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A REVIEW REPORT ON COMPARATIVE STUDY OF WASTE GLASS POWDER AS POZZOLANIC MATERIAL IN CONCRETE

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Abstract - *The present paper reviews the literature of use of glass powder as a replacement of cement to assess the pozzolanic activity of fine glass powder in concrete and compare its performance with other pozzolanic materials like silica fume and fly ash. Nowadays glass is used in many forms in day-to-day life. It has limited life span and after use it is either stock piled or sent to landfills. Since glass is non-biodegradable, landfills do not provide an environment friendly solution. Hence there is strong need to utilize waste glasses. Many efforts have been made to use waste glass in concrete industry as a replacement of coarse aggregate, fine aggregate and cement. Its performance as a coarse aggregate replacement has been found to be non-satisfactory because of strength regression and expansion due to alkali-silica reaction.*

Key Words: CSH Gel, Waste Glass Powder (WGP), Compressive Strength, Flexural Strength, Split Tensile Strength, Capillary Absorption, Alkali-Silica Reaction (ASR)

1. INTRODUCTION

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues and a change over from the mass-waste, mass consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if does not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required. The term glass contains several chemical diversities including soda-lime silicate glass, alkali-silicate glass and boro-silicate glass. These types of glasses glass powder have been widely used in cement and aggregate mixture as pozzolana for civil works. The introduction of waste glass in cement will increase the alkali content in the cement. It also helps in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering for example - in cement, as pozzolana (supplementary cementitious materials) and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability. Therefore, it is considered ideal for recycling Recently, Glasses and its powder has been used as a construction material to decrease environmental problems. The coarse and fine glass aggregates could cause ASR (alkali-silica reaction) in concrete but the glass powder could suppress their ASR tendency. An effect similar to supplementary cementations materials (SCMs). Therefore glass is used as a replacement of supplementary cementitious materials.

2. LITERATURE REVIEW

Rakesh Sakale et. al. [1] studied the replacement of cement by waste glass powder in steps of 10%, 20%, 30% and 40% respectively by volume of cement and its effects on compressive strength, split tensile strength, workability and flexural strength are determined. It is found that the compressive, flexural and split tensile strengths of concrete increase initially as the replacement percentage of cement by glass powder increases and become maximum at about 20% and later decrease. The workability of concrete reduces monotonically as the replacement percentage of cement by glass powder increases. The replacement of cement up to about 20% by glass powder can be done without sacrificing the compressive strength.

Oluko et. al. [2] investigated the compressive strength of Compressed Stabilized Earth Block (CSEB) by partially replacing the cement (stabilizer) in the block with Waste Glass Powder (WGP) and it was found from the results that, as WGP is added to compressed stabilized earth block, its strength reduces. Although, the strength for CSEB without waste glass had the highest strength, CSEB with WGP indicated strengths higher than 3N/mm^2 recommended as minimum strength for CSEB at 28 days for the percentage of replacements used in this study, the highest of which was 60%. No optimum value was observed for WGP addition to the CSEB as replacement for cement, however, sufficient strengths good enough for handling at early stages of the CSEB whether at particle size of 150 µm or 75 µm were

achieved at 20% replacement of cement with WGP in CSEB. It could be concluded that the role of WGP in CSEB is more of filler than a binder.

Shuhua Liu et. al. [3] carried out a research to ascertain the inhibitory effect of waste glass powder (WGP) on Alkali-Silica Reaction (ASR) expansion induced by waste glass aggregate. These studies showed that there is ASR risk with an ASR expansion rate over 0.2% when the sand contains more than 30% glass aggregate. However, WGP can effectively control the ASR expansion and inhibit the expansion rate induced by the glass aggregate to be under 0.1%. The specific surface area of WGP and the ASR expansion have an anti-correlation, which leads the pozzolanic reaction more intense and faster and higher inhibitory effect on ASR expansion. The ASR expansion can be controlled in a safe range when WGP content is 10%, 20% and 30% with its specific surface area greater than 1137.40, 604.37 and 71.34m2/kg, respectively, or with low average particle size according to the calculation.

Raghavendra K. and Virendra Kumara K. N [4] investigated about the compressive strength, split tensile strength and water absorption of M40 grade of concrete mixes with 20% constant replacement of waste glass powder in cement and partial replacement of waste foundry sand in fine aggregate. From the test results, strength was achieved very less on 7th and 14th days but it increases on the 28th day. High strength values were found at 40% replacement level in strength parameters. The compressive strength and split tensile strength of concrete at 7, 14 and 28 days increases initially as the percentage of replacement of waste glass powder and waste foundry sand increases and becomes maximum at a proportion respectively around A40, A40.

Ana Mafalda Matos [5] aimed to evaluate the use of waste glass powder in powder type SCC. It could be concluded that waste glass powder can be used successfully in SCC further improving chloride penetration and water absorption by capillarity, maintaining strength levels. Although soda lime glass presents a high alkali content, use of ground waste glass as cement replacement in mortar, improved resistance to ASR. These results corroborate the pozzolanic nature of glass powder and its behaviour with time. Although glass powder is a little coarser than cement, it still brings advantages when incorporated in cement.

