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ADDITION OF CRUSH WASTE GLASS PARTICLES AS PARTIAL REPLACEMENT OF FINE AGGREGATES IN CONCRETE

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Abstract — *In order to make concrete industry sustainable, the use of waste materials in place of scarce natural resources is one of the best approaches. An enormous quantity of waste glass is generated all around the world. In India, 0.7% of total urban waste generated comprises of glass. In this study, fine aggregates were partially replaced by waste glass in different ratios (10%, 20%, 30% and 40%) by weight for two different concrete grades (M-25 and M-30). The fresh concrete was tested for workability and concrete specimens were subjected to various non-destructive& destructive tests after 28 days of curing, to assess the effect of this replacement on properties of concrete.*

From the results, it was found that the slump of concrete containing waste glass as fine aggregate replacement decreased with increasing waste glass content with some loss of workability. The destructive and non- destructive tests revealed an increase in concrete strength with 20% waste glass replacement compared to conventional concrete. The mixes with waste glass replacement showed a more consistent structure under ultrasonic pulse velocity assessment. The study indicated that Waste glass can effectively be used as fine aggregate replacement (up to 20%) without loss of strength.

Keywords*- concrete; waste glass; fine aggregate; workability; properties of concrete;*

I. INTRODUCTION

Numerous waste materials are generated from manufacturing processes, service industries and municipal solid wastes. The increasing awareness about the environment has tremendously contributed to the concerns related to disposal of the generated wastes. Solid waste management is one of the major environmental concerns in the world. With the scarcity of space for land filling and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. The use of waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. One such waste is glass, which could be used in various applications.

Glass is an ideal material for recycling. The use of recycled glass saves lot of energy and the increasing awareness of glass recycling speeds up focus on the use of waste glass with different forms in various fields. One of its significant contributions could be in the construction field where the waste glass can be reused for concrete production. Several studies have shown that waste glass that is crushed and screened is a strong, safe and economical alternative to sand used in concrete. . Using waste glass in the concrete construction sector is advantageous, as the production cost of concrete will go down. The amount of waste glass has gradually increased over the years due to an ever-growing use of glass products. Most of the waste glass has been dumped into landfill sites. The land filling by waste glass is undesirable because of its fragility. When waste glasses are reused in making concrete products, the production cost of concrete will go down. Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand. Estimated cost for housing is more and some construction materials like natural sand are also becoming rare. Waste glass is used as aggregates for concrete. The objective of this study is to examine the influence of waste glass when used as direct replacement for natural fine aggregate in concrete, and thereby to assess the fundamental engineering properties of waste glass concrete.

II. MATERIALS

The ingredients of concrete consist of Cement, fine aggregate, coarse aggregates& water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. The ingredients are described in details with their properties are as follows.

Cement

Portland pozzolona cement (PPC) of Birla (43 grade) Shakti brand (ISI mark) obtained from a single batch throughout the investigation was used. Manufacturer's certificate regarding properties of that batch was obtained.

Fine Aggregate

Aggregate most of which passes 4.75 mm IS sieve. Fine aggregate / sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of grain or particle, but is distinct from clays which contain organic minerals. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds.

Coarse Aggregates

Coarse aggregate used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

Waste Glass

Waste glass was collected from Ganjre Glass House, MIDC, Amravati, consisting of waste window glass (Soda Lime glass). It was pulverized in Los Angeles abrasion apparatus and then sieved through 4.75 mm IS sieve. The specific gravity of waste glass was found to be 2.41. Chemical composition of glass, as supplied by the manufacturer, is presented in Table 1.

Table 1.Chemical Composition of Glass

Oxides	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O
Percentage	70.4	1.9	1.2	10.3	14.0	0.4

III. EXPERIMENTAL INVESTIGATION

Mix Proportion

The concrete mix design was carried out by using IS 10262 [10]. The grade of concrete used was M-25 and M-30with water to cement ratio of 0.45. The mixture proportions used in laboratory for experimentation are shown in Table 2.

