EXPERIMENTAL INVESTIGATION ON PROPERTIES OF GEOPOLYMER CONCRETE WITH RECYCLED CARBON FIBRE AND RECYCLED AGGREGATE

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Abstract - This study aims to contribute to sustainable construction practices by promoting the use of alternative materials, reducing the industry's ecological footprint while ensuring the concrete's structural integrity in geopolymer concrete, encouraging the adoption of eco-friendly practices in the construction industry. In this thesis experimental study on M25 grade of geopolymer concrete by incorporating recycled carbon fiber and recycled aggregates. The aggregates content is partially replaced with Recycled aggregates in varying proportions (0%, 10%, 20%, 30%, 40% and 50% by weight of coarse aggregate) and recycled carbon fiber (RCF) in varying percentages (i.e., 0%, 5%, 10%, 15%, and 20% by weight of cement) for M25 grade concrete. The concrete mixtures produced are meticulously tested, focusing on properties such as slump, compressive strength, and flexural strength.

***Key Words*:** Geopolymer concrete, Recycled aggregates, Recycled carbon fiber.

1: INTRODUCTION

Geopolymer concrete is a type of concrete that is produced using a different binder system than traditional Portland cement. Instead of cement, which is the key ingredient in conventional concrete, geopolymer concrete relies on a binder formed from the chemical reaction of aluminosilicate materials. This reaction typically involves materials like fly ash, slag, or metakaolin mixed with an alkaline activator solution.

Recycled Carbon Fiber: Carbon fiber can be recycled, and recycling efforts for carbon fiber composites have been growing in recent years due to the material's increasing use in various industries, including aerospace, automotive, and sports equipment. Here are some key points about recycling carbon fiber:

PROJECT OBJECTIVES:

- Develop various geopolymer concrete mix designs by incorporating different percentages of recycled carbon fiber.
- Investigate the effect of varying fiber content on the fresh properties of geopolymer concrete, such as workability, slump, and strength.
- Conducting compressive strength tests on hardened M25 geopolymer concrete specimens with different carbon fiber and recycled aggregate contents.
- Evaluate the flexural strength of M25 geopolymer concrete with recycled carbon fiber and recycled aggregate contents.
- Summarize the findings, highlighting the advantages and limitations of geopolymer concrete with recycled carbon fiber and recycled aggregate contents.

2. LITERATURE REVIEW

Abdulkareem et al. (2016): Investigated the fresh and hardened properties of fly ash-based geopolymer concrete incorporating palm oil fuel ash. The study focused on optimizing mix proportions to achieve the desired workability, strength, and durability. Exploring the synergies between different waste materials contributes to sustainable geopolymer concrete formulations, aligning with circular economy principles.

Bernal et al. (2015): Investigated the use of alternative activators, such as sodium aluminate, in the geopolymerization process. The study explored the effects of activator composition on the microstructure and mechanical properties of geopolymer concrete. By diversifying activator options, researchers can tailor geopolymer formulations to specific project requirements and environmental considerations.

Jiang et al. (2019): Explored the incorporation of waste ceramic powder as a supplementary material in fly ash-based geopolymer concrete. The study investigated the effects on mechanical properties and microstructure, highlighting the potential of utilizing ceramic waste in sustainable geopolymer formulations.

Silva et al. (2012): Fly ash-based geopolymer concrete has gained prominence due to its eco-friendly and sustainable nature. explored the potential of utilizing fly ash as a primary material in geopolymer concrete, paving the way for environmentally friendly construction practices. This research contributed to the development and characterization of geopolymer concrete, emphasizing the importance of utilizing industrial by-products to create durable and eco-conscious construction materials.

Zhang et al. (2011): Investigated the effects of fiber reinforcement, specifically polypropylene fibers, on the mechanical properties and fracture behavior of fly ash-based geopolymer concrete. The study provided insights into the role of fibers in enhancing the ductility and toughness of geopolymer concrete, expanding its applicability in structural applications.

3: METHODOLOGY

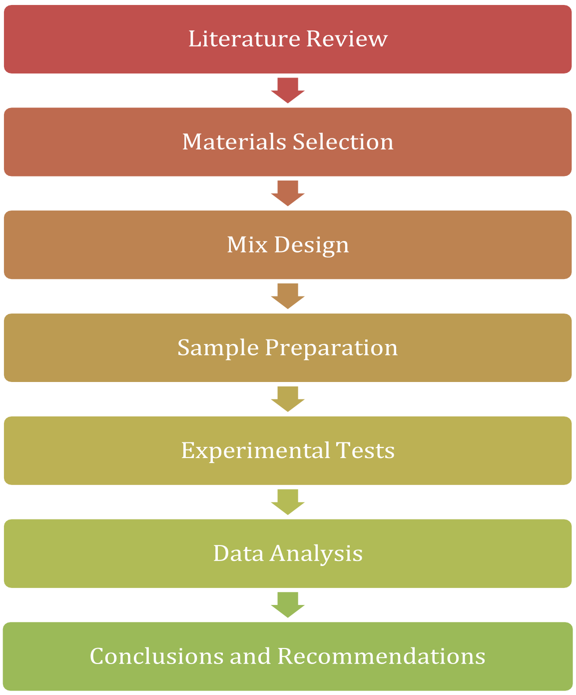

Fig -1 Flow Chart of Methodology

4. EXPERIMENTAL PROGRAMME

Table -1: Physical Properties of Cement (OPC 53)