Jitendra B. Jangid and A.C. Saoji [6] studied the replacement of Glass Powder varying partially from 0 to 40%, at interval of 10% and tested for its Workability, Compressive Strength, Split Tensile Strength, Alkalinity test, Density Measurement, Water Absorption test, Volume of permeability test and Ultrasonic Pulse Velocity test for the age of 7, 28 and 56 days and was compared with those of conventional concrete. The overall test result showed that Waste Glass Powder could be utilized in concrete as a good substitute of cement. It was also found that Workability of concrete decreases as percentage of glass powder increases. Slump value of experiment's concrete ranges from 60 to 80 mm highest compressive strength was observed when Glass Liquid Powder (GLP) replacement is about 20%. Highest split tensile strength was observed when GLP replacement is about 20%.

Ashutosh Sharma and Ashutosh Sangamnerkar [7] showed that waste glass, if ground finer than 600µm shows a pozzolanic behaviour. It reacts with lime at early stage of hydration forming extra CSH gel there by forming denser cement matrix. Thus early consumption of alkalis by glass particles helps in the reduction of alkali-silica reaction hence enhancing the durability of concrete. Numbers of test were conducted to study the effect of 5%, 10% and 15% replacement of cement by glass powder on compressive strength and durability. The particle size effect was evaluated by using glass powder of size 600µm-100µm.The results showed that the maximum increase in strength of concrete occurred when 10% replacement was done with glass powder. Then found result

- Conventional concrete shows a 3 days compressive strength as 9 N/mm and 2.5% replacement of glass powder in cement increased the compressive strength by 37% in 3 days.
- 10% replacement of glass powder increment increased the compressive strength by 52.6% in 3 days.
- 15% replacement of glass powder in cement increased the compressive strength by 39.8% in 3 days.

M. Adaway and Y. Wang [8] aimed to determine the level of glass replacement resulting in optimal compressive strength. Three concrete samples were tested at 7 and 28 days for glass replacement proportions of 15, 20, 25, 30 and 40%. Compressive strength was found to increase up to a level of 30% at which point the strength developed was 9% and 6% higher than the control after 7 and 28 days respectively. This demonstrates that concrete containing up to 30% fine glass aggregate exhibits higher compressive strength development than traditional concrete. The optimum percentage replacement of sand with fine glass aggregate was determined to be 30%.Compressive strength was found to increase with the addition of waste glass to the mix up until the optimum level of replacement.

Veena V. Bhatt and N. Bhavanishankar Rao [9] studied the influence of replacement of cement by glass powder and found that there was an increase of 27% strength after replacing 20% glass powder, when w/c ratio was kept constant. Slump test was carried out and the slump was found to be 70 to 72mm even with 20% replacement. It was also found that with the increase in glass content, percentage of water absorption decrease. Considering the strength criteria, the replacement of cement by glass powder is feasible upto 20%.

Prema Kumar W P et. al. [10] concluded that cement in concrete is replaced by waste glass powder in steps of 5% from 0% to 40% by volume and its effects on compressive strength, split tensile strength, workability and weight density are determined. The results were found to be-

- The 7 days, 28 days and 60 days compressive strengths of concrete increase initially as the replacement percentage of cement with glass powder increases, and become maximum at about 20% and later decreases.
- The split tensile strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and becomes maximum at about 20% and later decrease.
- The slump and weight density of concrete decrease monotonically as the replacement percentage of cement with glass powder increases. The workability decreases when cement is replaced partially with glass powder.
- The study showed that there is a great potential for the utilization of glass powder in concrete as partial replacement of cement. About 30% of cement may be replaced with glass powder of size less than 100 µm without any sacrifice on the compressive strength.

Dr. G. Vijayakumar et. al. [11] examined 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; for the results obtained , it was found that glass powder size less than 75micro meter to prevent alkali silica reaction. After the study it was found that the conventional concrete tested at 28 days compressive strength as 31.1 N/mm2, split tensile strength of 2.27N/mm^2 and flexural strength of 3.25N/mm^2

1. Replacement of glass powder in cement by 20%, 30% and 40% increases the compressive strength by 19.6%, 25.3% and 33.7% respectively.
2. Replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively.

Replacement of glass powder in cement by 20%, 30% and 40% increases the flexural strength by 83.07%, 99.07% and 100% respectively.

3. CONCLUSIONS

Waste glass, if ground finer than 100µm shows a pozzolanic behaviour.

2. The smaller particle size of the glass powder has higher activity with lime resulting in higher compressive strength in the concrete mix.
3. Compared to fly ash concrete, finer glass powder concrete had slightly higher early strength as well as later strength.
4. Micro structural examination shows that glass powder produces a denser matrix which improves the durability property of concrete.
5. The coefficient of capillary absorption test also indicates that incorporation of finer glass powder improves durability.
6. Glass powder of size 150µm - 100µm exhibit initiation of alkali aggregate reaction.
7. 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.
8. The fine glass powder can be used as a replacement for expensive material.
9. It can be concluded that 20% of glass powder of size less than 100µm could be included as cement replacement in concrete without any unfavourable effect.

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