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Experimental Investigation of Green Concrete

Dr.A. Karthik[1], S. Bharathi[2], Dr.A.M. Arunmohan[3], Arwin S[4], Hariharan A[5]
[1,3]Associate Professor, Department of Civil Engineering, Sethu Institute of Technology, Kariapatti, India.
[2]Assistant Professor, Department of Civil Engineering, Sethu Institute of Technology, Kariapatti, India.
[4,5]Final Year M.E Student, Department of Civil Engineering, Sethu Institute of Technology, Kariapatti, India.
Email: *karthikcivil@sethu.ac.in[1], bharathysanthanam@sethu.ac.in[2], arunmohan@sethu.ac.in[3], arwin1995@gmail.com[4], Hariharancivil.157@gmail.com[5]*

Abstract
To mitigate pollution and promote material reuse, natural coarse aggregates are substituted with recycled aggregates. This substitution not only facilitates the reduction of carbon dioxide emissions but also contributes to environmentally friendly practices. This research delves into the criteria for selecting materials suitable for recycled aggregates. The study involved replacing natural aggregates with recycled aggregates at varying percentages (0%, 20%, 40%, 60%, 80%, 100%). The incorporation of recycled aggregates in specific proportions enhanced the properties of both fresh and hardened concrete, particularly up to the optimum percentage, as demonstrated through tests such as the slump test and compressive strength test, splitting tensile strength. Laboratory test results revealed decrease in compressive strength as the percentage of recycled aggregate increases. Nevertheless, up to a 20% replacement level, the mixtures attained the desired mean strength. Consequently, for structural concrete, it is feasible to replace natural aggregates with recycled aggregates within the range of 20%.

Keywords: *Recycled Aggregate, Impact Value, Compressive Strength, Flexural Strength, Splitting Tensile Strength.*

1. Introduction
To get sustainable issue in construction area, researchers and company center on using waste concrete as a fresh construction material. It is called recycled aggregate (RA) which can be produced by concrete crusher. Using RA has big opportunity to maintain healthy atmosphere, the properties and characteristics of RA has not been fully investigating so far. While it is hard to regulate the characteristic of RA, every researcher who study recycled aggregate must execute experiment of their concrete, which will be used for RA, to increase the characteristics of their specimens. The quality of RA could be different by its parent concrete because the parent concrete was planned for its purpose such as permeable, durable and high strength concrete [1]. For example: w/ratio of concrete will give an impact on water absorption capacity of RA which is correlated to uniqueness of concrete issue such as durability, permeability, strength and elastic modulus. There is a remarkable turn down in high-quality aggregate accessible for construction use. Globally aggregate use is estimated to be 10-11 billion tonnes every year, of this, about 8 billion tonnes of aggregate (sand, gravel, and crushed rock) are being used in PCC every year. The environmental impact of devastate concrete is considerable. Not just is there the environmental impact of transport the waste concrete away from the location but the waste concrete also fills up precious space in landfills. Construction and demolition waste makes up a large portion of all generated solid waste [2]. The charge of worth aggregate has enlarged beyond the rise rate and it is expected that this tendency will carry on as additional limitations are placed on this source in the future. Concrete construction and

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demolition waste will be recycled if it is less expensive than disposing of it in a landfill and RAC will be used if it is less costly than natural aggregate of comparable quality. RAC use is based on financial side, together with the charge of transport construction and demolition waste and natural aggregate, the charge of construction and demolition disposal, and government intervention on tipping fees and mandatory usage through legislation. Around 60% of aggregate charge is due to transportation [3, 4].

