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Partial Replacement of Lime Sludge and Glass Powder by Fine Aggregate in Self Compacting Concrete (SCC)

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Abstract: In the course of present time, being a developing nation it is important that the waste that is rendered useless from industries to their convenient sites is properly dumped and even recycled if possible leading one step to sustainable development. With the increasing cost of living construction cost has raised its bar and is quite expensive with using conventional materials due to the unavailability of natural materials. In this study we try to resolve these issues by partially replacing lime sludge and glass powder by fine aggregate in self compacting concrete (SCC).
Keywords: lime sludge, glass powder, mortar, cement, self compacting concrete (SCC)

I. INTRODUCTION

A. Self-Compacting Concrete (SCC)

It is a flowing concrete mixture that is able to consolidate under its own weight.

SCC is suitable in difficult conditions and even in congested reinforcement sections due to its highly fluid nature. The issue of hearing-related damages on the worksite which is induced by the vibration of concrete can be minimized with the help of SCC. The other advantage of SCC is the reduction in the time which is required to place large sections.

"Modern" SCC was introduced in association with the drive pursued in Japan in the late 1980's towards the better quality of concrete because the primary factor responsible for poor performance of concrete structures is due to the lack of uniform and complete compaction.

B. Lime Sludge

Waste from sugar mills, paper mills, acetylene, $NaCO_3$, soda ash and fertilizers industries is a type of lime sludge. Environmental, health, land fill problems were generated by the lime sludge industries. As such the research scholars and industries utilize their industrial waste which helps in the prevention of environmental pollution because the emission of CO_2 will gradually decreased production of cement. Development of material and technologies which would help in the utilization of various wastes in an economical and effective manner is a strong need so as to develop the product. Nowadays many industrial waste materials and agricultural waste have been tried as pozzolan and most construction industries are seeking other materials which do possess cement like properties. Efforts are being made by the researchers to partially replace the waste materials in place of cement thus find a material which is more suitable for construction. Research is being conducted to improve the strength of concrete by the addition of various admixtures to the concrete.

C. Glass Powder

Industrial waste should be dismantled as it is very harmful for environment as well as to the humans. Being an inorganic product glass can be made into a rigid substance without crystallization just by the cooling. Recycling process of glass requires conditioners which are expensive so it is stored as an alternative because it is cheaper to store than to recycle. There has been a considerable decrease in the recent years in the recycled glass demand especially for mixed glass.

A part of cement has been replaces by the use of industrial mineral wastes like silica fumes, fly ash and blast furnace slag as pozzolana and is being used by the concrete industry. The utilization of this material brings about economy in concrete manufacturing in addition to this pozzolanic reaction gives strength to the concrete. According to a worldwide estimate several million tons of waste glasses are generated, out of which the percentage of this waste which is recycled is only 20% and the rest that is about 80% of the waste is thrown here and there or land filled. This is harmful both to the environment as well as to the animals.

Medicinal bottles, waste containers, bulbs, window glasses, electronic equipments, windscreen, tube lights, liquor bottles etc. are the main source of waste glass.

II. LITERATURE REVIEW

A. Research And Development Of

1) *Self-Compacting Concrete:* S Girish (2010)[1] This paper presents the results of an experimental investigation carried out to find out the influence of paste and powder on self-compacting concrete mixtures. Tests have been conducted for 63 mixes with constant water content varying from 175 l/m3 to 210 l/m3 with three different paste contents. Among the different water contents and w/c ratios studied, for each series of experiments, w/c ratio and more importantly, water is kept constant. Slump flow, V funnel and J-ring tests were carried out to examine the performance of SCC. The results indicate that the flow properties of SCC increase with an increase in the paste volume.

Hajime Okamura and Masahiro Ouchi (2003)[2] addressed the two major issues faced by the international community in using SCC, namely the absence of a proper mix design method and jovial testing method. They proposed a mix design method for SCC based on paste and mortar studies for super plasticizer compatibility followed by trail mixes. However, it was emphasized
that the need to test the final product for passing ability, filling ability, and flow ability and segregation resistance was more relevant.

