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A REVIEW PAPER ON EFFECT OF GLASS AS INGREDIENT IN CONCRETE

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ABSTRACT

Concrete is the second material which widely use in the world. Now days, there are various researches and experiments continuously going on to finding out the suitable alternative different ingredients of concrete i.e. cement is replaced by fly ash, stone dust, glass powder, ground granulated blast-furnace slag etc. and sand is replaced by stone dust, fly ash, fondry sand, waste glass etc. Since recently the results of studies are shown that the waste glass can be effectively used in concrete as a pozzolana and as a aggregate. The waste glass when grounded to very fine powder shows some pozzolanic properties because of silica content. Therefore by replacing the cement by glass powder to some extent can contribute improvement in properties concrete in fresh as well as hardened state . So utilization of waste glass powder when used at optimum amounts can enhance the performance of concrete. Their use in concrete would substantially reduce carbon-dioxide emissions generated during the production process of ordinary Portland cement. Several environmental issues are closely related with the sustainable development of the cement and concrete industry. This paper present literature review on replacement of cement as well as sand by waste glass powder.

Keywords: Glass Powder, Replacement, Pozzolonic Properties, Silica Content, Portland Cement.

I. INTRODUCTION

The effect of global warming has impacted everyone on the planet and is a well-recognised concept. More energy is consumed at different levels to produce cement, which releases large amounts of carbon dioxide (CO2) and also responsible to the green house gases. Recycling of construction as well as industrial waste helps saving the limited landfill space and also cost incurred in disposal. The energy requirement for recycling of material is less than that of the production of virgin materials. It is possible to us this waste material in construction activity which has worldwide spread. The use of recycled waste glass in Portland cement and concrete has continuously attracting a lot of interest worldwide due to the increased disposal costs, environmental concerns and effectiveness. Major ingredient in waste glass is lime silica which causes the improvement in properties of concrete. It counts 80% in waste glass of containers, jars and bottles. The glass being mainly a silica-based material in amorphous form can be used in cement-based applications.The main concerns for the use of crushed glass is its silica content. Ground glass is considered a pozzolanic materials and as such can exhibit properties similar to other pozzolanic materials such as fly ash, metakaolin, slag and wheat husk ash.

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II. LITERATURE REVIEW

2.1 J.M. Khatib, Et. Al., (2012)

This paper investigates the performance of concrete containing glass powder as partial substitution of cement. Portland cement (PC) was partially replaced with 0-40% glass powder. Testing included ultrasonicpulse velocity, compressive strength and absorption. Specimens were cured in water at 20°C. The results indicate that the maximum strength of concrete occurs at around 10% glass powder. Beyond 10% glass powderthe strength of concrete reduces and is lower than that of the control.

2.2 Mayur B. Vanjare, Et. Al., (2012)

The paper deals with the ingredient of mixtures i.e. glass powder, fly ash, super plasticizer, cement by observing the importance in self compacting concrete. Self compacting concrete (SCC) reduces the total time of construction, costs, improves durability , makes concrete easier to achieve a better final product. Usually, SCC mixtures have high contents of fines in order to obtain the required rheological properties to achieve self compactability which contains high content of portland cement. The aim of this work is to study SCC of medium characteristic strength. The slump of concrete in which cement is replaced by glass powder was decrease with increase in percentage of glass powder which depends on the size and content of glass. The drying shrinkage of concrete with glass powder was higher and decreased with an increase in the fineness of the glass.

2.3 Dr. G.Vijayakumar Et. Al., (2013)

In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. In this study, finely powdered waste glasses were used as a partial replacement of cement in concrete and compared it with conventional concrete. This work examines the possibility of using glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete. From the results, it was found that glass powder can be used as cement replacement material upto particle size less than 75μm to prevent alkali silica reaction.

2.4 Mohit Mahajan Et. Al., (2014)

In this study, experimental investigation were made to find out the strength properties i.e. compressive strength and flexural strength of concrete by partial replacement of both cement & sand. In which cement is replaced by glass powder as a pozzolana and sand by pond ash in concrete. The cement & sand content were replaced by glass powder & pond ash respectively at the percentage of 5%, 10%, 15%, 20% and it is found that at 10% addition of glass powder and 10% addition of pond as a replacement of cement and sand respectively shows higher compressive as well as flexural strength.

2.5 B.Naga Niranjan Kumar Et. Al., (2016)

In this experimental investigation, influence of glass powder in high performance concrete (HPC) is observed. 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 reaction strengthens the transition zone which causes improved strength and impermeability of the concrete This is known as pozzolanic action (chemical mechanism).

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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. This effect reduces the thickness of transition zone and leads to densely packed stronger and less permeable concrete.

High performance concrete consist of all ingredients of conventional cement concrete (CCC) with chemical admixtures as super plasticizer and mineral admixtures are improving the utility of concrete. 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. The HPC strength parameter ranges from low of 40Mpa to 90Mpa. This is made possible by reducing W/C ratio and use WGP.