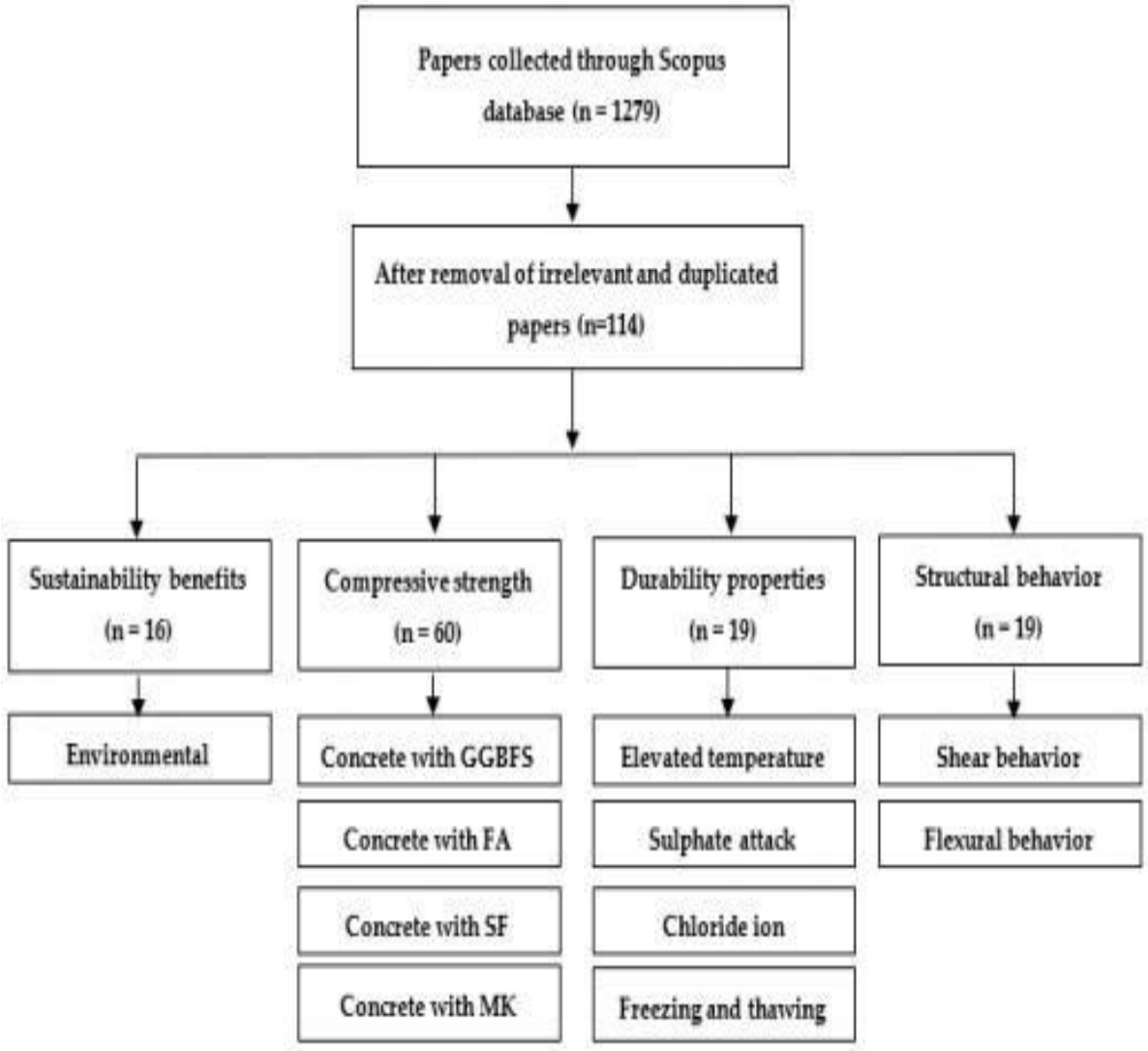

Figure 1 Flowchart for Papers Collected Through Scopus

2. Material Used

Cement: In this research work, OPC conforming to IS: 8112-1989 is used. The properties of cement used are shown in Table 1 and Figure 1 & 3.

Sand: Locally existing sand with 4.75 mm maximum dimension is used as FA, having specific gravity, fineness modulus and unit weight as given in Table 2 & 3.

Natural Aggregate: Crushed stone with 20 mm maximum size having specific gravity, fineness modulus and unit weight as given in are usedas natural aggregate.

Recycled Aggregate: The RAC passing through 20mm and retained on 4.75mm sizeaggregate is used [5, 6].

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Table 1 Properties of Cement (FA)

Physical Property	Result
Fineness of cement	9%
Normal Consistency	27%
Initial setting time (minutes)	35
Final setting time (minutes)	370
Specific Gravity	3.14

Table 2 Properties of Sand (FA)

Physical Property	Result
Fineness modulus	3.2
Specific Gravity	2.67
Surface Texture	Even
Particle shape	Curved

Table 3 Properties of Sand Material (FA)

PhysicalProperty	Result
Fineness modulus	7.56
SpecificGravity	2.70
Particle shape	Angular

3. Project Analysis

3.1 Data Interpretation

Grade of concrete, size of cube casting, different proportion of the materials like glass and fly ash etc. which replaces the cement etc. are interpreted as shown in Table 4.

