

Mechanical Properties of Concrete Incorporating Recycled Aggregate and Glass Aggregate

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ABSTRACT: In the past few years many research and modification has been done to produce concrete which has the desired characteristics. Concrete is one of the most common materials used in the construction industry. The current area of research in the concrete is introducing Recycled aggregate and glass aggregate in the ordinary concrete. Generation of waste glass and demolished material as by-product of construction site and industries causes environmental problems because of its improper disposal. Thus, its usage in building material, construction and in other fields is essential for reduction of environmental problems. This research is carried out to produce an eco - friendly concrete. This project demonstrates the use of waste glass and demolished material as a partial replacement by coarse aggregate in concrete of two groups. In which first group concrete contains natural coarse aggregate as a coarse aggregate and second group concrete contains recycled aggregate and glass aggregate as a coarse aggregate. Ingredients for group 1 concrete are cement, course aggregate, natural coarse aggregate and same for group 2 concrete are cement, course aggregate, recycled aggregate and glass aggregate. An experimental investigation is carried out on a concrete containing recycled aggregate and glass aggregate in the range of 0%, 5% 10%, 15%, and 20% by weight for M-30 grade concrete for both groups. Material was produced, tested and compared with conventional concrete in terms of strength. These tests were carried out on standard cube, cylinder and beam for 7 and 28 days to determine the mechanical properties of concrete. The aim of this research is to know the behaviour and mechanical properties of concrete after addition of industrial waste in different proportion by tests like compressive strength, split tensile and flexural strength. The research is a resource for exploring the potential use of as recycled aggregate and glass aggregate an alternative to virgin raw materials.

KEYWORDS: Recycled aggregate and Glass aggregate, Ordinary Portland cement (OPC), Low cost, Eco-friendly, Compressive strength, Split tensile strength, Flexural Strength.

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I. INTRODUCTION

Recent developments in science and technologies have made the manufacture of various new building materials possible through the use of industrial waste products such as glass aggregate and demolished material. Among the products demolished material from reconstruction site has been given considerable attention due to its significant quantities on global basis. India is a developing country so there is a large production of waste material like glass and demolished material on regular basis. To have sustainable economic development with respect to earth's eco-system, it is necessary to reduce the consumption of natural resource like stones and rocks aggregate. So more effort shall have to be taken to reduce the disposal problem of the waste material and to minimize the consumption of natural aggregate. Glass is one of the oldest man-made materials. It is produced in many forms, including packaging or container glass, flat glass, bulb glass, and cathode ray tube glass, all of which have a limited life in the forms in which they are produced. Hence, glass need to be reused/recycled in order to avoid environmental problems that can be created, if they will be stockpiled or sent to landfills. Theoretically, glass is 100% recyclable material. Waste glass creates serious environmental problems, mainly due to the inconsistency of waste glass streams. With increasing environmental pressure to reduce solid waste and to recycle as much as possible, the concrete industry has adopted a number of methods to achieve this goal. At present a large portion of potentially useful construction and demolition waste is disposed of in landfill sites, creating environmental problems due to scarcity of such sites, unplanned disposal, and environmental cost of transporting demolition waste. The use of coarse recycled concrete aggregates as a replacement for natural coarse aggregates in concrete offers a sustainable solution to these problems. However, the use of RCA may potentially reduce concrete quality as coarse RCAs are generally of poorer quality than natural coarse aggregates, with greater water absorption and lower density. This reduced quality is due to the fact that coarse RCA consists of both original. Aggregate and adhered mortar; thus the quality of the RCA depends not only on the original aggregate, but also on the quality and quantity of adhered mortar. The use of RCA also affects the characteristics of the interfacial transition zones between aggregates and cement paste, which in turn affects the strength characteristics of concrete containing RCA. When considering the mechanical properties of concrete with RCA, most of the previous researches confirmed that the reduction in stiffness (i.e., elastic modulus) is higher than the reduction in strength. Another important consideration is the possible reduction in workability of concretes incorporating coarse RCA, due to the increased angularity and surface roughness of RCA when compared to natural coarse aggregates. This is of particular importance for the increasingly popular form of concrete known as Self-Compacting Concrete.

