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Durability Performance of Concrete (M-45) Fine Aggregate Partially Replaced with Crushed Waste Glass

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Abstract: ***Durability of concrete is as the ability to resist weathering action, chemical attack, and abrasion while giving the desired engineering properties. Concrete require different degrees of durability depending on the exposure environmental conditions. The retrogression of concrete structures is due to effect of attrition of reinforcing bars which is occurred due to the chloride incursion.so it is necessary to study the concrete durability nature before making its usage in present construction. The present research is focused on studying the effect of using sustainable material in concrete preparation. To know the effective usage of crushed waste glass in concrete and significance in Durability properties for different replacements was studied .The present research work was done using materials like cement, Fine aggregate, coarse aggregate, waste crushed glass, super plasticizer in order to know that at which combination of mix there will be optimum effect on properties of concrete. In this research Waste crushed glass was used as fractions of 10%,20%,30% and 40% by weight of crushed glass used. The durability tests to test resistance against acid environment chloride penetration and abrasion resistance tests are performed. The optimum value of acid resistance was observed when fine aggregate was replaced with 30% of fine aggregate with crushed waste glass, less abrasion loss at 30% replacement and chloride penetration also effective at 30% replacement.***

Keywords: ***Fine aggregate, Crushed glass, Acid attack, Abrasion resistance***

I. INTRODUCTION

Concrete is the mostly used construction material playing an important role in the development of present civilization and is considered as the second most consumed substance after water on earth. The construction industry is the second largest industry of the country after agriculture. The rate of development of construction industry is increasing in high range all over the world especially in the developing countries due to rapid economic and industrial developments. Automatically increasing concrete demand, in turn increase demand for the raw materials for preparation of Concrete. As per the statistics Worldwide, about three tons of concrete is being used annually per person.

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The utilization of crushed waste glass in fine aggregate has pulled in a ton of intrigue worldwide due to the depletion of natural resources and increased disposal costs. When Fine aggregate is replaced with the waste crushed glass, it has been observed that the crack width continues expanding after 25% replacement [2].

The waste crushed glass when used in concrete is said to be the best replacement for river sand. By utilizing this material, natural sand in concrete can be reduced. The ground glass when used as a partial replacement for both the cement and fine aggregate, SCC with satisfactory fresh properties can be produced by incorporating up to104 kg/m ground glass, about10% cement and 10% sand, without the need for VMA [3].It reduces the total cost of Concrete with 10–20% glass replacing the cement exhibiting a high resistance to chloride ion penetration [4].

The usage of river sand in concrete leads to depletion of natural resources, lowers the water table, hydraulic structures will settle down and erosion of the river bed.

If fine aggregate is replaced by waste glass by specific percentage and in specific size range, it reduces the usage of fine aggregate and thereby reducing the effects of river dredging which in turn makes manufacturing industry sustainable.

In my present investigation the glass utilized was carefully made into tiny pieces suitable for fine aggregate replacement. The composition of the glass constitutes silica (SiO_2), calcium oxide (CaO), and sodium oxide (Na_2O) .

The main contribution of the glass powder in concrete is increasing the density of concrete there by reduction in the pore system and generating high durability properties. The utilization of glass powder in concrete increases the mechanical properties (compressive strength, splitting tensile strength, flexural strength, and Elastic Modulus).

These mechanical characteristics will improve with time due to the pozzolanic activity of the glass powder [5].

The following durability tests were done on M60 grade concrete fine aggregate partially replaced with Waste crushed glass which is found to be more effective in durability considerations of concrete. The optimum values of all durability values tested were observed to be at 30% replacement.

II. MATERIALS

A. Cement: In my research work OPC of 53 has been used. One of the significant job of cement is it has an extraordinary capacity to hold the constituents used for Preparing concrete together and make as one unit.

Figure 1 cement

B. Fine aggregate: Particles of size less than 4.75mm are known as fine aggregates. The sand taken was belongs to Zone II confirming IS 2386 Part-II with a specific gravity 2.6 for mix of concrete.

Figure 2 Fine Aggregate

C. Waste Crushed Glass: The fine aggregate in the Nominal mix was replaced with waste crushed glass which is collected and crushed in to fine aggregate size. Waste crushed glass with 10%, 20%, 30% and 40% and of fineness modulus of Waste crushed glass 2.64 was used. The glass is hard material and has been blended in with fine aggregate in the said percentages.