2.6 G. M. Sadiqul Islam Et. Al., (2016)

In this experimental investigation, chemical properties of both clear and colored glass were evaluated. After undergoing Xrayfluorescence (XRF) technique, it was found that there is minor difference in composition between color and clear glass. By keeping same water to binder ratio i.e. cement and glass, flow and compressive strength tests on mortar and concrete were carried out by adding 0–25% ground glass. With increase in glass addition, mortar flow was slightly increased while a minor effect on concrete workability was noted.

Packing and pozzolanic effects were examined and evaluated by keeping same mix proportion and 1% super plasticizing admixture dose (by weight of cement). Results were obtained with an increase in compressive strength of mortars with admixture. Also tests were conducted over mortar and concrete cube with 1 year curing shows recycled glass mortar and concrete has better and more strength than control mix. It was found that 20% replacement of cement with waste glass proved to be cost and the environment efficient.

III. METHODOLOGY

3.1 J.M. Khatib, Et. Al., (2012)

The control mix (C1) has a proportion (by weight) of 1 (cement): 2 (sand): 4 (coarse aggregate) and the water to cement ratio (W/C) is 0.5. In Mixes C2 to C5, the cement is partially replaced with 10%, 20%, 30% and 40% glass powder. For each mix, 15 cubes of 100mm in size were prepared. Before casting, the slump test was conducted to assess the workability. Specimens were cast in steel moulds and placed in a room at 20°C for 24 hours until demoulding. Thereafter, all specimens were placed in water at 20°C. The cubes were used to determine the compressive strength and ultrasonic pulse velocity (UPV). Testing for UPV was determined at 1 day, 7, 14, 21 and 28 days whereas the compressive strength was determined at 28 days only.

3.2 Mayur B. Vanjare, Et. Al., (2012)

In this experimental investigation, basic tests on cement i.e. fineness, normal consistency, Vicat initial setting time, Vicat final setting time, Specific gravity, Compressive strength at 7-days and 28-days. On fly ash, tests of colour and specific Gravity. Aggregate undergone the tests of the normal consistency, specific gravity, fineness modulus, surface texture, particle shape, crushing value, impact value. On glass powder (GP) physical properties were i.e. color and specific gravity.

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The mix proportion was done based on the method proposed by Nan. et.al.[7]. The mix designs were carried out for concrete grades M20, M25 and M30. This method was preferred as it has the advantage of considering the strength of the self compacting concrete (SCC) mix. The water to powder ratio was varied so as to obtain SCC mixes of various strengths. A total of 12 trial mixes were done by varying the proportions of water and powder within the calculated ranges. All the ingredients were first mixed in dry condition. Then 70% of the calculated amount of water was to be added to the dry mix and mixed thoroughly. Then, 30% of water was mixed with the super-plasticizer and included in the mix. Then, the mix was checked for self compact ability by flow test, Vfunnel test and L-Box test.

3.3 Dr. G.Vijayakumar Et. Al.,(2013)

In this experimental investigation, Ordinary Portland cement of 43 grade, the fine aggregate conforming to grading zone II, machine crushed blue granite stone angular in shape was used as coarse aggregate with 16 mm passing through 12.5 mm retained and other 25 mm passing through 20mm retained. In this experiment, glass powder with particle 75 µm used with specific gravity 2.6. concrete mix design prepared as per IS 10262-2009 with varying percentage of replacement of cement by waste glass powder which were 10%, 20%, 30% and 40%. The physical and chemical characteristic was studied and the chemical components of the glass powder used in the concrete were also determined by XRF. Slump test with 80-100mm on fresh concrete and compressive, tensile and flexural strength test were conducted on hardened concrete. Also alkalinity test was conducted on 28 days cured specimen.

3.4 Mohit Mahajan Et. Al.,(2014)

In this experimental investigation, cement used of OPC (43 Grade), name of Ultratech, sand satisfies Zone II, 20mm maximum size of aggregates, the fine glass powder with particle size is less than 90micron was used as a cement replacement, pond ash under the category of Zone II. Basic test on cement and specific gravity, water absorption and fineness modulus of fine, coarse aggregate, glass powder and pond ash is taken.

The mixes were designed as per IS 10262-2009. Varying percentage of replacement of Cement by glass powder from 5%, 10%, 15%, 20% and sand by pond ash from 5%, 10%, 15%, 20% were used to designed the mixes and found out their suitable. Cubes of 150mm and beam of 100mmX100mmX500mm were casted for compressive and flexural strength respectively with a slum of 25-50mm. One controlled and 16 Combinations were designed and three cubes and one beam are prepared for 7-days testing & 28-days testing respectively. Workability test taken on fresh concrete and compressive strength and flexural strength is taken on harden concrete on varying proportion and combination of pond ash and glass powder.

3.5 B. Naga Niranjan Kumar Et. Al., (2016)

In this research, glass used as natural sand replacement in high performance concrete (HPC) in form of crushed product with a size distribution between 3mm ~ 0.3mm. No materials passing 150 and 75 micron fractions. Slump loss was observed after addition of glass powder. Mix observed to be cohesive with reduction in bleeding. The moisture content of the glass as supplied was considered insignificant at 0.29%. The powder glass used in this research was neither a fine aggregate nor pozzolana. It was used as a filer or micro-aggregate.