II. RELATED WORK

Recycled aggregate and glass aggregate can be used as partial replacement for coarse aggregate in concrete to improve its properties and economy. Many studies have been reported on strength and durability property of concrete. Therefore present is important and its finding will be very useful in concrete technology area, wherein coarse aggregate are to be replaced with structure grade concrete. From the total literature review no one author has used combination of both glass aggregate and recycled aggregate as partial replacement of coarse aggregate. Previous studies are either based on recycled aggregate or glass aggregate but there is no study on combination of glass aggregate and recycled aggregate. Therefore there is scope to find out properties by partially replacing the glass aggregate and recycled aggregate as coarse aggregate. The present research, experimental research and investigation can be carries out to investigate the effect of glass aggregate and recycled aggregate on partial replacement of coarse aggregate on the strength and duality properties of concrete.

III. MATERIAL AND METHOD

2.1 MATERIAL:

2.1.1 Cement:

Ordinary Portland cement 53 grade was used. It was tested as per Indian standard specification (BIS-1489 part 1:1991). Test results are given below in Table 2.1.1.

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Table 2.1.1: Physical Properties of Ordinary Portland Cement

Physical Properties		IS-1489:1991	Test Result
Setting time (mm)	Initial	30 Mini	92.5
	Final	600 Max	249
Specific gravity		-	3.15

2.1.2 Fine Aggregates:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and Artificial Sand is being used as fine aggregate conforming to the requirements of IS: 383. Natural sand and artificial sand is screen, to eliminate deleterious materials and over size particles.

2.1.3 Coarse Aggregate:

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being use.

2.1.4 Demolished material:

Recycled aggregates are composed of rubble from building, road and other source.

2.1.5 Glass aggregate:

Glass is a hard brittle substance, typically transparent or translucent made by fusing sand with soda and lime and cooling rapidly. Glass aggregate obtain by recycled broken glass.

2.1.6 Water:

Portable water is used for mixing and curing on addition of higher percentage (%) of demolished material the requirement of water increases for the same workability.

2.2 METHOD:

Compression test is most common test conducted on hardens concrete, because most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. Characteristics properties of coarse aggregate are shown in Table 2.2.

The compressive strength test is done on (150x150x150mm) cubes, split tensile test is done on (150x300mm) cylinder and flexural strength test is done on (10x10x500mm) beam. At the age of 7 and 28 days on specimens are cured and tested.

Table 2.2: Properties of coarse aggregate

Parameter	Coarse aggregate
Specific gravity	2.61
Water absorption	0.3%
Sieve analysis	Conforming to table-2 IS 383-1970
Crushing value	36.03%
Impact value	11.53%

2.2.1 Nominal mix proportion:

An experimental investigation is carried out on a concrete containing glass aggregate and recycled aggregate in the range of 0%, 5% 10%, 15%, and 20% by weight for M-30 grade concrete for both groups. Material was produced, tested and compared with conventional concrete in terms of strength. These tests were carried out on standard cube, cylinder and beam for 7 and 28 days to determine the mechanical properties of concrete, as shown in Table 2.2.1 for mix design.

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Table 2.2: Concrete mix design proportion for Concrete

Sr. No	Type of Concrete	Coarse aggregate replaced by GA & RA	Concrete mix design proportion					
			W/C Ratio	Cement	FA	CA	RA	GA
i.	CM	0%	0.48	1	2.17	3.22	-	-
ii.	GR(I)	5%	0.48	1	2.17	3.06	0.16	-
iii.	GR(II)	10%	0.48	1	2.17	2.89	0.22	0.096
iv.	GR(III)	15%	0.48	1	2.17	2.73	0.32	0.16
v.	GR(IV)	20%	0.48	1	2.17	2.57	0.39	0.26