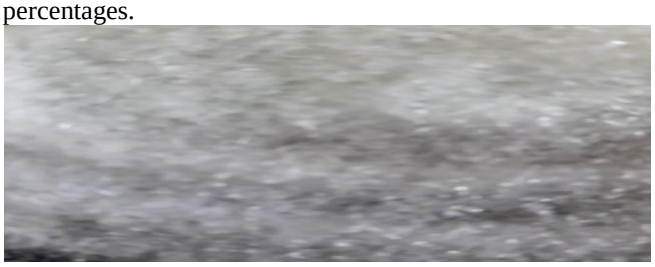


Figure 3 Waste crushed glass

D. Coarse aggregate: The coarse aggregate incorporate sand and controls the size and shape that impact necessity of cement and furthermore diminish the effect of shrinkage. The coarse aggregate utilized in my work is of size 20 mm and specific gravity 2.7.

Figure 4 Coarse Aggregate

E. Water: Water is a vital component in concrete. By adding water in the mix, it reacts with cement chemically and attains binding property to cement paste. Potable - water has been utilized for the mix.

F. Super plasticizer: Super plasticizer SP430 was utilized for reducing water content and segregation. By reducing water content strength and workability can be increased.

Figure 5 Super plasticizer

Table 1 Mixes with crushed waste glass percentage.

Sl. No	MIX	Cement Quantity/ Kg/	Fine Aggregate kg/m3	Coarse Aggregate Kg/m3	w/c ratio	Super plasticizer kg/m3	Waste Crushed glass kg/m^3
1	Nominal	400	702.468	1190.21	0.4	6	0
2	MC10	400	632.22	1190.21	0.4	6	70.2
3	MC20	400	561.97	1190.21	0.4	6	140.5
4	MC30	400	491.73	1190.21	0.4	6	210.74
5	MC40	400	421.48	1190.21	0.4	6	280.98

III. Tests conducted:

A. Acid attack test

B. Abrasion resistance of concrete

C. Rapid Chloride Penetration Test

Table2: Tests and Samples

S.NO	TEST NAME	SPECIMENSIZE (mm)
1	Acid attack	Cube of 150X150X150
2	Abrasion Resistance	300mm X100mm
3	RCPT	Cylinder50X100mm

A. Acid Attack Test: After immersion of cube specimens of size 150mm*150mm*150mm for curing. They are allowed to dry without any moisture content for 1day before the Acid attack tests to be conducted. After the drying period of specimen, initial weights are to be taken. Cubes must be placed in prepared HCl and H_2SO4 solution for a period of 56 days in acidic solutions. In this test (5%) Hydrochloric acid and H_2SO_4were used. The PH was supervised periodically and has kept stable throughout the test process. The weight loss has been calculated after 56daysof immersion in acid solution. The Loss of weight were calculated as per the IS 456(PART-1 And PART-2)1967guidelines.The values were tabulated. The formula to be used for calculation of weight loss and strength loss are given below. %Loss in weight of cubes=$\{(W_I-W_F)/W_I\}X100$

Where W_I=Initial weight of the specimen in kg

W_F=Final weight of the specimen in kg

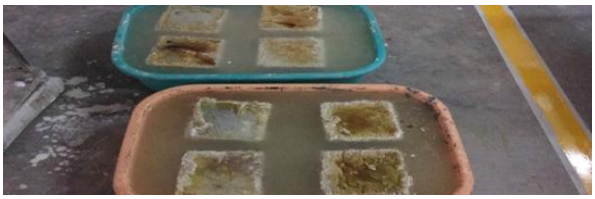
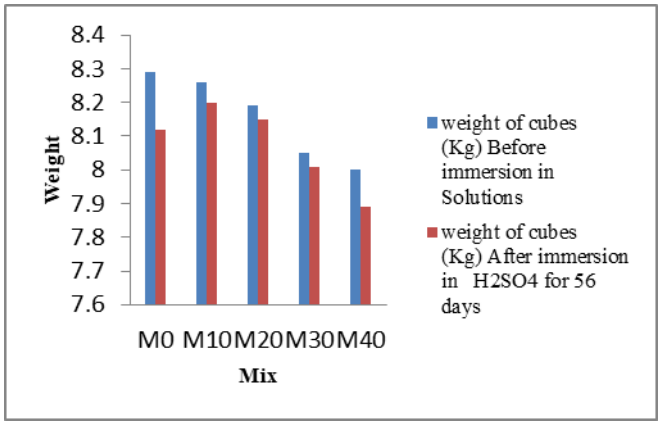