Table 4 Mix Proportions

Grade of concrete	M25
Nominal concrete	4 cubes of 1:1:2 ratio
Cement replaced by glass in the concrete	4 cubes with 15% replace cement
Cement replaced by glass and fly ash both in the concrete	4 cubes with 15% replace cement4 cubes with 30% replace cement
4 cubes with 45% replace cement (Glass: fly ash = 1:1)	
4 cubes with 30% replace cement	
4 cubes with 45% replace cement	

4. Results and Discussion

Compressive Strength Test:

When 28 days of curing was completed than (150 mm X 150mm) blocks were tested in CTM machine, as shown in Table 5-10.

5. Experimental Work & Results

Mix Design for M-40 Grade: Mix design as per IS 10262-2009 & IS 456-2000 the ratio of M-40 grade concreteare given below in the Table 4. Aggregate **Impact Value:** Aggregate Impact Value test is the good indicator of strength and durability from the test results we can say that natural aggregate and recycled aggregate are having wide difference of impact value, which again shows that rock of recycled aggregate is stronger than that of natural aggregate, as shown in Table 11 & Figure 4 [7, 8].

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Table 5 Cement 15% Replaced by Glass

Concrete	Test result (N/mm^2)	Average strength obtained (N/mm^2)	Average strength required (N/mm^2)	ITR value	Result
M25	31.91	35.15	28.3	>22 OKAY	PASS
	33.59				
	37.33				
	37.77				

Table 6 Cement When 30% Replaced by Glass

Concrete	Test result (N/mm^2)	Average strength obtained (N/mm^2)	Average strength required (N/mm^2)	ITR value	Result
M25	26.82	29.82	28.3	>22 OKAY	PASS
	24.91				
	32.88				
	34.67				

Table 7 Cement When 45% Replaced by Glass

Concrete	Test Result (N/mm^2)	Average strength Obtained (N/mm^2)	Average strength Required (N/mm^2)	ITR value	Result
M25	24.67	25.67	28.3	<22 INVALID	FAIL
	21.92				
	26.87				
	28.23				

Table 8 Cement When 15 % Replaced by (Glass+ Fly Ash)

Concrete	Test result(N/mm^2)	Average strength obtained (N/mm^2)	Average strength required (N/mm^2)	ITR value	Result
M25	36.54	37.94	28.3	>22 OKAY	PASS
	35.06				
	38.24				
	37.92				

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Table 9 Cement When 30% Replaced by (Glass+ Fly Ash)

Concrete	Test result (N/mm^2)	Average strength obtained (N/mm^2)	Average strength required (N/mm^2)	ITR value	Result
M25	24.71	30.13	28.3	>22 OKAY	PASS
	27.16				
	31.02				
	33.64				

Table 10 Cement When 45% Replaced by (Glass+ Fly Ash)

Cement	Water	FA	CA	W/C Ratio
336 kg/m^3	151 kg/m^3	768 kg/m^3	889 kg/m^3	0.41
1	0.41	1.83	2.65	0.41

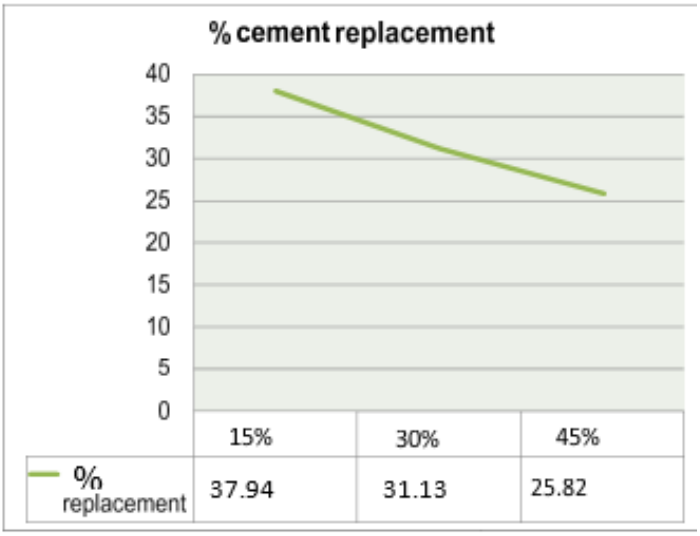

Figure 2 Comparison of Compressive Strength of Concrete When Replaced by (Glass+Flyash) In Different Proportion Through Line Graph

