

Suitability of Waste Glass Powder as a Partial Replacement of Cement in Fibre Reinforced Concrete

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ABSTRACT: Concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. The environmental and economic concern is the biggest challenge concrete industry is facing. In this paper, suitability of use of waste glass powder as partial replacement of cement in fibre reinforced concrete is discussed so that issues concerned with environment will get some alternative. Cement was replaced by waste glass powder as 0% to 40% in increment of 5% in M30 mix. The concrete specimens were tested for compressive strength, splitting tensile strength, flexural strength at 7days, 28 days, 60days, 90days and 180days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using waste glass powder as partial replacement of cement at 20% by weight.

KEYWORDS: Fibre reinforced concrete, waste glass powder, strength.

I. INTRODUCTION

Irrespective of the nature of their products, almost all industries produce waste. Effective disposal of wastes therefore is a challenging task. In olden days solid wastes were used as landfills in low-lying areas. Waste disposal in landfill sites however are unsustainable in the long run. Industrial wastes like fly ash, silica fume, blast furnace slag etc. and other wastes of plastics, glass, tiles and agriculture are causing environmental pollution. Recycling of wastes is therefore emerging as an important component of technology for making contribution towards sustainability. Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of greenhouse gases, such as CO₂, to the atmosphere. Among the greenhouse gases, CO₂ contributes about 65% of global warming.

The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. Consequently efforts have been made in the concrete industry to use waste materials as partial replacement of coarse or fine aggregates and cement. The interest of the construction community in using waste or recycled materials in concrete is increasing because of increased disposal cost and environmental concerns. The waste glass from in and around the small shops is packed as a waste and disposed as landfill. Glass is an inert material which could be recycled and used many times without changing its chemical property. Besides using waste glass as cullet in glass manufacturing, waste glass is crushed into powder and can be used as replacement in concrete. Since the demand in the concrete manufacturing is increasing day by day, the utilization of cement leads to exploitation of natural resources and production of cement causes emission of CO₂, a greenhouse gas. The glass being mainly silica based material which is amorphous can be used in cement based application. Due to its silica content, glass powder is considered as pozzolonic material and can possess properties of pozzolonic materials such as fly ash, calcined clay, metakaolin, slag, etc. This paper gives experimental reports for replacement of cement with waste glass powder in fibre reinforced concrete.

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Fiber-reinforced concrete (FRC):

Concrete is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. Regular concrete is therefore normally reinforced with steel reinforcing bars. For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. Their main purpose is to increase the energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete. Concrete containing a hydraulic cement, water, fine or fine and coarse aggregate and discontinuous discrete fibers is called fiber-reinforced concrete (FRC). There is considerable improvement in the post-cracking behavior of concretes containing fibers. Although in the fiber-reinforced concrete the ultimate tensile strengths do not increase appreciably, the tensile strains at rupture do. Compared to plain concrete, fiber reinforced concrete is much tougher and more resistant to impact.

II. MATERIALS

For preparation of mix of grade M20, materials used and their specification details are given below:

1. Cement: The cement used in this study was 43 grade ordinary Portland cement (OPC) confirming to IS: 8112-1989.
2. Fine aggregate: Locally available sand confirming to zone II with specific gravity 2.62 was used. The testing of sand was done as per Indian specification IS: 2386 (Part III)-1963.
3. Coarse aggregate: Coarse aggregate used was 20mm and down size and specific gravity 2.76. Testing was done as per Indian standard specification IS: 2386 (Part III)-1963.
4. Glass powder: Waste glass available locally was collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this experiment glass powder having partials size less than 90 micron was used.
5. Water: the water used was portable, fresh, colorless, odourless, and tasteless water that is free from organic matter of any type.
6. Polypropylene fibers: polypropylene fibers are specially engineered for use in concrete and mortar as a micro reinforcement system. They possess very high tensile strength, but their low modulus of elasticity and higher elongation do not contribute to the flexural strength. Polypropylene (PP) is a versatile thermoplastic material, which is produced by polymerizing monomer units of polypropylene molecules into very long polymer molecules or chains in the presence of a catalyst under carefully, controlled heat and pressure.

