International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

Experimental study on durability properties of concrete with fine aggregate partially replaced by waste crushed glass

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Abstract - Concrete is one of the largest consumed materials all over the world. River sand is one of the ingredients used in Concrete preparation. As increased construction practices leads to high demand in consumption of ingredients of concrete. Sand is one of the significant raw materials. It's getting depleted due to excessive digging. This affects the nearby localities as well the stability of hydraulic structures nearby. The Environmental effects and depletion of natural materials dragging the researchers 'attention towards new sustainable materials in the construction field. At the same time Dumping of solid wastes in to precious open lands leads to the invention of alternative sustainable materials in the production of concrete. In this research work, waste crushed glass was used in different proportions in concrete preparation as partial replacement for fine aggregate. Glass was used in 10%, 20%, 30% and 40% of sand weight for different grades of concrete like M30 and M45. Mechanical and durability properties for all three different grades were evaluated and compared with the conventional concrete. This research is aimed to carryout tests to find out Strength properties in compression, tensile and flexural on M30 and M45 grades of concrete after curing of 7, 14, 28 and 90 days. The evaluated values were compared with conventional concrete of same day's strength. The strength tests were carried out for all the grades mentioned. A concrete structure is said to be durable, if it performs with its intended level of functionality and serviceability for an expected life. Durable concrete must have the ability to withstand weathering conditions to which it is exposed and not to deteriorate. Concrete will deteriorate due to adverse mechanical, physical, or chemical causes. Durability tests such as Acid attack test were carried on Concrete with glass. The current research work describes the optimum percentage of fine aggregate replacement with glass in concrete. In the research concrete of M30 and M45 Grades prepared for testing mechanical as well as Durability properties with glass in 10%, 20%, 30% and 40%by weight of river sand. For all two grades tested from the results it was found that 30% replacement is effective.

Key Words: Concrete Workability, Test for Compression, Strength in tension, Flexural Strength, Durability tests, Acid attack test, Rapid chloride penetration test.

1. INTRODUCTION

The present research work is to do experimental study on generating concrete with Waste crushed glass. Fine aggregate total was partly supplanted with unused crumpled glass in preparation of specimens. The normal sand was swapped by waste cut-glass in percentages of 0, 10, 20, 30 and 40. In this study, M30 and M45 grades of concrete and concrete specimens are prepared. To study on the prepared M30 and M45 grade concrete as per the mix design workability test, Strengths in compression, split tensile and flexure. Compression test on 150 mm cube, Tension test with of 150x300 mm cylinders Flexure test on prisms of size 500mm Length and cross-section 100x100mm. By using the industrial wastes in concrete, we can save the natural resources as well as to overcome the problem of dumping waste materials on land.

1.1 Cement

In the research grade OPC53 cement approving to IS 269 updated in 2015 was used. Adhesive (Cement) is of the important ingredients in concrete mix which will bind all the materials in concrete. Numerous experiments were conducted to find out the specific gravity, Initial and final setting time, Normal Consistency and compressive strength in laboratory and the values were evaluated.

Table -1: Format of cement integrated

Ingredient	%
SiO_2	19.7
Al_2O_3	5.67
Fe_2O_3	4.68
CaO	61.81
MgO	0.84
SO_3	2.48
Iron Oxide	1.21

Table -2: Modulus of fineness for fine aggregate

Sl. No	Sieve size mm	Retained mass on sieve (gms)	Cumulative mass retained on Sieve (gms)	Cumulative % mass retained on sieve	% of mass Passing through Sieve
1	20	0	0	0	100
2	10	0	0	0	100
3	4.75	8	8	0. 8	99.2
4	2.36	39	47	4.7	95.3
5	1.18	210	257	25.7	74.3
6	600	340	597	59.7	40.3
7	300	311	908	90.8	9.2
8	150	92	1000	100	0
Total		1000		257.7	

Table -3: Modulus of coarse aggregate

Sl.No.	Sieve Size mm	Mass retained (gms)	Cumulative Mass retained (gms)	Cumulative % mass retained	% passing
1	80	0	0	0	100
2	40	0	0	0	100
3	20	200	200	4	96
4	10	4400	4600	92	8
5	4.75	400	5000	100	0
6	2.36	0	0	0	0
7	1.18	0	0	0	0
8	600µm	0	0	0	0
9	300 µm	0	0	0	0
10	150 µm	0	0	0	0

Table -4: Crushed glass properties

Sl. No.	Property	Value
1	Specific gravity	2.6
2	Fineness modulus	2.64

2. MIX DESIGN

The range of ingredients for M30 and M45 mix concrete as per IS 456- 2000, IS 10262-2009 & ACI 211 Methods are listed below.

