concrete containing glass powder less than 90 micron with replacement of cement 2%, 4%, 8%, 16%, and 20% respectively. Total 10 cubes were casted 2 cubes for each mixture. Table-5and fig. 6 shows the compressive strength of sample on the 3 days.**

COMPRESSIVE STRENGTH OF CONCRETE REPLACED BY GLP (3 DAYS)

S.NO	AVERAGE COMPRESSIVE STRENGTH(N/MM^2)		COMPRESSIVE STRENGTH (N/MM^2)
	TRAIL MIX-1	TRAIL MIX-2	
1	21.77	19.77	17.77
2	21.77	20	20.44
3	22.22	20.22	18.22
4	23.22	20.66	18
5	12	16	14



Cube-1 cube-2

- It is found from above result that addition of GLP increase the 3 days strength of all samples. It is seen from above result that GLP is taking small part in earl strength gain in concrete. Also it is observed that mixture containing cement replacement by 20% GLP get lowest strength to that of 2%, 4%, 8%, & 16%, replacement.

COMPARATIVE COMPRESSIVE STRENGTH OF VARIOUS PERCENTAGE REPLACEMENT OF GLASS POWDER WITH CEMENT.

Sr. No	Mixtures	**Average compressive strength (N/mm2)**		
		3 days	7 days	28 days
1	mix-0	16.4	21.9	28.5
2	Mix1-2%	19.77	23.55	31.00
3	Mix2-4%	21.00	24.22	32.00
4	Mix3-8%	20.22	23.61	35.40
5	Mix4-16%	20.60	25.80	35.50
6	Mix5-20%	14.00	19.00	27.00

- It is found from above result that addition of GLP increase the strength of all samples. It is seen from above result that GLP is taking small part in earl strength gain in concrete. Also it is observed that mixture containing cement replacement by 20% GLP get lowest strength to that of 2%, 4%, 8%, & 16%, replacement.

5. CONCLUSION

The data presented in this paper show that there is great potential for the utilization of waste glass in the form of glass powder.

It is considered that the glass powder form would provide much greater opportunities for value adding and cost recovery, as it could be used as a replacement for expensive materials such as silica fume, fly as hand cement

- Waste glass, if ground finer than 100μm shows a pozzolanic behavior. The smaller particle size of the glass powder has higher activity with lime resulting in higher compressive strength in the concrete mix

Micro structural examination shows that glass powder produces a denser matrix which improves the durability property of concrete. The coefficient of capillary absorption test also indicates that incorporation of finer glass powder improves durability.

Glass powder of size 150μm - 100μm exhibit initiation of alkali aggregate reaction. The presence of ettringite confirms this. The data presented in this study indicates that silica fume is best SCM. It gives highest compressive strength because of its smaller grain size and spherical shapes. The results obtained from the present study shows that there is great potential for the utilization of best glass powder in concrete as replacement of cement.

- It can be concluded that 20% of glass powder of size less than 100μm could be included as cement replacement in concrete without any unfavorable effect

REFERENCES

[1] Dr. G.Vijayakumar, Ms. H. Vishaliny and Dr. D. Govindarajulu, "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production", International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013).

[2] 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.

[3] M.N.Bajad, C.D.Modhera and A.K.Desai, "Chloride Ion in Con-Glass-Crete", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN 2249-6866 Vol.2, Issue 2 June 2012 32-40.

[4] Ahmad Shayan, Chief Research Scientist ARRB Transport Research, "Value-added Utilization of Waste Glass in Concrete", Iabse Symposium Melbourne 2002.
[5] C Yasui, M Nagamitu, R Takata, M Ohya, S Sato, T Nonaka, Matsue National College Of Technology, Japan, "Examination Of Asr In Waste Glass Materials", 30th Conference On Our World In Concrete & Structures: 23 - 24 August 2005, Singapore.
[6] A. Oner and S. Akyuz, "An experimental study on optimum usage of GGBS for the compressive strength of concrete," Cement and Concrete Composites, vol. 29, no. 6, pp. 505–514, 2007.
[7] W. Jin, C. Meyer, and S. Baxter, "Glascrete—Concrete with glass aggregate," ACI Structural Journal, vol. 97, no. 2, pp. 208–213, 2000.
[8] A. Shayan and A. Xu, "Value-added utilization of waste glassing concrete," Cement and Concrete Research, vol. 34, no. 1, pp.81–89, 2004.
[9] C. Meyer, N. Egosi, and C. Adela, "Concrete with waste glasses aggregate," in Recycling and Reuse of Glass Cullet. Proceedings of the International Symposium, Concrete technology unit office and University of Dundee, March 2001.
[10] I. B. Topc¸u and. Canbaz, "Properties of concrete containing waste glass," Cement and Concrete Research, vol. 34, no. 2, pp.267–274, 2004.
[11] 26. C. M. Sangha, A.M. Alani, and P. J.Walden, "Relative strength of green glass cullet concrete," Magazine of Concrete Research, vol. 56, no. 5, pp. 293–297, 2004.
[12] G. Chen, H. Lee, K. L. Young et al., "Glass recycling in cement production-an innovative approach," Waste Management, vol.22, no. 7, pp. 747–753, 2002.
[13] Z. Xie and Y. Xi, "Use of recycled glass as a raw material in the manufacture of Portland cement," Materials and Structures/Materiaux ET Constructions, vol. 35, no. 252, pp. 510–515, 2002.
[14] N. Neithalath and N. Schwarz, "Cement pastes incorporating coarse glass powder hydration, strength, and heat development, "Materials and Structures. In press.
[15] N. Schwarz, M. DuBois, and N. Neithalath, "Electrical conductivity based characterization of plain and coarse glass powder modified cement pastes," Cement and Concrete Composites, vol. 29, no. 9, pp. 656–666, 2007.
[16] Y. Shao, T. Lefort, S. Moras, and D. Rodriguez, "Studies on concrete containing ground waste glass," Cement and Concrete Research, vol. 30, no. 1, pp. 91–100, 2000.
[17] C. Shi, Y. Wu, C. Riefler, and H. Wang, "Characteristics and pozzolanic reactivity of glass powders," Cement and Concrete Research, vol. 35, no. 5, pp. 987–993, 2005.
[18] A. Shayan and A. Xu, "Performance of glass powder as pozzolanic material in concrete: a field trial on concrete slabs, "Cement and Concrete Research, vol. 36, no. 3, pp. 457–468, 2006.

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