III. METHODOLOGY

Experimentation was done on prepared mix of grade M20 with w/c ratio 0.45. 3 sets of mix were prepared for testing, normal mix, mix in which cement is replaced with glass powder and mix in which glass powder and 0.03% of glass fibres were used. For investigation of results following tests were conducted:

- Compression Test
- Flexural Test
- Split tensile Test

IV. RESULTS

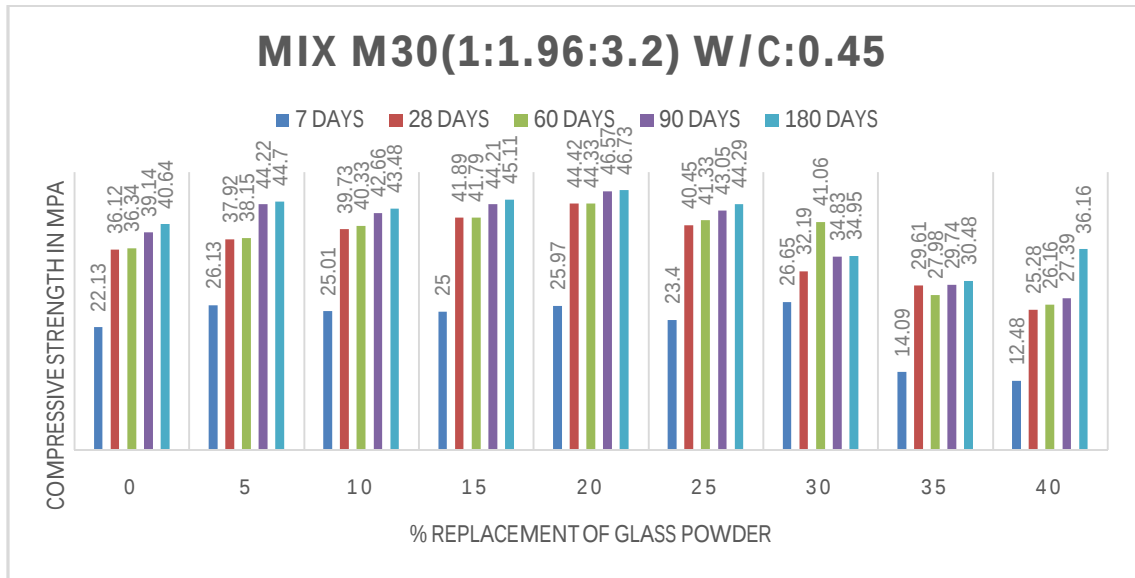
Experimentation was done on fibre reinforced concrete cubes, beams and cylinders and tests conducted to check their strengths. Results of tests conducted are graphically represented in this paper as follows:

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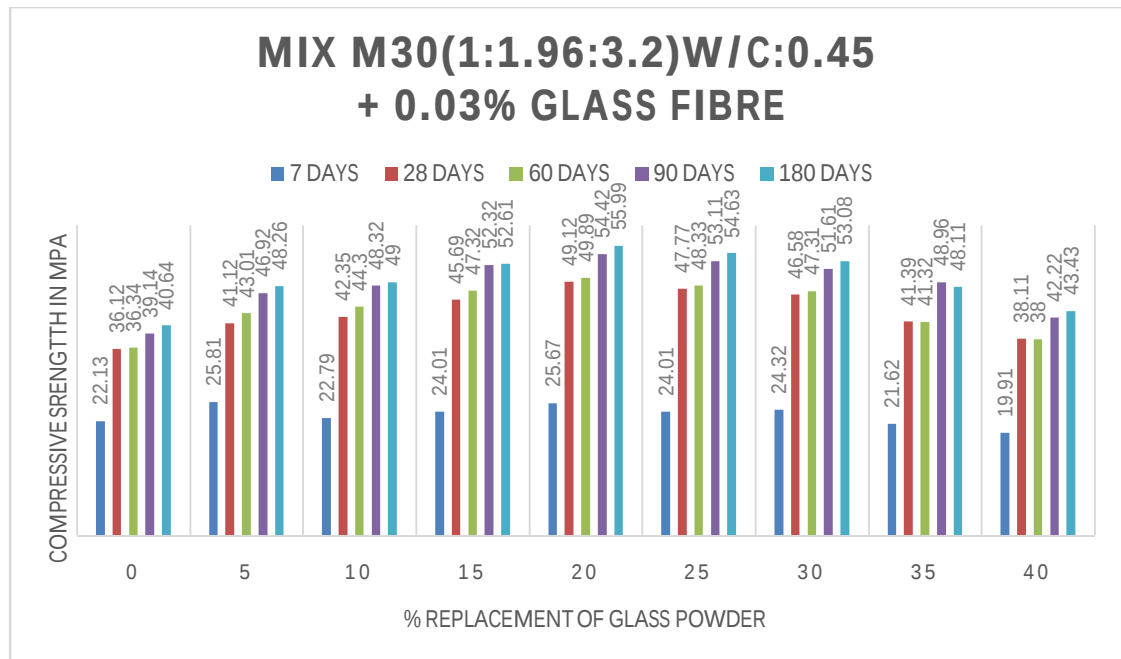
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1. Compressive strength test:



Compressive Strength is maximum at 20%. It is decreasing if replacement of cement exceeds 10%.



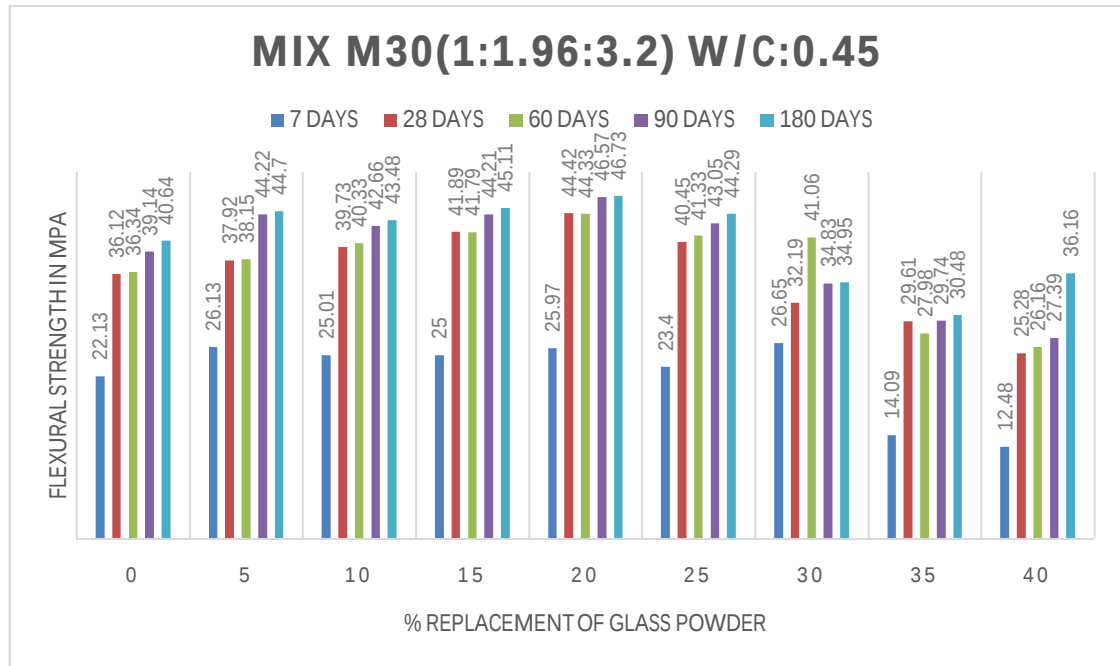
Compressive strength is slightly larger with fibre reinforced concrete. It seems that strength is maximum at 20% replacement of cement with glass powder.