Pratibha Aggarwal (2008)[3] presented a procedure for the design of Self compacting concrete mixes based on an experimental investigation. At the water/powder ratio of 1.180 to 1.215, slump flow test, V-funnel test and L-box test results were found to be satisfactory, i.e. passing ability, filling ability and segregation resistance are well within the limits. SCC could be developed without using VMA as was done in this study. Further, compressive strength during the curing process for 7, 28 and 90 days was also determined. By using the OPC 43 grade, normal strength of 25 MPa to 33 MPa at 28-days was obtained, keeping the cement content around 350 kg/m^3 to 414 kg/m^3.

Felekoglu (2005)[4] has done research on effect of w/c ratio on the fresh and hardened properties of SCC. According to the author adjustment of w/c ratio and super plasticizer dosage is one of the key properties in proportioning of SCC mixtures. In this research, fine mixtures with different combinations of w/c ratio and super plasticizer dosage levels were investigated. The results of this research show the optimum w/c ratio for producing SCC is in the range of 0.84-1.07 by volume. The ratio above and below this range may cause blocking or segregation of the mixture.

Sri Ravindra rajah (2003)[5] et al made an attempt to increase the stability of fresh concrete (cohesiveness) using increased amount of fine materials in the mixes. They reported about the development of self-compacting concrete with reduced segregation potential. The systematic experimental approach showed that partial replacement of coarse and fine aggregate with finer materials could produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. The results of bleeding test and strength development with age were highlighted by them. The results showed that fly ash could be used successfully in producing self-compacting high-strength concrete with reduced segregation potential. It was also reported that fly ash in self-compacting concrete helps in improving the strength beyond 28 days.

Nan Su (2001)[6] proposed a new mix design method for self-compacting concrete (SCC). First, the amount of aggregates required is determined, and the paste of binders is then filled into the voids of aggregates to ensure that the concrete thus obtained has flow ability, self-compacting ability and other desired SCC properties. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer (SP) to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC, and the results indicate that the proposed method could produce successfully SCC of high quality.

B. Glass Powder

M. Iqbal Malik (2013)[7] conducted a study of concrete involving use of waste glass as partial replacement of fine aggregates. In this study fine aggregates were replaced by waste glass powder as 10%, 20%, 30% and 40% by weight for M25 mix. The concrete specimens were tested for compressive strength, splitting tensile strength, durability (water absorption) and density at 28 days 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 fine aggregates up to 30% by weight for particle size of range 0-1.18mm. 20% replacement of fine aggregates by waste glass showed 15% increase in compressive strength at 7 days and 25% increase in compressive strength at 28 days. Fine aggregates can be replaced by waste glass up to 30% by weight showing 9.8% increase in compressive strength at 28 days.

Asokan Pappu (2007)[8] In this paper the author has discussed and reported the status on generation and utilization of both non-hazardous and hazardous solid wastes in India, their recycling potentials and environmental implications in detail. To safeguard the environment, efforts are being made for recycling different wastes and utilize them in value added applications. During different industrial, mining, agricultural and domestic activities, India produces annually about 960 MT of solid wastes as by-products, which pose major environmental and ecological problems besides occupying a large area of land for their storage/disposal. Looking to such huge quantity of wastes as minerals or resources, there is a tremendous scope for setting up secondary industries for recycling and using such solid wastes in construction materials. Though many lab processes, products and technologies have been developed based on agro-industrial wastes, non-acceptability of the alternative and newly developed products among users due to lack of awareness and confidence is to be removed. However, environment friendly, energy-efficient and cost effective alternative materials developed from solid wastes will show good market potential to cater to people's needs in rural and urban areas. To effectively utilize these wastes as a raw material, filler, binder and additive in developing alternative building materials, detailed physical-chemical, engineering, thermal, mineralogical and morphological properties of these wastes are to be evaluated and accurate data made available.