C=CEMENT, FA=FINE AGGREGATE, CA=COARSE AGGREGATE, RA=RECYCLED AGGREGATE, GA=GLASS AGGREGATE

IV. RESULT AND DISCUSSION

Keeping in mind the gap in the research area, the 4th objective of this study is to determine the mechanical properties of concrete containing recycled aggregate and glass aggregate as partial replacement of coarse aggregate. For this purpose different test on harden concrete were conducted at the age of 7 and 28 days like compressive strength on 150 x 150 x 150 mm size cube, splitting tensile strength on 150 mm X 300 mm cylinder, flexural strength on beam of size 100 x100 x 500 mm. As per IS 516 Total 90 number of specimen were tested, Compressive Strength Test Results are shown in Table 3.1, Split Tensile Strength Test Results are shown in Table 3.2, Flexural Strength Test Results are shown in Table 3.3.

Table 3.1: Compressive Strength Test Results

Sr. no	Code	% replaced	Breaking load @ 7 days			Breaking load @ 28 days			Average breaking load		Average ultimate comp. strength @7 days	Average ultimate comp. strength @28 Days
			Specimen no.			Specimen no.			7 days	28 days		
			1	2	3	1	2	3				
i.	CM	0%	576.3	893	895	1060	1197	1078	788.1	1111.6	35.02	49.40
ii.	GRI	5%	829	562.5	776.2	976	764.1	1171	722.5	970.06	32.11	43.11
iii.	GRII	10%	944.6	945.6	853.8	1189	980	1031	914.6	1066.7	40.64	47.40
iv.	GRIII	15%	661	566.1	510.1	683.6	511.3	546.7	579.1	580.53	25.73	25.80
v.	GRIV	20%	432.2	501	495	645.5	533	601	476.1	593.16	21.16	26.36

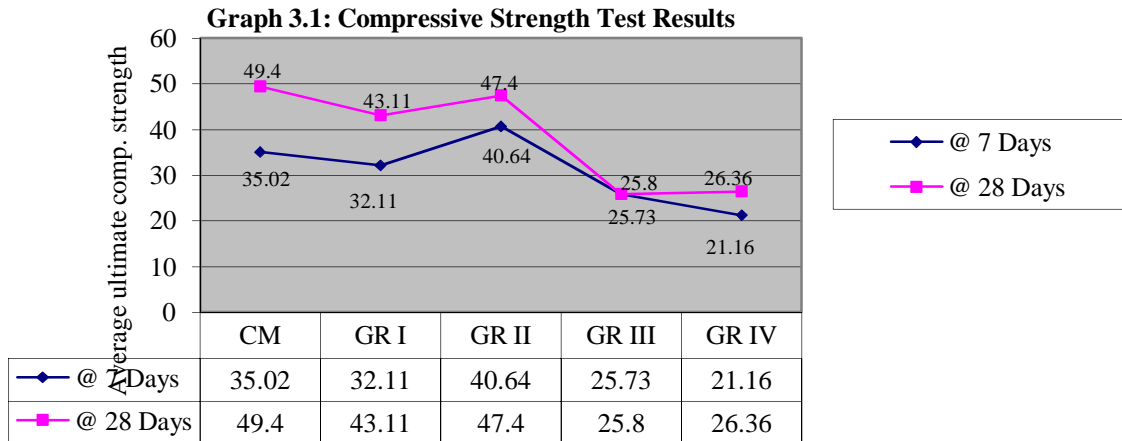
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Graph 3.1 shows the optimum values for GR II for modified mix design at 7 and 28 Days for Compressive Strength.



Discussion of Result:

- (i) The results for 10% replacement of Recycled aggregate and glass aggregate with coarse aggregate gives increase in the compressive strength of concrete at both 7 and 28 days results as shown in Graph 3.1.
- (ii) Results at 15%, and 20% replacement of Recycled aggregate and glass aggregate with coarse aggregate gets fall down as shown in Graph 3.1.