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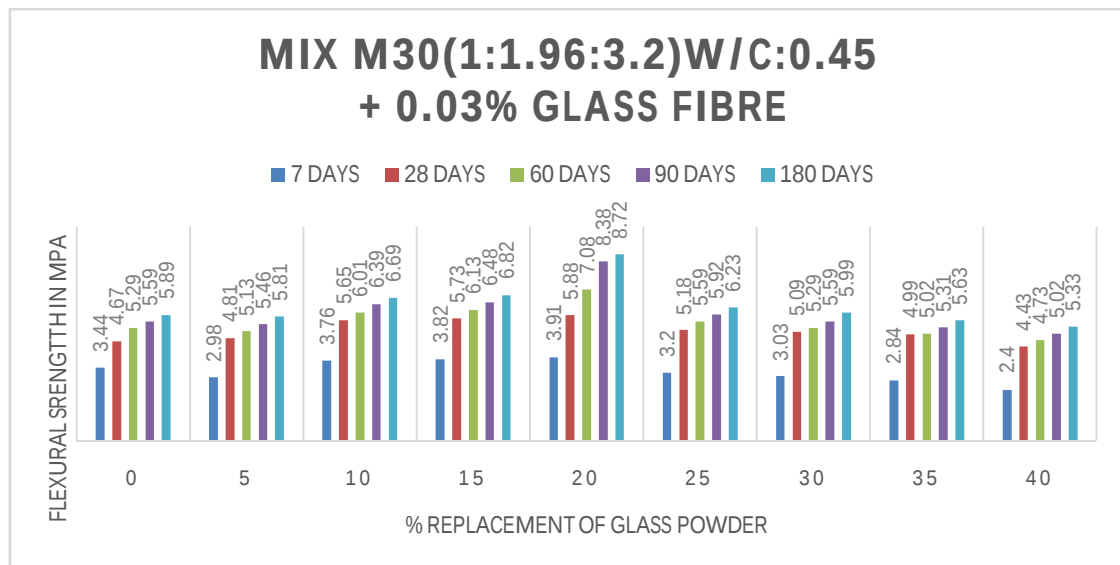
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2. Flexural strength test:



Flexural strength is also maximum at 20% replacement of cement with glass powder. After this strength goes on decreasing.



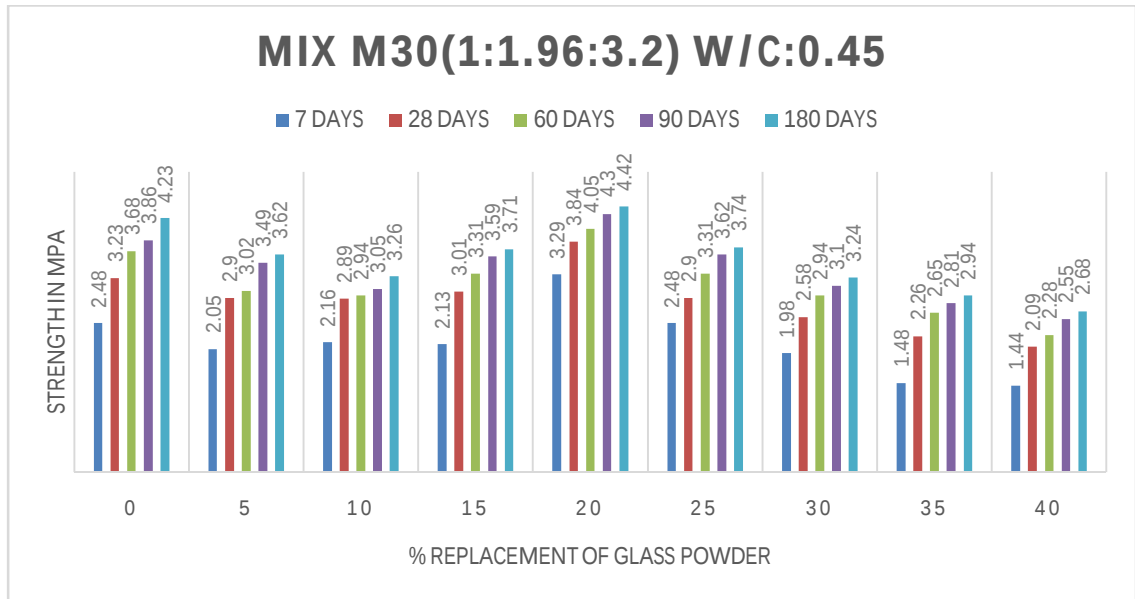
Flexural strength goes on increasing with addition of glass fibres. The strength is found to be higher than that of nominal mix.