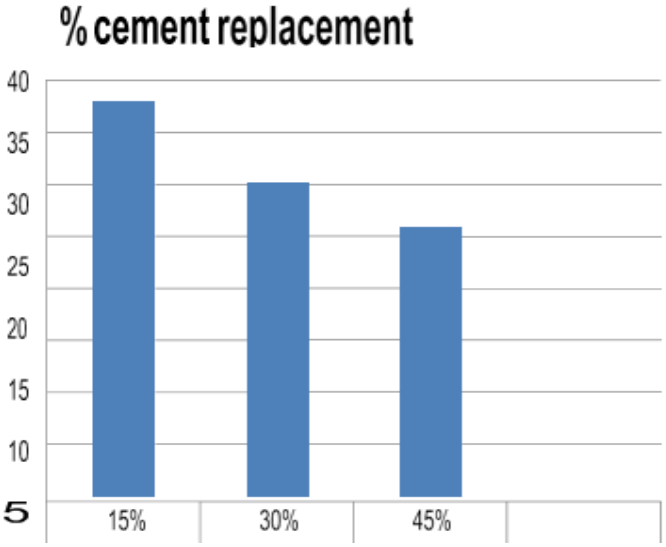

Figure 3 Comparison of Compressive Strength of Concrete When Cement Is Replaced by (Glass + Fly Ash) In Different Proportion by Bar Graph

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Table 11 Result of Aggregate Impact Value

S.No	Details	Recycled Aggregate			Natural Aggregate		
		Trial 1(kg)	Trial 2 (kg)	Avg. (kg)	Trial 1 (kg)	Trial2 (kg)	Avg.(kg)
1)	Total wt. of aggregates sample fillingthe cylindrical measure= W1	0.546	0.586	11.33 %	0.614	0.616	7.64%
2)	Wt. of aggregates passing 2.36mmsieve after thetest= W2	0.066	0.062		0.054	0.040	
3)	Wt. of aggregates retained on 2.36mmsieve after thetest = W3	0.898	0.524		0.558	0.570	
4)	Difference inWt.=W1- (W2+W3)						
5)	Aggregate impactvalue= (W2/W1)*100	12.08 %	10.58 %		8.79 %	6.49%	

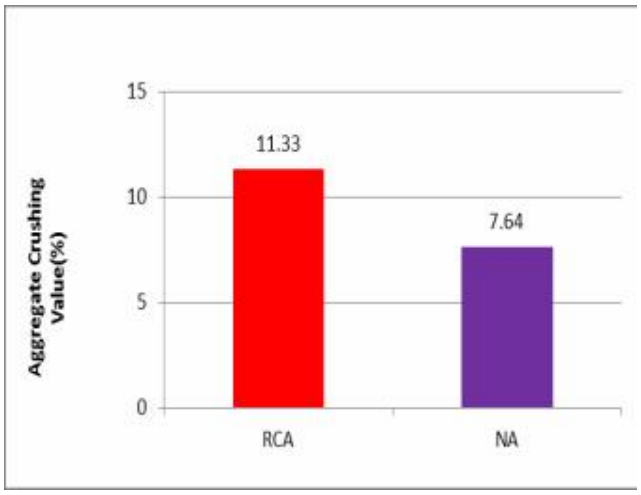

Figure 4 Impact Value of Recycled Aggregate and Natural Aggregate

Slump Test: From the below table 8 shows that the result of slump tests the value of slump decrease when percentage of recycled aggregate increases, as shown in Table 12 & Figure 5.

Table 12 Slump Test Result

Percentage of Recycled Aggregate inthe mix	Percentage of Natural Aggregate inthe mix	Slump (mm)
0%	100 %	110
20%	80 %	95
40%	60 %	84
60%	40 %	78
80%	20 %	71
100%	0%	65