Table 3.2: Split Tensile Strength Test Results

Sr. no	Code	% replaced	Breaking load @ 7 days			Breaking load @ 28 days			Average breaking load		Average ultimate Split Tensile strength @7 days	Average ultimate Split Tensile strength @28 days
			Specimen no.			Specimen no.			7 days	28 days		
			1	2	3	1	2	3				
i.	CM	0%	144.4	173.2	174	182.2	200.5	163.1	163.9	182.2	2.31	2.58
ii.	GRI	5%	169	193.4	172.7	170.8	195.3	224	178.4	196.7	2.52	2.78
iii.	GRII	10%	190.8	157.8	162.6	189.3	179.8	220.1	170.4	196.4	2.41	2.77
iv.	GRIII	15%	109.3	100.9	104.6	125	120.5	103.8	104.9	116.4	1.48	1.65
v.	GRIV	20%	112.9	113.6	101.7	160.8	134	179.5	109.4	134.7	1.54	1.90

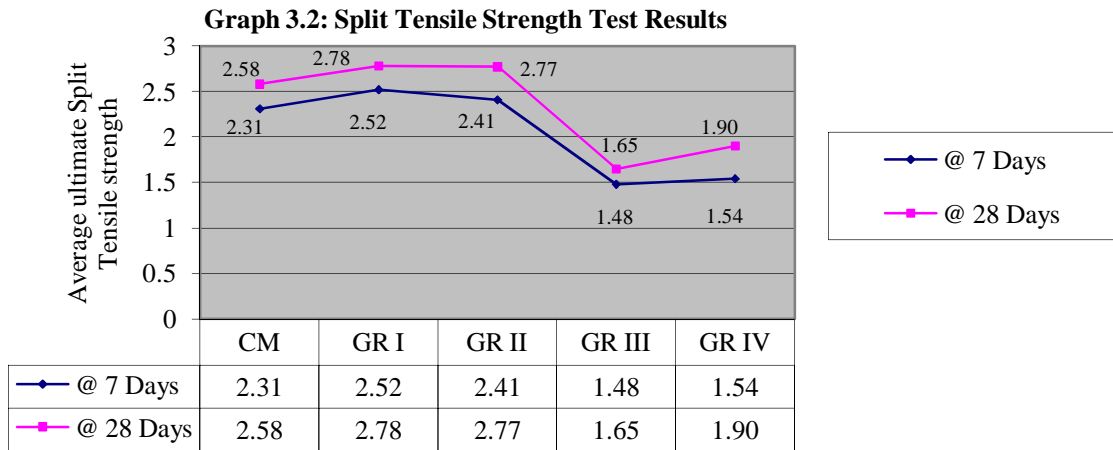
Graph 3.2 shows the optimum values for GR II for modified mix design at 7 and 28 Days for Split Tensile Strength.

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Discussion of Results:

(i) The results for 5% & 10% replacement of Recycled aggregate and glass aggregate with coarse aggregate gives increase in the split-tensile of concrete at both 7 and 28 days results as shown in Graph 3.2.

(ii) Results at 15% and 20% replacement of Recycled aggregate and glass aggregate with coarse aggregate gets fall down as shown in Graph 3.2.

Table 3.3: Flexural Strength Test Results

Sr. no	Code	% replaced	Breaking load @ 7 days			Breaking load @ 28 days			Average breaking load		Average ultimate Flexural strength @7 days	Average ultimate Flexural strength @28 days
			Specimen no.			Specimen no.			7days	28days		
			1	2	3	1	2	3				
i.	CM	0%	14	12	13	17	14	16	13	15.66	5.67	8.44
ii.	GRI	5%	12	12.5	9.5	16.5	14.4	15	11.3	15.3	5.82	7.52
iii.	GRII	10%	11.5	12	11.5	17.5	14	16	11.66	15.83	6.42	7.87
iv.	GRIII	15%	5.1	6.3	5.4	6	8	5.5	5.6	6.5	2.52	3.2
v.	GRIV	20%	7.5	7	6	7.5	7	7	6.83	7.16	2.11	3.45