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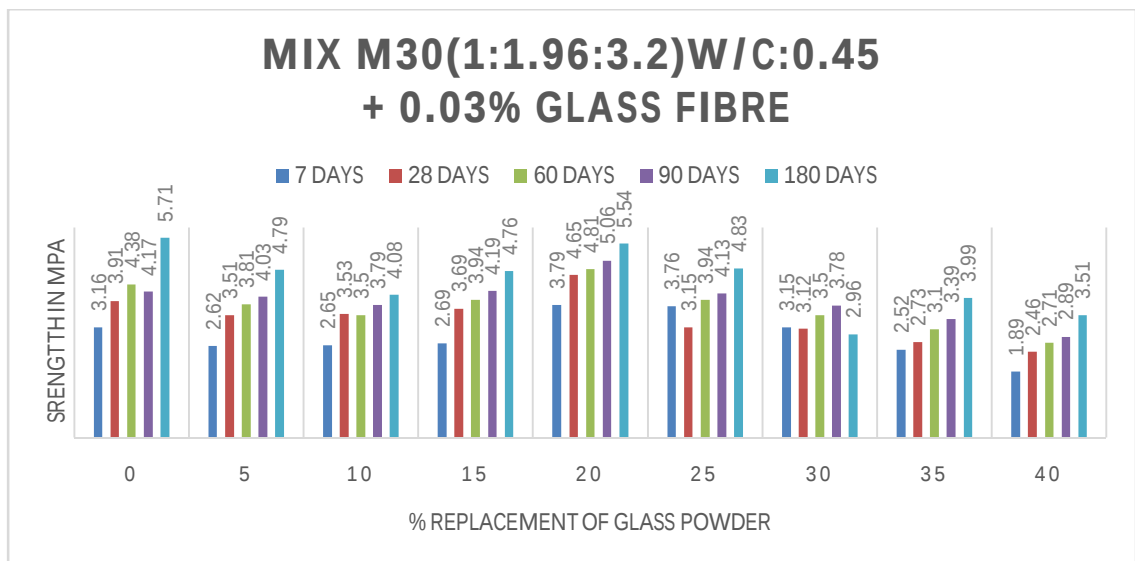
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3. Split Tesile Test:



Split tensile strength is slightly lower than flexural strength values. It is also maximum at 20% replacement.



The split end tensile strength is seems to be maximum at 20% replacement of cement with glass powder in fibre reinforced concrete.

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V. CONCLUSIONS

I have chosen this topic because of most developing country facing shortage of post consumers disposal waste site and it's become very serious problem for this reasons regenerating and using waste products as resources and prevent environmental pollution From the above mentioned work of various researches and our present experimental work it is clear that glass can be used as a partial replacement of cement in concrete because of its increased strength parameter like compressive strength split tensile strength and flexure strength. As disposal of waste by product problem is a major problem in today's world due to limited land fill space as well as its escalating prices for disposal utilization of waste glass in concrete will not only provide economy, it will also help in reducing disposal problem. The present study shows that there is a great potential for the utilization of glass powder in concrete as partial replacement of cement. About 20% of cement may be replaced with glass powder of size less than 100um. Without any sacrifices on the strength. There is a great potential for utilization of waste glass in concrete in several forms, including fine aggregate coarse aggregate and glass powder. It is considered that the glass powder 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 fumes, metakaolin, calcined clay, fly ash and cement used for manufacturing of fibre reinforced concrete. There is a need for being concerned about sustainability of concrete in India and minimising the CO₂ emission. There is also a need to minimize wastage of precious natural resources by making their efficient and judicious use. Based on experimental observation higher strength were achieved when 20% cement was replaced by glass powder in concrete the compressive strength of concrete increases as the replacement percentage of cement with glass increases and become maximum at about 20% and later decreases. The split tensile strength of concrete increases as the replacement percentage of cement with glass powder increases and become maximum at about 20% and later decreases.

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