Table 2.Mix proportion by weight

Mix	W/C	Amount of cement Kg/m3	Fine aggregate Kg/m3	Coarse aggregate Kg/m3
M 25	0.45	379	889	972
M30	0.45	420	871	952

Tests on Fresh Concrete

Slump Test: The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959 [11].

Tests on hardened concrete

Non-destructive tests and destructive tests are performed on concrete specimens. From each concrete mixture, cubes of size 150mm, cylinders of size 150mm x 300mm and beams of size 100mm x 100mm x 500mm were cast for determining compressive strength, splitting tensile strength and flexural strength of concrete respectively. The concrete specimens were cured under normal conditions as per IS 516-1959 [12] and were tested at 28days for determining compressive strength as per IS 516-1959 [13], splitting tensile strength as per IS 5816-1999 [14] and flexural strength as per IS 516-1959 [15]. Rebound hammer and ultrasonic pulse velocity tests were performed as per IS 13311 (Part 1) : 1992.

IV. RESULTS & DISSCUSION

Effect of waste glass on slump value

The result of the slump tests are illustrated in Table 1 & Fig. 1.It can be seen that the slump values decrease as the waste glass content increases in both the mixes. This is due to sharper and irregular geometric forms of the glass particles compared to sand particles, which may give rise to high friction and much less fluidity. Following table shows the values of slump for M - 25 and M - 30 grade of concrete.

Table 3. Slump cone test results

Waste Glass %	Slump (mm)	
	M – 25	M - 25
0 %	135	184
10 %	94	160
20 %	70	110
30 %	39	84
40 %	25	65