C. Mannava Anusha (2016)[9]

Glass powder (GP) used in concrete making leads to greener environment. In shops, damaged glass sheets & sheet glass cuttings are go to waste, which are not recycled at present and usually delivered to landfills for disposal. Using GP in concrete is an interesting possibility for economy on waste disposal sites and conservation of environment. This project examines the possibility of using GP as fine aggregate replacement in concrete. Natural sand was partially replaced (0%-30%) with GP in concrete. Tensile strength, Compressive strength (cubes and cylinders) and Flexural strength up to 28 days of age were compared with those of high performance concrete made with natural sand.

Ahmad Shayan (2004)[10] The data presented in this paper show that there is great potential for the utilization of waste glass in concrete in several forms, including fine aggregate, coarse aggregate and GLP. It is considered that the latter 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 SF, fly ash and cement. The use of GLP in concrete would prevent expansive ASR in the presence of susceptible aggregate. Release of alkali from GLP did not appear to be sufficient to cause deleterious ASR expansion. Strength gain of GLP-bearing mortar and concrete is satisfactory. Micro structural examination has also shown that GLP would produce a dense matrix and improve the durability properties of concrete incorporating it. It has been concluded that 30% GLP could be incorporated as cement or aggregate replacement in concrete without any long-term detrimental effects. Up to 50% of both fine and coarse aggregates could also be replace in concrete of 32-MPa strength grade with acceptable strength development properties.

L. M. Fedrico (2009)[11] The success, or lack thereof, in utilizing waste glass in concrete can be attributed to observed ASR damage. Although the collective understanding of ASR has improved dramatically through extensive research, it is still not possible to predict damage based on either the composition of the reactants or the reaction product. This prevents a fine level of control over the reaction. As researchers moved from waste glass as an aggregate to waste glass as a replacement for OPC, pozzolanic properties were observed at particle sizes below 300 lm. These pozzolanic properties, however, are relatively weak, especially at larger particle sizes, and require enhancement. One possible form of enhancement used for natural pozzolans was chemical treatment.

D. Lime Sludge

Vaishali Sahu (2014)[12] study the use of fly ash and lime sludge as partial replacement of cement in mortar .The fly ash and ordinary Portland cement was sieved and portion retained on 90 micron was used. The sludge was oven dried for about 16-18 hours at 60°C and the lumps were broken gently using the pestle. It was sieved through 150 micron sieve and portion retained on 90 micron sieve was used. Two sets of mortar mix (type I and type II) were prepared, each set with two different types of binders. Type I mortar is cement less mortar, where 100% cement is replaced with a combination of fly ash and lime sludge with 0 & 1% of gypsum. Type II mortar consists of 20% cement content, fly ash and lime sludge. All the sets of mortar were prepared with 1:3 binder-to-sand ratio. They concluded that the addition of gypsum showed positive effect on strength due to accelerated pozzolanic reaction. For type I mortar(mortar with 0% cement content), the highest strength of 6 N/mm2 was observed ,for binder with 1% gypsum, after 28 days curing period. By increasing the content of Lime sludge and subsequent decrease of Fly ash content under mortar with 20% cement showed increased strength of binder IV as compared to binder III. The maximum strength achieved after 28 days curing for type II mortar was 14 N/mm2.

K. Archaneswar Kumar (2016)[13] This research work presents an investigation of compressive strength of cement mortar by adding Lime sludge and Fly ash as partial replacement of cement in various percentages. In this work cement has been replaced by four proportions of Fly ash & Lime sludge. The four proportions are (100 % cement +0 % Fly ash + 0% Lime sludge), (75 % cement + 12.5 % Fly ash + 12. 5% Lime sludge), (50 % cement + 25 % Fly ash + 25% Lime sludge) &(25 % cement + 37.5 % Fly ash + 37.5 % Lime sludge). It has been observed from the 7, 14 and 28 days tests of compressive strength of cement mortar that compressive strength decreases as the percentage of Lime sludge increases in the mix when compared with controlled concrete. Results indicated that the decrease in compressive strength with the increase in Lime sludge replacement.

