INFLUENCE OF GLASS POWDER ON THE PROPERTIES OF CONCRETE

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ABSTRACT

Concrete is a construction material composed of cement, aggregates (fine & course) water and admixture. Today many researches are on going into the use of Portland cement replacement, using many waste materials like fly ash, rice husk, furnace slag, marble powder and silica flume.The main objective of present study to use of glass powder to increase the compressive strength of concrete. Glass powder is used as a binder with partial replacement of cement which takes some part of reaction at the time of hydration; also it is act as a filler material. Present days most of the ways glasses have been dumped in to land fill site. When waste glasses are re-used in making concrete production, the production cost of concrete will go down.In this report we are going to discuss the strength effect of replacement of cement by glass powder, the cement is replaced at 10%, 20% 30%. The compressive strength of concrete cubes is tested for 3, 7, 28 days were found. The highest replacement level is 20% by WGP (waste glass powder). The performance of design mix and properties of materials are good.

Keywords: Glass powder

I. INTRODUCTION

Concrete is a composite construction material composed of aggregate, cement and water. There are many formulations that have varied properties. The aggregate is generally coarse gravel or crushed rocks such as lime stone or granite, along with a fine aggregate such as sand. The cement commonly Portland cement and other cementitious materials such fly ash and slag cement, serve as a binder for the aggregate. Various chemical admixtures are also added to achieve varied properties. Water is then mixed with this dry composite which enables it to be shaped and then solidified and hardened into rock-hard strength through a chemical process called hydration. The water reacts with the cement which bonds the other components together, eventually creating a robust stone-like material. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason it is usually reinforced with material that are strong in tension (often steel). Concrete can be damaged by many processes, such as freezing of trap. concrete is widely used for making architectural structures, foundations, +brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Famous concrete structures include the Burjkhalifa (world's tallest building), the Hoover Dam, the Panama Canal and the Roman Pantheon ped water.

HIGH PERFORMANCE CONCRETE:

High performance concrete (HPC) is cement based concrete, in which each ingredient performs effectively to contribute towards fresh concrete as well as hardened concrete properties. There is neither a unique definition nor any specification for HPC. The American Concrete Institute (ASI) defines HPC as "Concrete which meets special performance and uniformity requirements that cannot always are achieved routinely by using only conventional materials and normal mixing, placing and curing practices, the requirements may involve enhancement of characteristics such as placement and compaction without segregation, long term mechanical properties, early age strength, toughness, volume stability or service life in severe environments". HPC consist of all ingredients of Conventional cement concrete (CCC) with chemical admixtures as super plasticizer and mineral admixtures are improving the utility of HPC. The performance of cement concrete can be improved in terms of both strength and durability considering impermeability characteristics, which is achieved by adopting lower water-cement ratio and using pozzolanic admixtures such as fly ash or WGP.In HPC, generally the bond between cement and aggregates is very good. A high fineness modulus of fine aggregate (2.8 – 3 and more) is required. In HPC, a usually a lower value for maximum size of aggregate is desirable. Since larger particles of aggregate introduce heterogeneity in the system, incompatibility between cement aggregate may occur due to changes in modulus of elasticity, Poisson ratio, creep and shrinkage. It should be noted that the HPC has a very high degree of durability because of very low permeability and stronger-denser transition zone between aggregate and cement paste in concrete. However, these gains have to be optimized between aggregate and cement paste in concrete. However, these gains have to be optimized through a proper mix design procedure. Though studies on HPC have been carried out extensively by researchers, there is no standard procedure for the design of HPC mixes. It is felt that the conventional methods of design of concrete mixes may not be suitable for HPC because, with the addition of silica fume, admixtures for achieving the same workability. Hence, a new water cement ratio law has to be established for HPC. Further, the compressive strength and workability properties of HPC mixes are greatly influenced by several parameters viz., fine aggregate, coarse aggregate, water cement ratio, and percentage of silica fume. Consequently, developing a standard mix design procedure for HPC mixes requires in extensive understanding of the relation between these parameters and the properties of the resulting mix. It has now been realized in the construction industry that in addition to compressive strength, other attributes like durability and those related to construction aspects are equally important. The HPC strength parameter ranges from low of 40Mpa to 90Mpa.