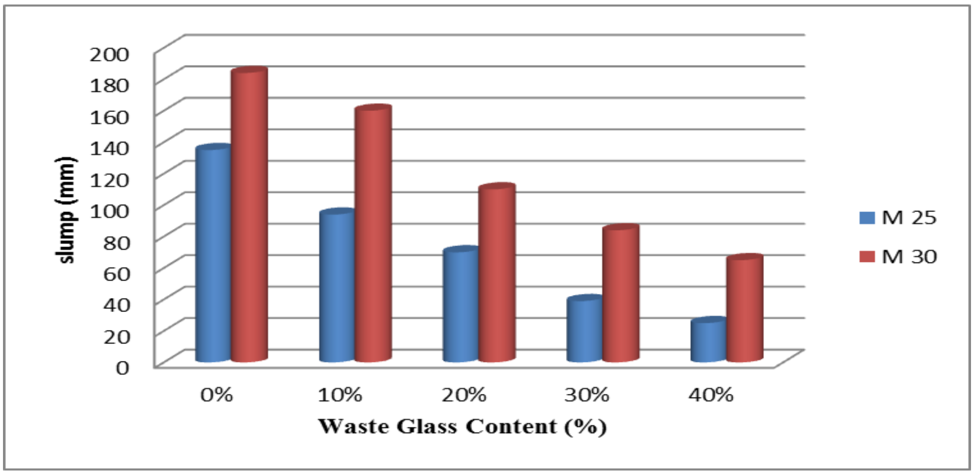

Figure 1. Variation of slump with waste glass content

Effect of waste glass on compressive strength

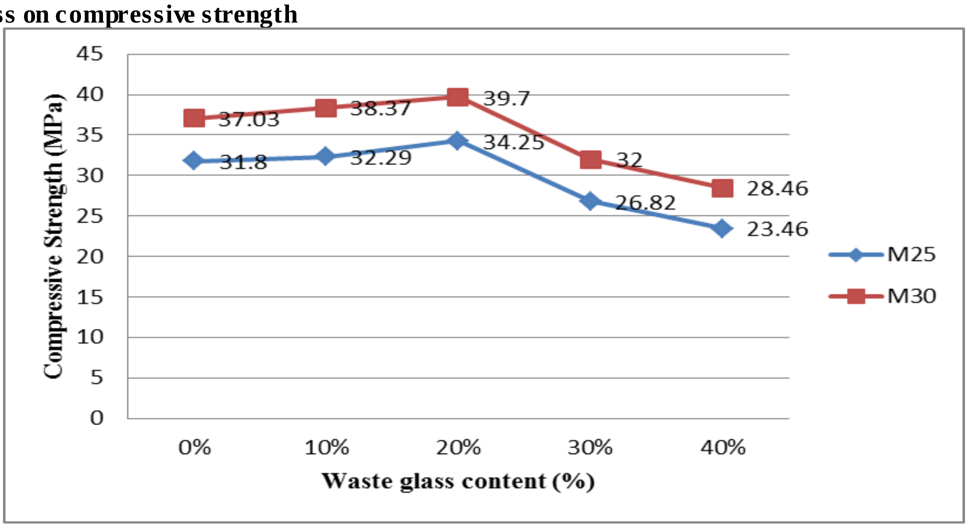

Figure 2. Compressive strength of cubes at 28 days

The compressive strength of waste glass concrete mix of M-25 and M-30 grade concrete at 28 days is shown in Fig. 2. Trend illustrates increment in compressive strength initially. The highest compressive strength is obtained at 20% replacement of waste glass fine aggregates, which is an increase in compressive strength of M-25 and M-30 grade of concrete by 6.73% and 6.92% respectively as compared to conventional mix. However further increase in percentage of waste glass results in decreased compressive strength.

Effect of waste glass on split tensile strength

The split strength for M-25 and M-30 mix is representing in the Fig. 3. The result shows the tensile strength of 40% replacement of fine aggregate with waste glass was much higher than that of conventional mix. The split tensile strength was 2.62 Mpa and 3.09 Mpa for M-25 and M-30 grade of concrete, which is an increase up to 35.88% and 37.22%

respectively. At 20% replacement of waste glass as fine aggregate, there was hardly any change as compared to conventional concrete.

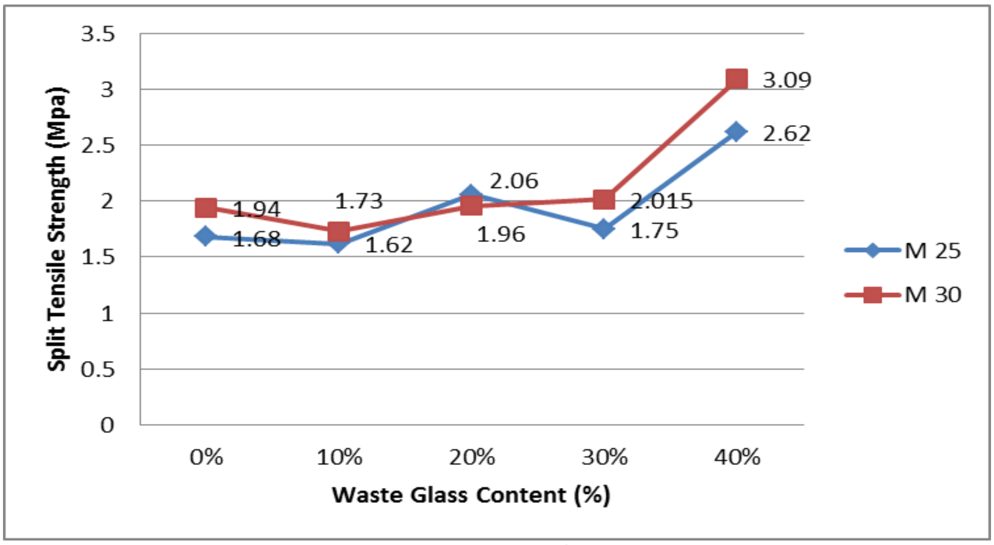

Figure 3. Split tensile strength of cylinders at 28 days

Effect of waste glass on flexural strength

The flexural strength of the waste glass concrete of M-25 and M-30 grade are shown in Fig.4. It was observed that at 10% replacement by waste glass, the flexural strength of waste glass concrete actually decreased. But 20% replacement of waste glass as fine aggregate showed remarkable increase in flexural strength from 4.66 Mpa to 8.73 Mpa and 5.05 Mpa to 8.50 Mpa for M-25 and M-30 grade of concrete, which was 46.62% and 40.59% greater than conventional concrete, respectively.