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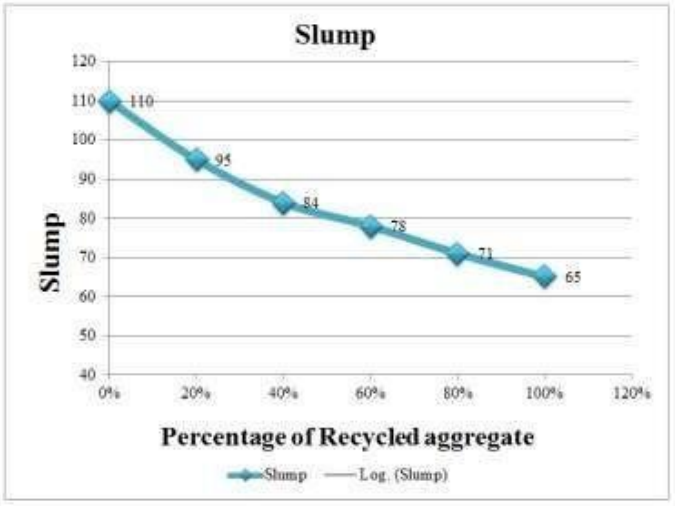

Figure 5 Variation in Slump Value

6. Testing of Concrete

Compressive Strength: The compressive strength test by Compression Testing machine shows an increasing trend of the compressive strength with age of the concrete specimens. Table-9 below shows the increase ofthe compressive strength with age recorded during the test, as shown in Table 13 and Figure 6 [9].

Table 13 Variation of Compressive Strength with Age

% ofRA	0%	20%	40%	60%	80%	100%
7 Days	32.96 MPa	34.16 MPa	32.07 MPa	30.81 MPa	30.21 MPa	28.81 MPa
28 Days	47.18 MPa	48.81 MPa	45.70 MPa	44.81 MPa	44.22 MPa	43.88 MPa

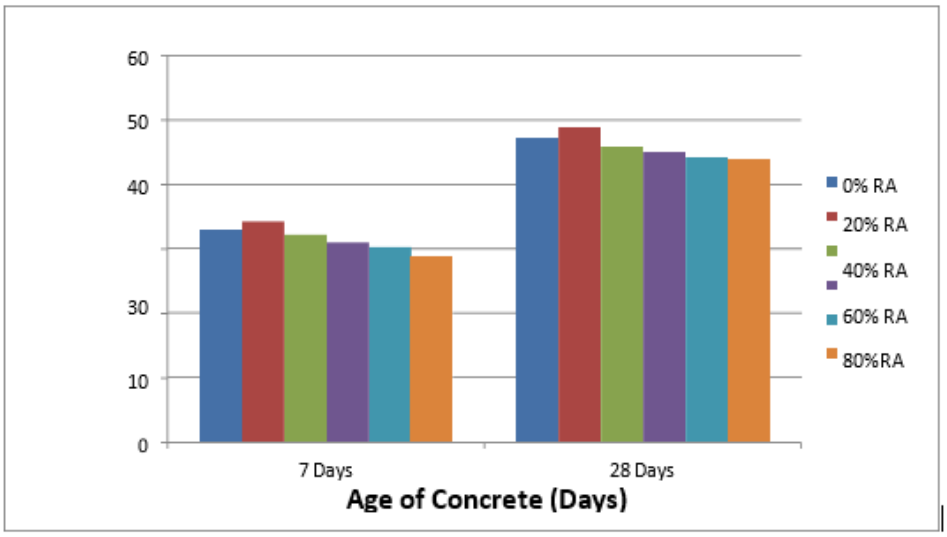

Figure 6 Variation in Compressive Strength with Increasing % of Recycled Aggregate

Conclusion

Based on experimental observations, following conclusions can be drawn,

- The water absorption capacity of recycled

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aggregate is more than naturalaggregate. It is about 3.1% more than the natural aggregate

- From the result of crushing value & impact test the recycled aggregate is havingmore resistance to the wear and tear than the natural aggregate.
- The work ability of the concrete considerably reduces as the amount of recycledaggregate increases in the concrete mixture
- Optimum compressive strength observed when recycled aggregate replacement is about 20%.
- We can replace cement by glass safely up to 30%and little more but we cannot replace it by45 % & more
- We can replace cement by (glass + fly ash) up to 30% but we cannot replace it by 45 % &more.
- 28 days' strength obtain from (glass + fly ash) is more than 28 days strength of glassreplacement.
- On strength, criteria by glass + fly ash replacement is better than by only glass-replacement
- It reduces the CO_2 emission up to 30%
- At 15% replacement by glass powder strength came 24.2% more than normal concrete.11.At 30% replacement strength came 5.37% more than normal concrete
- At 15 % replacement by (glass +fly ash) strength came 34 % more than normal concrete.
- At 30% replacement by glass + fly ash strength came 6.48% more than normal concrete

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