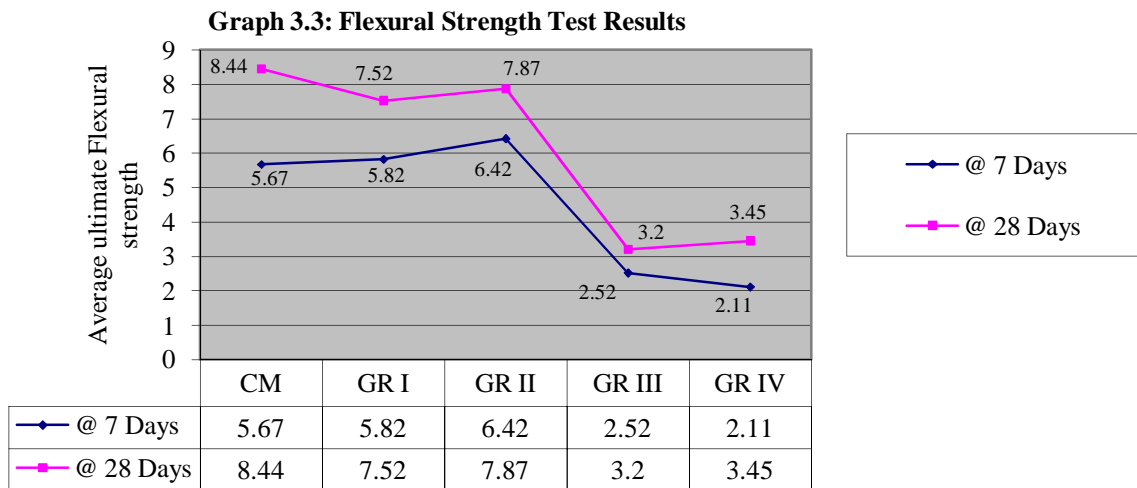
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Graph 3.3 shows the optimum values for GR II for modified mix design at 7 and 28 Days for Flexural Strength.



Discussion of Result:

- (i) The results for 10% replacement of Recycled aggregate and glass aggregate with coarse aggregate gives increase in the split-tensile of concrete at both 7 and 28 days results as shown in Graph 3.3.
- (ii) Results of this test at 5%, 15% and 20% replacement of recycled aggregate and glass aggregate as coarse aggregate gets fall down as shown in Graph 3.3.

V. CONCLUSION

Based on above results following conclusion are made regarding properties of concrete incorporating recycled aggregate and glass aggregate:

- Compressive strength of concrete increases with increase in percentage of recycled aggregate and glass aggregate as compare to normal concrete. It is maximum for 10% replacement and after that it goes on decreasing.
- Split tensile strength increases with increase in percentage of recycled aggregate and glass aggregate up to 5% and 10% replacement after that it decreases.
- There was adverse effect on flexural strength of beam model. As recycled aggregate and glass aggregate content increases upto 10% replacement strength increases and there is decrease in flexural strength of concrete.
- As the concrete mainly design for compressive strength, it gives all good results for that therefore use of recycled aggregate and glass aggregate as coarse aggregate will be beneficial.
- Concrete structures are the main part of infrastructural development; it needs natural coarse aggregate in large proportion. As we know it is not easy to get natural coarse aggregate due to limited natural resource. Therefore, project work suggest the best alternative waste material i.e. recycled aggregate and glass aggregate in the replacement of natural coarse aggregate and it helps in reducing demand of natural coarse aggregate surely.
- Use of recycled aggregate and glass aggregate in concrete reduces the production of waste through demolished structure and glass industries i.e. it's an eco-friendly building material.

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- It can be conclude that the recycled aggregate and glass aggregate is good material as a alternative for the coarse aggregate.
- As the recycled aggregate and glass aggregate is cheap in cost than the natural coarse aggregate and artificial coarse aggregate. It also gives reduction in cost of concrete production, it will give economy.
- From this project we got the conclusion that as the proportion of glass increases in concrete strength of concrete decreases. So, it is beneficial to use recycled aggregate as compared to glass aggregate.
- This research leads to developed an eco-friendly and economical concrete in construction sector and innovative building material.

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