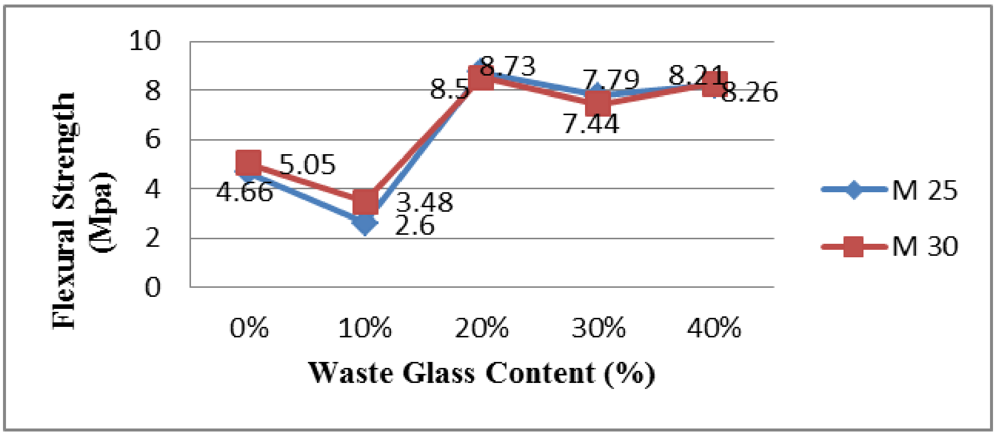

Figure 4.Flexuralstrength of cylinders at 28 days

Effect of waste glass on rebound number

The rebound number of the waste glass concrete of M-25 and M-30 grade for the specimens with various percentages of waste glass fine aggregate are shown in Fig. 5. From fig it could be observed that all concrete mixes were of good quality. When 10% fine aggregates were replaced by waste glass particles, it resulted in a slightly increased rebound number. At 20% replacement, the increase in rebound number was sharp, as compared to conventional concrete mix, which may indicate a more compact or consistent micro structure for waste glass concrete. However, further increase in the percentage of waste glass aggregate resulted in decrease in rebound number as compared to 20% waste glass fine aggregate concrete.