. **Table -5:** Mix Design of M30

Sl .No	Mix	Cement	F.A	W.CG	C.A	SP	W /C ratio
		kg/m³					
1	MCG0	351	736.16	0	1195	0	0.45
2	MCG10	351	662.5	73.6	1139	5.2	0.45
3	MCG20	351	588.96	147.2	1139	5.2	0.45
4	MCG30	351	515.36	220.8	1139	5.2	0.45

Table -6: Mix Design of M45

Sl. No	Mix	Cement	F.A	C.A	W/C ratio	SP	WCG
		kg/m³					
1	MCGO	400	702.468	1190.21	0.4	6	0
2	MCG10	400	632.22	1190.21	0.4	6	70.2
3	MCG20	400	561.97	1190.21	0.4	6	140.5
4	MCG45	400	491.73	1190.21	0.4	6	210.74

3. METHODOLOGY

Workability is the capacity of doing a work with concrete is defined as the ease with which we can mix, convey, place, compressed and finish the concrete. Assessment for workability for the mixes was examined for getting slump values. In this study Slump cone test was adopted for getting the slump values for the proportioned mix. Slump cone is the one apparatus with which we can find workability of the mix both in field and laboratory. The slump cone consists of a conical shape of lower diameter 200mm and upper diameter 100 mm and of height 300 mm made with a 6mm thick sheet along with the tamping rod.

Fig -1: Workability Test

3.1. COMPRESSION TEST

Compressive strength of the cube tested in 2000 kN compression testing machine as per the guide lines given in IS 516 1959.The machine giving the failure load has a least count of 10 kN. The cube was positioned in the machine and the load on the cube is applied at a rate of 14N/mm² /minute till the failure of specimen and the failure or ultimate load is noted. The strength of cube in compression will be calculated dividing the ultimate load with cross sectional area of the cube. This test is conducted on specimens for 7, 14, 28 and 90 days curing, as shown in fig-1.

Fig -2: Specimen test in compression

3.2. TENSILE TEST

The test was led in 2000 kN capacity machine which is used for compressive strength testing as shown in fig-2. The cylinders of diameter150 mm and length 300 mm are tested. Experiment was preceded conferring to guide lines given in IS: 5816: 1999. At the specimen failure the load is noted. At the crack formation, the splitting tensile strength is found. Main aim intended for this test is to know load at which specimen crack at the boundaries. Strength in Tension is found at extreme stresses the material can resist by straining prior to cracking. The test is conducted by placing specimen between upper and lower platters of machine. The formula to be used in evaluating the yielding values in tension is expressed as stated below in the current effort; this trial has been conducted on cylindrical specimens after 7, 14 28 and 90 days curing.

Fig -3: Cylindrical Test for specimen

3.3. FLEXURAL STRENGTH

The resisting power of specimen to stand against bending is termed as strength in flexure also called as modulus of rupture or bending strength of material. The examination is carried after 7, 14 and 28 and 90 days of curing of beams. The marks must be given on the beam specimen with definite distance as per Indian standards the load should act at middle third of the specimen and need to be correctly positioned on the roller supports. Load was applied slowly without any shocks. The extreme load on which the beam failed was taken as flexural load resisted by the specimen. The beamshave been cast as per the guide lines the Indian codes mentioned in IS 516 and was updated in 1959

Fig -4: Flexure Test for specimen

4. RESULTS AND DISCUSSION

Samples of 180 cubes, 180 cylinders and 180 prisms were used for experimental work to get the mechanical properties. Total of 90 cylinders with 100 mm diameter and 50 mm thick for RCPT test and 15 specimens of size 300 mm diameter and 100 mm thick for Abrasion test. The fine aggregate was substituted with crumpled glass in percentages 0, 10, 20, 30and 40. For each mix with replacement specimens were prepared, experiments done on7, 14, 28 days age. Without WCG percentage called as Nominal mix. For test samples the intended strength of concrete was adopted as M30 and M45 grades. The designed mixes were arrived based on code IS10262-2009 and ACI-211.

Table-7: Cube specimens number prepared

S.NO	Mix Proposition	Cube specimens size150mm			
		7 Dyas	14 Days	28 Days	90 Days
1	MCG0	3	3	3	3
2	MCG10	3	3	3	3
3	MCG20	3	3	3	3
4	MCG30	3	3	3	3
5	MCG45	3	3	3	3

Table-8: Cylindrical specimens number prepared

S.NO	Mix Proposition	No. of Cube specimens (150x150x150mm)			
		7 Dyas	14 Days	28 Days	90 Days
1	MCG0	3	3	3	3
2	MCG10	3	3	3	3
3	MCG20	3	3	3	3
4	MCG30	3	3	3	3
5	MCG45	3	3	3	3