MECHANISM OF HPC:

According to Neville "HPC is a concrete to fulfill specified purpose and no special mystery about it no usual ingredients or special equipments has to use. But to understand the behavior of concrete and will to produce a concrete mix within closely controlled tolerances". Concrete is a three-phase composite material, the first two phases being aggregates and bulk hydrated cement paste (HCP) and third being the "transition zone". The transition zone is the interfacial region between the aggregate particles and bulk "HCP". It is the weakest link and if this is strengthened, then the strength and impermeability (durability characteristics) of the concrete are improved to a greater extent. This is made possible by reducing W/C ratio and use WGP. WGP improves the above properties by pozzolanic action and by reactive filler effect. Waste glass powder contains a very high percentage of amorphous silicon dioxide which reacts with large quantity of Ca(OH) produced during hydration of cement. This gives strength as well as improves durability. This is known as pozzolanic action (chemical mechanism). Another action, a physical mechanism called “filler effect” in which the small spherical shaped glass powder disperse in the presence of a super plasticizer to fill the voids between the cement particles and accelerates the hydration of cement since glass powder is fine reactive filler. This results in well packed concrete mix. Due to pozzaloanic action there is reduction in pore sizes. This effect along with the improved particle distribution results in reduction of the thickness of transition zone and leads to densely packed stronger and less permeable concrete.

II STUDY ON WASTE GLASS POWDER

WASTE GLASS POWDER

Definition:

Glass is one of the oldest man-made materials. It is produced in many forms such as packaging or container glass, flat glass, and bulb glass, all of which have a limited life in their manufactured forms and therefore need to be recycled so as to be reusable in order to avoid environmental problems that would be created if they were to be stockpiled or sent to landfills. Quantities of waste glass have been rising rapidly during the recent decades due to the high increase in industrialization and the considerable improvement in the standards of living, but unfortunately, the majority of these waste quantities are not being recycled but rather abandoned causing certain serious problems such as the waste of natural resources and environmental pollution.Recycling of this waste by converting it to aggregate components could save landfill space and also reduce the demand for extraction of natural raw material for construction activities. Theoretically, glass is a fully recyclable material; it can be recycled without any loss of quality. There are many examples of successful recycling of waste glass: as a cullet in glass production, as raw material for the production of abrasives, in sand-blasting, as a pozzolanic additive, in road beds, pavement and parking lots, as raw materials to produce glass pellets or beads used in reflective paint for highways, to produce fiberglass. Waste glass can also be produced from empty glass bottles and pots, and come in several distinct colors containing common liquids and other substances. This waste glass is usually crushed into small pieces that resemble the sizes of gravels and sands. In its original form, glass comes as a balanced combination from three main raw natural materials: sand, silica, and limestone, in addition to a certain percentage of recycled waste glass utilized in the manufacturing process. Table below lists some of approximate compositions and the corresponding uses of various common forms of glass.

Physical properties

The glass as natural sand replacement in concrete trials was a crushed product with a size distribution between 3mm ~ 0.3mm. The clear and green glass was very clean with no materials passing 150 and 75 micron fractions.

Table 1: Composition of Glass

Type of Glass	Composition (by weight)	Usages
Soda-Lime-Silica	73% Silica – 14% Soda – 9% Lime – 3.7% Magnesia – 0.3% Alumina	Glass Widows – Bottles – Jars
Boro-Silicate	81% Silica – 12% Boron Oxide –4% Soda – 3% Alumina	Pyrex Cookware – Laboratory Glassware
Lead (Crystal)	57% Silica – 31% Lead Oxide – 12% Potassium Oxide	Lead Crystal Tableware
Alumino-Silicate	64.5% Silica – 24.5% Alumina – 10.5% Magnesia – 0.5% Soda	Fiberglass Insulation – Halogen Bulbs

Workability:

With the addition of glass powder, the slump loss with time is directly proportional to increase in the silica content due to the introduction of large surface area in the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.

Segregation and bleeding:

Glass powder reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the glass powder and hence the free water left in mix for bleeding also decreases. Glass powder also blocks the pores in the fresh concrete, so water within the concrete is not allowed to come to the surface.