Ahmad et al (2013)[14] carried out the study of concrete involving use of waste paper sludge ash as partial replacement of cement and concluded that 5% replacement of cement by waste paper sludge ash showed 10% increase in compressive strength at 7 days and 15% increase in compressive strength at 28 days. Cement in concrete can be replaced by waste paper sludge ash up to 5% by weight showing 15% increase in compressive strength at 28 days. With increase in waste paper sludge ash content, percentage water absorption increases. With increase in waste paper sludge ash content, average weight decreases by 4.58% for mixture with 20% waste paper sludge ash content thus making waste paper sludge ash concrete light weight. Workability of concrete mix decreases with increase in waste paper sludge ash content. Splitting tensile strength decreases with increase in waste paper sludge ash content and is more than reference concrete at 5% replacement According to Adepegba the annual cement requirement in Nigeria is about 8.2 million tones and only 4.6 million tones of Portland cement are produced locally. The balance of 3.6 million ton or more is imported. If alternative cheap cement can be produced locally, the demand for Portland cement will reduce. The search for suitable local materials to manufacture pozzolana cement was therefore intensified. Most of the increase in cement demand could be met by the use of supplementary cementing materials, in order to reduce the green gas emission (Bentur, 2002).

III. PHYSICAL AND CHEMICAL PROPERTIES OF MATERIAL USED

Table 1: CHEMICAL PROPERTIES OF LIME SLUDGE

OXIDES	Wt. %
Al_2SO_3	39.1
Sio_2	30.2
Fe_2O_3	25.8
K_2O	1.4
TiO_2	1.4
MgO	0.6
SO_3	0.6
P_2O_5	0.3
MnO	0.3
CaO	0.2

Table 2: PHYSICAL PROPERTIES OF LIME SLUDGE

Physical State	Thin to thick liquid
Colour	White to light brown
Odour	Neutral
Melting Point ($CaCO_3$)	Decomposes at T> 450°C
Relative Density	1.15- 1.40gr/cm^3
Solubility of ($CaCO_3$) in water	0.0166gr/l at 20°C
pH (dissolved)	7-9 in a saturated $CaCO_3$ solution at 25°C
Reaction with acid	Soluble with release of CO_2

Table 3: PHYSICAL OF GLASS POWDER

COMPOSITION	WEIGHT (%)	COMPOSITION	WEIGHT(%)
Na_2O	3.51	CeO_2	.27
S	0.054	Al_2O_3	1.52
Cr_2O_3	0.009	CaO	1.32
ZnO	0.52	Fe_2O_3	0.42
MoO_3	0.035	SrO	7.7
$Sb2O_3$	0.49	CdO	0.016
La_2O_2	0.052	HfO_2	0.39
MgO	0.57	SiO_2	54.1
K_2O	6.1	TiO_2	0.44
MnO	0.012	NiO	0.011
Ga_2O_3	0.007	ZrO_2	2
PdO	0.37	In_2O_3	0.18
BaO	9.4	PbO	10.9

Table 4: PHYSICAL CHARACTERISTICS OF GLASS POWDER

DESCRIPTION	SPECIFIC GRAVITY
Glass powder	2.6
Cement (OPC)	3.15
Fine Aggregate	2.62
Coarse aggregate	2.7
Water	1

Table 5: CHEMICAL PROPERTIES OF GLASS POWDER

pH	10.25
Color	Grayish White

IV. CONCLUSIONS

After performing the experimental investigation we might infer the following results:-

Partial replacement of lime sludge and glass powder in proportionate amounts may lead to decrease or an increase in the compressive strength of the material. We can also anticipate that mixing of lime sludge or glass powder could increase or even decrease the workability. Even in case of flexural strength we might find some insights about the flexural strength. An increase in the split tensile strength can also be expected if we mix both the components in an appropriate amount.