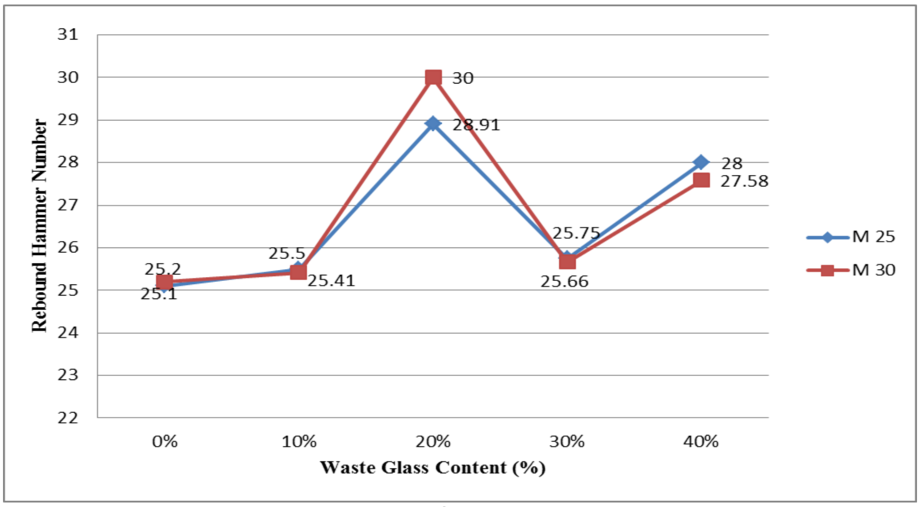

Figure 5. Rebound number for M25 and M30 grade concrete

Effect of waste glass on ultrasonic pulse velocity

Fig.6 shows the result of ultrasonic pulse velocity tests performed on the specimens with different percentages of waste glass. From fig it would be seen that all the concrete mixes with different percentages of glass resulted in good quality of concrete. The ultrasonic pulse velocity was higher by 4.64% and 2.97% respectively as compared to conventional concrete for M-25 and M-30 grades, for 20% replacement. However, further increase in percentage of waste glass resulted in decreased UV Pulse velocity.

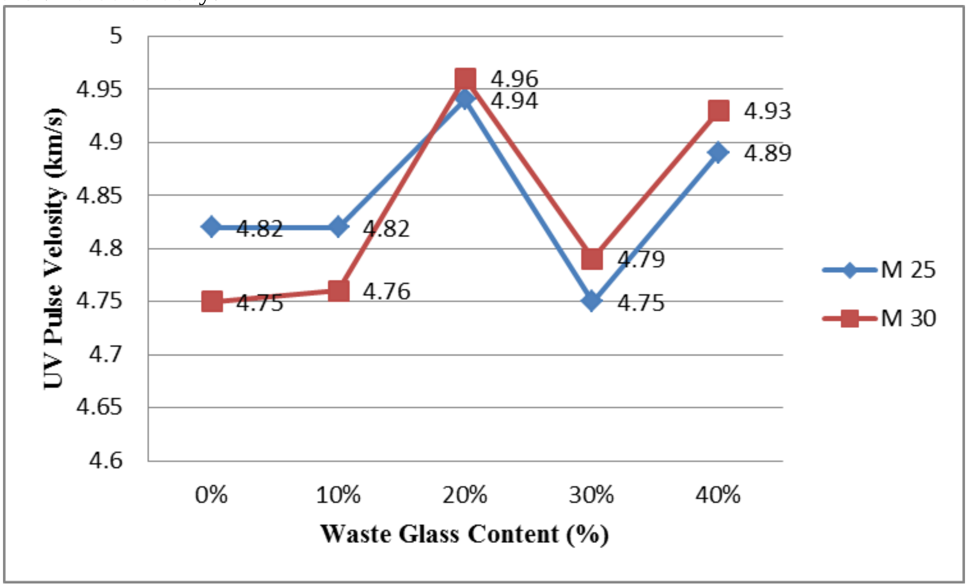

Figure 6. Ultrasonic pulse velocity for M25 and M30

V. CONCLUSION

- The slump of concrete containing waste glass as fine aggregate replacement decreased with increase in waste glass content, but in spite of this decline in slump, the mixes remained workable.
- Compressive strength of the concrete with partial replacement of fine aggregates by crushed waste glass increased. Best results were obtained for 20% replacement (@ 7% hike). Greater than 20% replacement resulted in unacceptable results.
- The split tensile strength results were erratic but showed maximum increase at 40% replacement of fine aggregates.
- The flexural tensile strength inexplicably fell at 10% replacement but kept on rising thereafter. Best results were obtained at 20% replacement of fine aggregates with crushed glass particles.
- The rebound number results reveal good quality concrete for all cases. At 20% replacement of fine aggregates, the results were the best.

- The ultrasonic pulse velocity test for mixes containing different ratios of waste glass as fine aggregate replacement shows good quality concrete for all percentages of replacements.
- The optimum replacement level of waste glass as fine aggregate is 20% effectively.
- Use of waste glass in concrete can prove to be economical.
- Use of waste glass in concrete will eradicate the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.

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