Waste glass working in concrete:

The crushed glass powder contained contaminants in the form of traces of polymers, poly vinyl butylene (PVB) from the ELV glass content, traces of acrylic from the architectural glass content. Ninety percent of the contaminant material was considered to be PVB. It was established that there was a small amount of organic material present in the crushed glass, but this was considered to be paper residue from the labels on the bottle glass. The moisture content of the glass as supplied was considered insignificant at 0.29%. The free lime content of crushed glass and glass powder is 1.22% and 0.26% respectively.The powder glass used in this project had a grading that it would not qualify as a fine aggregate and would not be a Pozzolana either. However, it can possibly be used in concrete as a filler or "micro-aggregate". This product is fine enough not to be susceptible to ASR even though it may not be fine enough to give much Pozzolana reaction.

Mechanism of action of waste glass powder:

In general researchers try to explain the mechanism of action of waste glass from a particular characteristic of observed behavior in concrete. However the characteristics of both materials are differ each other. But the properties of glass play a predominant role.Waste glass powder has a property that binds the aggregate together and gives concrete in strength. Due to their extreme fineness, the WGP particles occupy the voids between the cement grains, thus acting as a filler, reducing the porosity of bulk cement matrix and resulting in less permeable and durable concrete.

Applications:

1. Highly reactive Pozzolana used to improve motor and concrete.
2. Amorphous glass with high sio_2 contains extremely small particle size and large surface area.

Advantages of WGP:

The advantages of adding WGP to concrete can be one or more of the following:

1. Reduced the cost of production.
2. Increased workability of the mix due to fineness of particles.
3. Reduced dosage of super plasticizer to achieve target workability.

Fig 1: Initial stage of waste glass

Fig 2:Crushing of waste glass in to powder by Los-Angele abrasion machine

Fig 3: Partial replacement of fine aggregate with glass powder

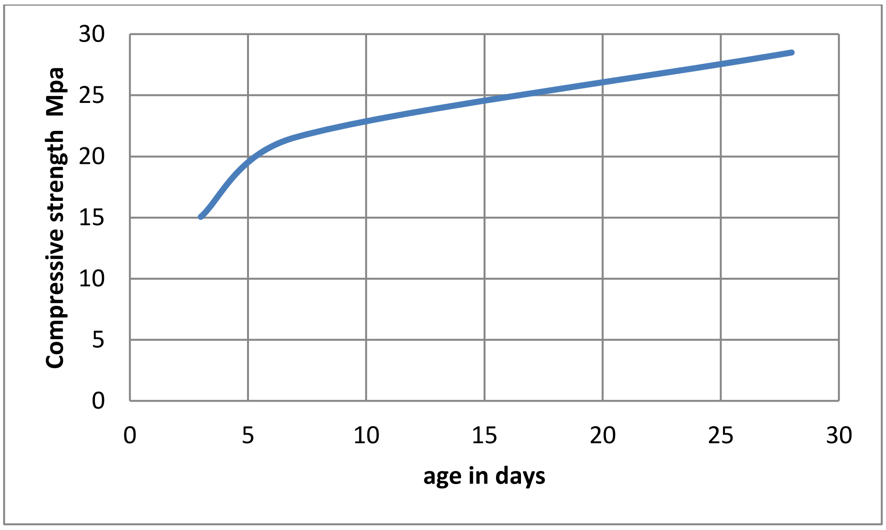
III. RESULTS AND DISCUSSIONS

Table 2 Compressive strength of the concrete for 3,7,28 days

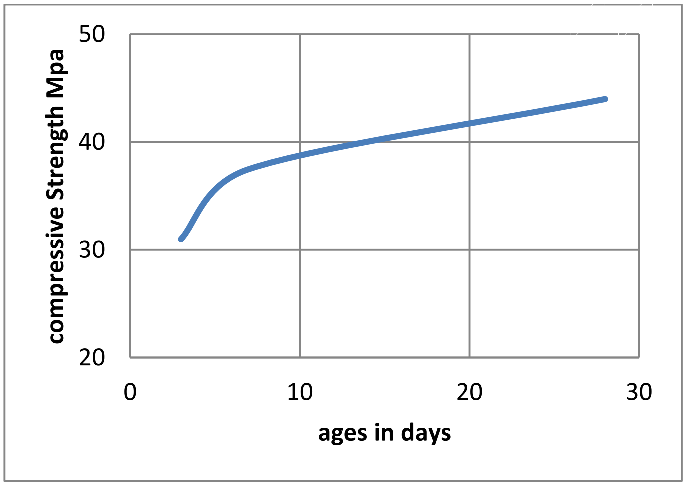
Percentages %	7 days MPa	14days MPa	28 days MPa	Slump value mm	Compaction factor
Normal concrete	15.06	21.56	28.5	36	0.87
Glass powder 5% + FA : 95%	23.77	31.23	37.6	31	0.82
Glass powder 10% + FA 20%	30.99	37.49	43.99	34	0.85
Glass powder 15% + FA 85%	35.12	41.02	48.3	35.3	0.86
Glass powder 20% + FA 80%	41.32	47.82	54.32	37	0.89