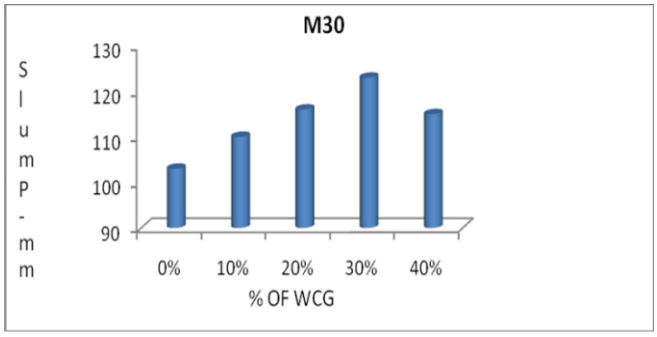

Chart-1: M30 Workability

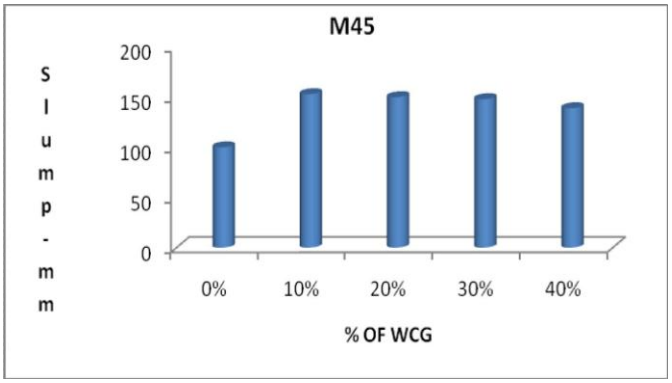

Chart-2: M45 Workability

Table-9: Compressive for M30 and M45

S.NO	Mix	Compressive strength (MPa)			
		7 Days	14 Days	28 Days	90 Days
1	MCG30	33.12	41.65	46.76	48.5
2	MCG45	31.04	39.91	44.35	46

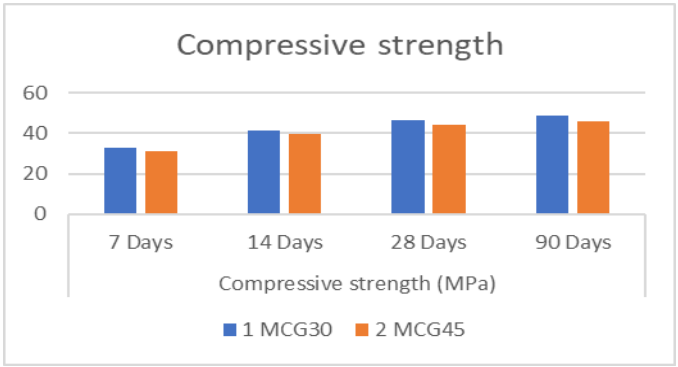

Chart-3: Compressive M30 and M45

Sr.No	MIX	Strength in Tension MPa			
		7 Days	14 Days	28 Days	90 Days
1	MCG30	3.25	3.85	4.5	5.3
2	MCG45	2.82	2.62	3.7	4.5

Table-10: Tensile Strength for M30 and M45

Sr.No	Mix Designation	Strength In Flexure (MPa)			
		7 Days	14 Days	28 Days	90 Days
1	MCG30	4.15	5.57	7.65	8.45
2	MCG45	3.85	4.87	6.92	7.45

Table-11: Flexure strength for M30 and M45

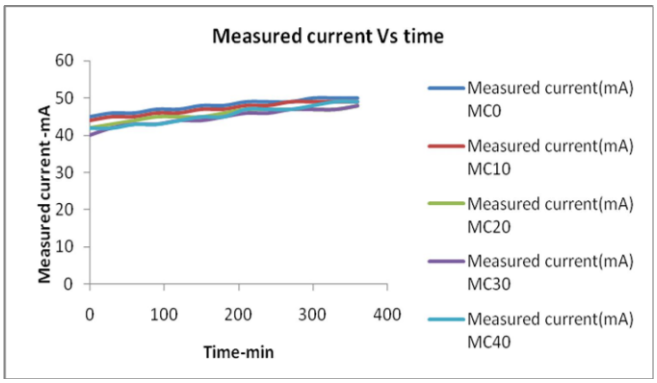

Chart-4: RCPT Values for M45

5. CONCLUSIONS

By using more fraction of Unused Cut-glass in concrete the fresh properties ofconcrete increases by addition of super plasticizer, indicated by increase in in slump values due to smooth & no absorbing surface of glass for all grades of concrete i.e. M30 and M45.

1. For M30 grade concrete Compressive strength at 90 days increment was found as 15.5% compared with Normal Concrete.
2. For M45 grade concrete Compressive strength at 90 days increment was found as 14.2% compared with Normal Concrete.
3. For M30 grade concrete Split tensile strength at 90 days increment was found as15.5% compared with Normal Concrete.
4. For M45 grade concrete Split tensile strength at 90 days increment was found as42.5% compared with Normal Concrete.
5. For M30 grade concrete Flexural strength at 90 days increment was found as 32.5% compared With Normal Concrete.
6. For M45 grade concrete Flexural strength at 90 days increment was found as 25.5% compared With Normal Concrete.
7. From Rapid chloride permeability test it was found that for 30% replacement the measured current was less for all grades of concrete implies 30% replacement is more effective.

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