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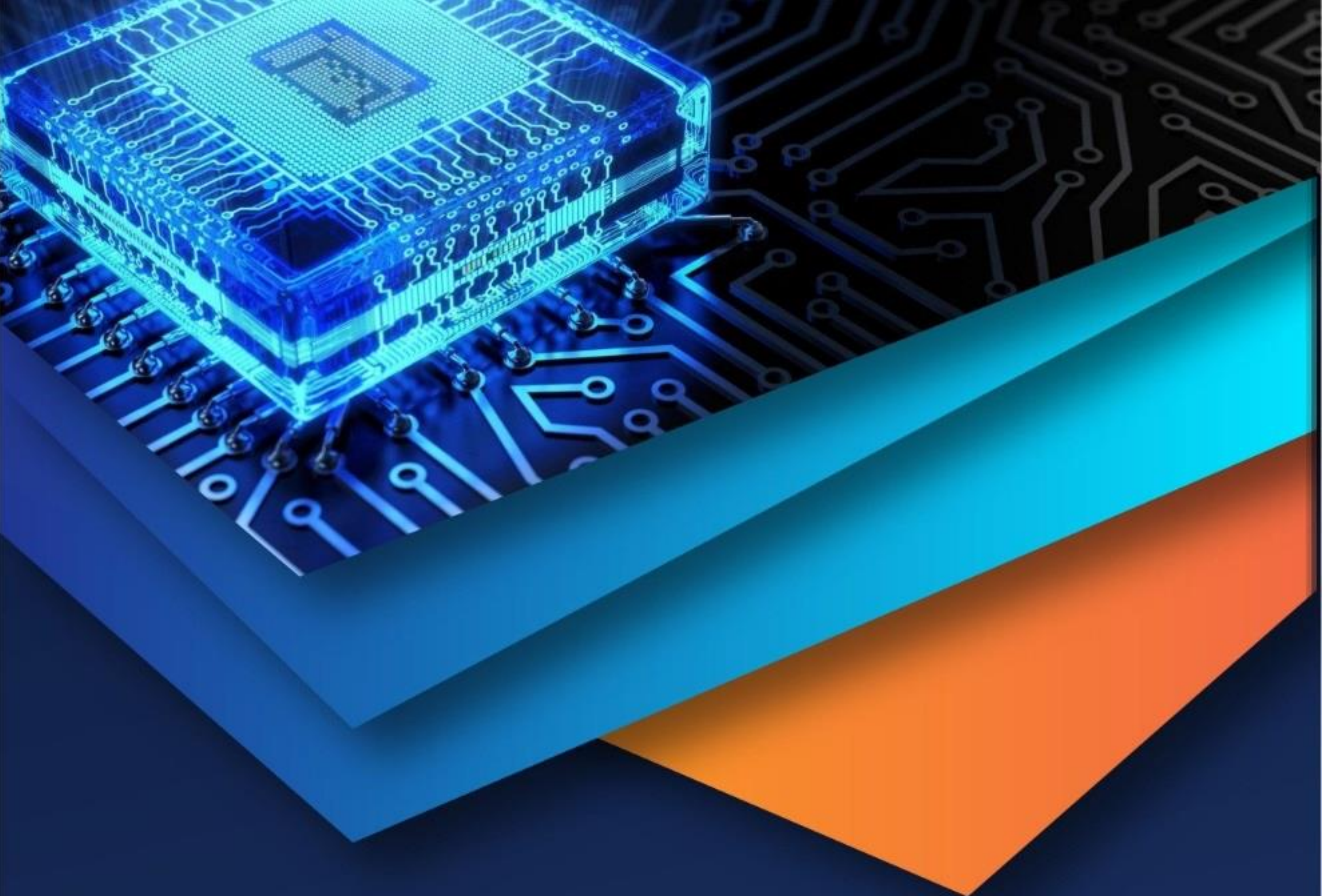

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