GRAPHS

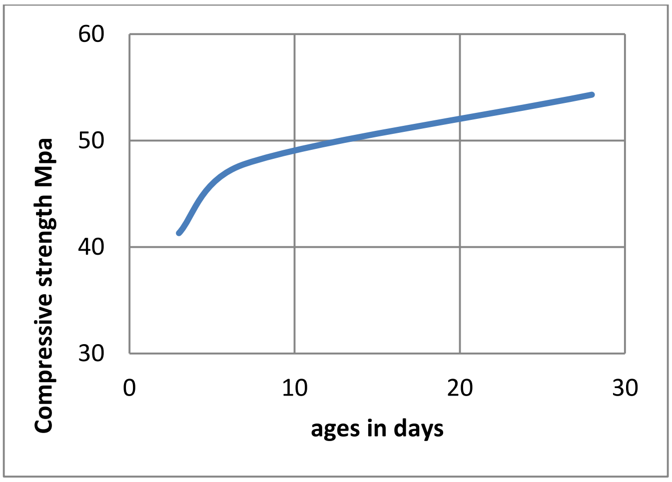
TRADITIONAL CONCRETE



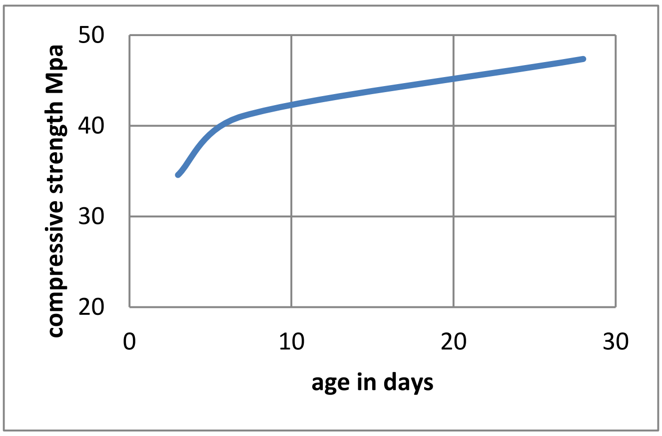
PROPORTION: 10% GP



PROPORTION : 15%GP



PROPORTION : 20% GP



DISCUSSION ON RESULTS

The above graph shows the comparison between the compressive strengths of concrete cubes with different percentages of waste glass powder. The curve which is in "Blue" color shows the variation of compressive strength of concrete in which the partial replacement of the fine aggregate is done with different percentages of waste glass powder.Whereas, the curve with the "Red" color represents the variation of compressive strength of concrete when the coarse aggregate is replaced with waste glass powder. From our experimental Investigations we have found that the partial replacement of fine aggregate with waste glass powder yields more compressive strength, when compared to the partial replacement of Coarse aggregate, because the glass powder has more tendency to fill the voids in concrete more effectively, where as in the case of coarse aggregate it doesn't happened. The maximum compressive strength of our concrete cubes was found at 20% of waste glass powder.The compressive strength of our cubes for 5% is 31.6, for 10% is found to be 43.99 Mpa, and for 15% it is 48.33 MPa, whereas for 20% it is found to be 54.32 Mpa. Hence it is evident that we obtain more compressive stress at 20% replacement. So, incorporating 20% of waste glass powder to partially replace the fine aggregate in concrete yields ideal results

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IV. CONCLUSION

[1] From our experimental investigations, the strength of traditional concrete cubes for 28 days were found to be 28.5 N/mm^2. As we further continued our investigation by adding waste glass powder to concrete by 5%,10%,

[2] 15% and 20%. After 28 days the compressive strengths are 31.6, 43.99, 48.3 and 47.56 respectively. When we compared the strengths of traditional concrete and concrete with partially replaced fine aggregate with glass powder exhibits more strengths. We have also found that the concrete cubes exhibit more strength when 20% of glass powder is added.

V. REFERENCES

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