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Cubes for compressive strength were casted with varying percentage of replacement of sand with glass powder with 0% to 20%. Tests of slump value and compaction factor of fresh concrete and compressive strength of hardened concrete were conducted.

3.6 G. M. Sadiqul Islam Et. Al., (2016)

In this experimental investigation, OPC cement used as per ASTM CEM I of strength class 42.5N with specific gravity 3.15. Specific gravity and fineness of clear and colored waste glass powders (prepared by ball mill) were 3.01 & 0.9%(#200 sieve) and 3.02 & 0.9% respectively as per ASTM standard mentioned above. Chemical composition of color and clear glass powder were examined using a XRF-1800 Sequential X-ray fluorescence spectrometer and found similar. The fine aggregate used for the study was prepared according to graded sand requirements ASTM C778(ASTM, 2013). For the flow test, sand grading was prepared as per EN 196-1 (EN, 2005).To evaluates the pozzolanic effect more clearly, mortar strength tests were carried out using superplasticizers. The water reducing admixture used in mortar work is based on polycarboxylate ether chemistry. For concrete work, the coarse aggregate size and amount was selected as per ASTM C33 (ASTM, 2016a).

Compressive strength test on mortar and concrete were carried out for targeted strength of M35 at age 28 days with slump of 100-125mm with varying percentage of replacement of cement by glass powder from 0% to 25%. Both mortar and concrete samples were tested for compressive strength at 7, 14, 28, 56, 90, 180 and 365 days.

IV. CONCLUSION

4.1 J.M. Khatib, Et. Al., (2012*)*

Experimental results shows that use of ground glass powder causes increase in slump with increased percentage in concrete mix. Use of ground glass powder causes reduction in use of cement and the associated energy demand and impact on air pollution and CO emission. Compressive strength exhibit higher value in 10% replacement of cement by glass powder. Also compressive strength shows decreasing trend for 20% replacement of cement by glass powder.

4.2 Mayur B. Vanjare, Et. Al., (2012)

Various properties of the glass powder integrated SCC mixes such as self compactability, compressive strength, and flexural strength were evaluated and compared with those of conventional SCC. From the experimental investigations, the following were conclusions derived a) The addition of glass powder in SCC mixes reduces the self compactability characteristics like filling ability, passing ability and segregation resistance. b) The flow value decreases by an average of 1.3%, 2.5% and 5.36%, the V-funnel time increased by an average of 6.21%, 15% and 22.54%, the L-box value observed to be decreased with an average variation of 1.5%, 3.2% and 5%, the compressive strength reduced by 6%, 15% and 20%, the flexural strength reduced by 2%, 3.7% and 6.75% for glass powder replacements of 5%, 10% and 15% respectively.

4.3 Dr. G.Vijayakumar Et. Al., (2013)

In this experimental investigation, it is found at 28 days that Conventional concrete shows at 28 days compressive strength as 31.1 N/mm2, split tensile strength of 2.27N/mm2 and flexural strength of 3.25N/mm. Replacement of glass powder in cement by 20%, 30% and 40% increases the compressive strength by 19.6%,

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25.3% and 33.7% respectively. Increases flexural strength by 83.07%, 99.07% and 100% respectively. Replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively

Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete. Very finely ground glass has been shown to be excellent filler and may have sufficient pozzolonic properties to serve as partial cement replacement, the effect of alkali-silica reaction (ASR) appear to be reduced with finer glass particles, with replacement level.

4.4 Mohit Mahajan Et. Al., (2014)

The 28-days compressive and flexural strength of modified concrete is increased of about 3.24% and 1.2% of controlled concrete at the 10% replacement of cement by glass powder and 10% replacement of sand by pond ash respectively. Also, Cost per cubic meter of modified concrete is reduced 3.7% of controlled concrete.

Workability of concrete is decreases with increase the percentage of pond ash because pond ash absorbs more quantity of water. Initial rate of gain of strength of concrete is low but at 28-days it meets with required strength in addition of glass powder and pond ash. Use of Pond ash in concrete can save the thermal industry disposal cost and produce a greener concrete for construction. Environmental effects from waste and residual amount of cement manufacturing can be reduced.

4.5 B. Naga Niranjan Kumar Et. Al., (2016)

From experimental investigations, it was 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. The maximum compressive strength of concrete cubes was found at 20% of waste glass powder. The compressive strength of cubes for 5%, 10%, 15% and 20% was 31.6MPa, 43.99 MPa, 48.33 MPa and 54.32 MPa respectively. Results shows that strength yields in case of fine aggregate replacement than coarse aggregate.

4.6 G. M. Sadiqul Islam Et. Al., (2016)

The optimum glass content is 20% considering mortar and concrete compressive strength at 90 days. In this age the compressive strength was found slightly higher (2%) than the control concrete specimen. In general, considering the similar performance with replaced material, glass addition can reduce cost of cement production up to 14%. In addition, production of every six ton glass powder concrete results in the reduction of each ton CO2 emission from cement production and save the environment significantly by reducing green-house gas and particulate production.

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