Figure 6 Specimens in HCL &H_2SO_4 Solution

Table 3: Weight of cube specimens in in H_2SO_4 curing

Sr. No	MIX	weight of cubes (KG)		
		Before immersion in Solutions	After immersion in H_2SO_4 for 56 days	Average% loss in weight- H_2SO_4
1	M0	8.29	8.12	1.5
2	M10	8.26	8.20	0.73
3	M20	8.19	8.15	0.50
4	M30	8.05	8.01	0.50
5	M40	8.00	7.89	1.37



Graph1: Weight of cubes before and after immersion in HCL & H_2SO^4 solution

A graph was drawn between weights before and after immersion in acid solutions graph was showing at 30% replacement the weight loss was very less. Overall comparing with conventional concrete the weight loss is less to the concrete fine aggregate replaced with Waste crushed glass.

B. Rapid Chloride Penetration Test:

RCPT is a quick process for determination of permeability nature of concrete specimen. Test was conducted by preferring the cylindrical specimens of size 50mm height and 100mm dia. First the RCPT diffusion cell has been filled with 2 different prepared NaCL and NaOH solutions of desired quantities. Silica gel is used as glue after insertion of concrete specimen between the two diffusion cells. The role of silica gel is to control the solution flow out of the cells during the current passage i.e., it is applied in order to stop the flow of fluids which has been poured. NaCLof 2.4M is filled in one chamber and NaOH of 0.3M is taken in another chamber. The migration of chloride ion was allowed through centrally inserted vacuum saturated RCPT specimen under DC voltage of 60 volts. The concrete resistance to chloride ion penetration has no bias because the value will be defined by ASTM-C1202 Code provisions. After six hour exposure period, If the interpretation is larger the coulomb it indicates more permeable the concrete specimen to the electricity. Low coulomb indicates the concrete is less permeable to the electric current. The average current flow through the cell is calculated by the formula

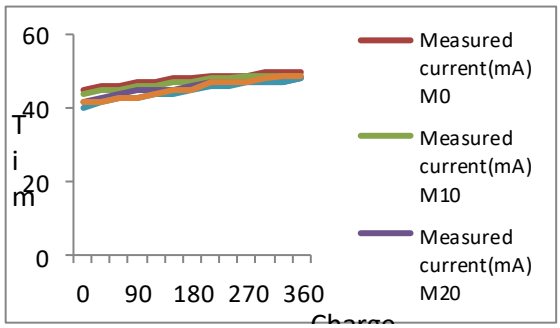
The average current(Q) = 900 (I0+2I30+ 2I60+2I90+2I120+----------+2I300+2I330+I360)

Q= current through cells
I0=Current in Amperes after application of voltage.
It=Current in amperes at T minutes after voltage is applied

Figure 7 RCPT Apparatus

Table 4 : Results of Rapid chloride permeability Test

Sr. No	Time (min)	Measured current(mA)				
		M0	M10	M20	M30	M40
1)	0	45	44	42	40	42
2)	30	46	45	43	42	42
3)	60	46	45	44	43	43
4)	90	47	46	45	43	43
5)	120	47	46	45	44	44
6)	150	48	47	45	44	45
7)	180	48	47	46	45	45
8)	210	49	48	47	46	47
9)	240	49	48	47	46	47
10)	270	49	49	47	47	47
11)	300	50	49	47	47	48
12)	330	50	49	47	47	49
13)	360	50	49	48	48	49
Cumulative charge(in coulombs)		1032.7	1013.	981.7	927.6	939.2



A graph was drawn between Charge passed and Time. It was showing 30% replacement was effective as charge passing is very less. Overall comparing with conventional concrete the charge passing is less in concrete with Waste crushed glass replacement.

C. Abrasion resistance of concrete:

The capability of concrete to resist the friction is called as abrasion resistance of concrete. In order to make the original structure look as it seemed as new one i.e., without any structural ruptures or damages this test was conducted .The compressive strength is closely related to abrasion resistance of concrete. The abrasion resistance of materials and durability of structure can be evaluated by different test processes such as under water method, sand blasting, revolving disk machine, dressing wheel machine etc. The procedure indicates the abrasion action of particles in water (silt, sand, gravel, and other hard materials). This test was performed according to ASTM C1138-1997. The machine which have been used for conductance of test is abrasion testing machine with rotating device, container and agitation paddle ,70 grade 100 chrome steel grinding balls, weighing basket, seating block, measuring scale seating block to test the specimen of size 300mm diameter and 100mm height.

A. Test to find the average depth of abrasion:

First weight of specimen is taken when it is exposed to air and water and also measured the dimensions of the specimen when it is going to be placed in the abrasion machine on the seating block. The specimen should be placed in such a way that its surface must expose to the drill shaft .Ascend the agitation paddle with drill press on to the specimen surface. The mass of the abrasion charge must be calculated.

After placing the specimen in the machine it should be run for 12 hours and after time period it will be lifted out with the help of wiring tied around the specimen After removal of the specimen, first thing we have to do is to rub off the tear off material which is adhered to the surface of the specimen and then the respective weights must be taken in presence of air and water and weighed values are to be noted. The test will be continued for 72 hours time period and for every 12 hours completion the readings must be taken as per the rules of code mentioned. While the test is going to be conducted we have look carefully whether the shaft drill is rotating and see the level of water and ensure if any leakages are observed before the start of running of machine.

Calculations:

Volume of specimen at any time 't'

$$\mathbf{V_t = (W_{air} - W_{water})/ G_w}$$

Where V_t =Volume of specimen at desired time in m3

W_{air} = Specimen weight in air kg

W_{water}=Specimen weight in water kg

G_w=Unit weight of water in kg/m3

The volume of concrete lost at the end of any time is

V Lt=Vi-Vt

S.NO	Charge passed (coulombs)	Chloride ion penetration
1)	Greater than 4000	High penetration
2)	2000-4000	Moderate penetration
3)	1000-2000	Low penetration
4)	100-1000	Very low penetration
5)	Less than 100	Negligible penetration

Where V Lt=volume of material lost at the end of the test in m3

Vi=Volume of specimen before testing in m^3

V_t=Volume of specimen at the end of the test in m^3

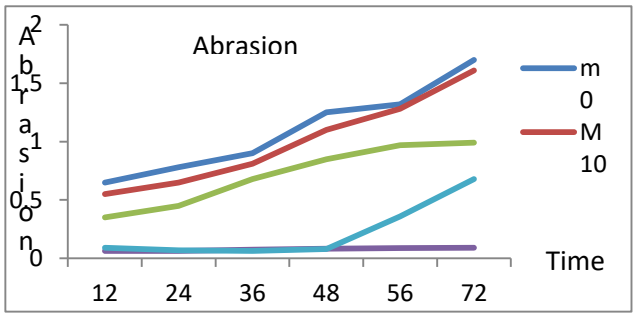
For calculation of average depth of the wear=ADA1=V lt/Na

Where A=Area of the top of specimen in m^2

Figure 8 Abrasion testing

Table 4 :Average depth of Abrasion

Sr. No	Time (hrs.)	Average depth of abrasion(mm)				
		M0	M10	M20	M30	M40
1	12	0.65	0.55	0.35	0.062	0.090
2	24	0.78	0.65	0.45	0.064	0.070
3	36	0.90	0.81	0.68	0.074	0.064
4	48	1.25	1.10	0.85	0.082	0.080
5	56	1.32	1.28	0.97	0.088	0.36
6	72	1.70	1.61	0.99	0.092	0.68



A graph was drawn between Average depths of abrasion to Time. The graph was showing at 30% replacement the abrasion depth is less i.e. loss is less.

Overall comparing with conventional concrete the abrasion loss is less to the concrete when fine aggregate is substituted by waste crushed glass is less.

III. RESULT & DISCUSSIONS:

- At 30% replacement the weight loss was very less. Overall comparing with conventional concrete the weight loss is less to the concrete fine aggregate replaced with Waste crushed glass.
- It was showing 30% replacement was effective as charge passing is very less. Overall comparing with conventional concrete the charge passing is less in concrete with Waste crushed glass replacement.
- At 30% replacement the abrasion depth is less i.e. loss is less. Overall comparing with conventional concrete the abrasion loss is less to the concrete when fine aggregate is substituted by waste crushed glass is less.

IV. CONCLUSIONS

- The utilization of waste crushed glass as a partial substitute of fine aggregate hikes the durability.
- The utilization of Waste crushed glass depicted many benefits such as high strength, toughness, as a good binder of all substances, and acts a resistor to chemicals temperature and exposure conditions with environment friendly nature.
- The loss in % of weight was very low M30 mix i.e., for fine aggregate replaced with 30%waste Crushed glass was noticed with less weight loss.
- The % crushed glass from durability point of view was found that 30% replacement is the optimum.

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