S. No	Property	Values
1	Specific Gravity	3.16
2	Fineness of Cement	4.5%
3	Normal Consistency	31.8%
4	Initial Setting Time	64 minutes
	Final Setting Time	540 minutes
5	Compressive Strength	53.6 N/mm2

Table -2 Sieve Analysis of Fine Aggregate

S. No	Sieve size	Weight retained (gm)	Cumulative	% Weight retained	% Weight passing
1	10	0	0	00.00	100
2	4.75 mm	1	1	00.08	99.92
3	2.36 mm	639	640	32.00	68.00
4	1.18 mm	450	1090	54.50	45.50
5	600 µm	124	1214	60.70	39.30
6	300 µm	386	1600	80.00	20.00
7	150 µm	95	1695	84.75	15.25
8	Pan	305	2000	100	00.00

Table -3 Sieve Analysis of Coarse Aggregate

S. No	Sieve size	Weight retained (gm)	Cumulative weight retained (gm)	% Weight retained
1	20 mm	00.00	00.00	00.00
2	16 mm	48.00	48.00	9.6
3	12.5 mm	47.7	95.7	19.14
4	10 mm	320.3	416	83.2
5	4.75 mm	77	493	98.6
6	Pan	6.0	499	99.8

Table -4 Properties of Recycled Carbon Fiber

S. No	Property	Description
1	Fibre length	60mm
2	Appearance	Black
3	Specific gravity	2.21
4	Bulk density kg/m3	1.785
5	Fineness modulus	5880

5. RESULTS AND DISCUSSIONS

Table -5 Slump Values for Different % of RA

Grade of concrete	% of RA	Slump (mm)
M25	0	54
	10	58
	20	62
	30	65
	40	70
	50	62

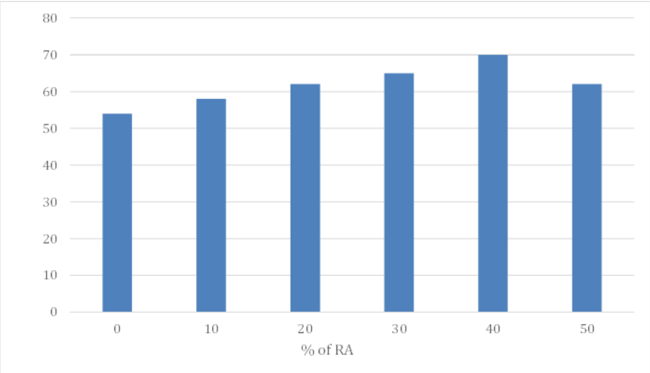

Fig -2 Slump Results for Different % of RA

Table -6 Compressive Strength for Different % of RA

% of RA	7 days	14 days	28 days
0	17	18	26.4
10	18	19.5	27.5
20	18.5	20.5	28
30	20	21	29.2
40	21.5	22	30.5
50	19.5	20	27

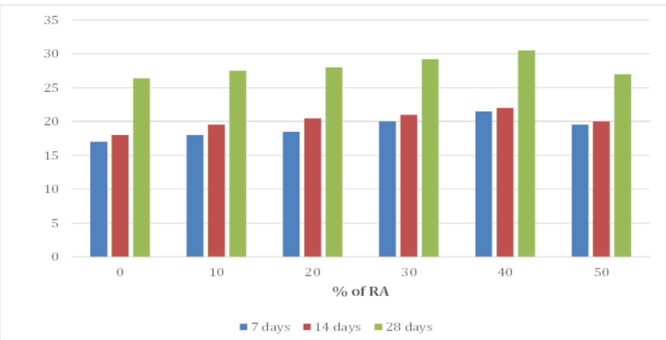

Fig -3 Compressive Strength of Different % of RA

Table -7 Flexural Strength for Different % of RA

% of RA	7 days	14 days	28 days
0	1.74	2.16	3.24
10	2.03	2.34	3.60
20	2.27	2.45	3.504
30	2.46	2.64	3.36
40	2.71	2.88	3.3
50	2.25	2.44	3.168

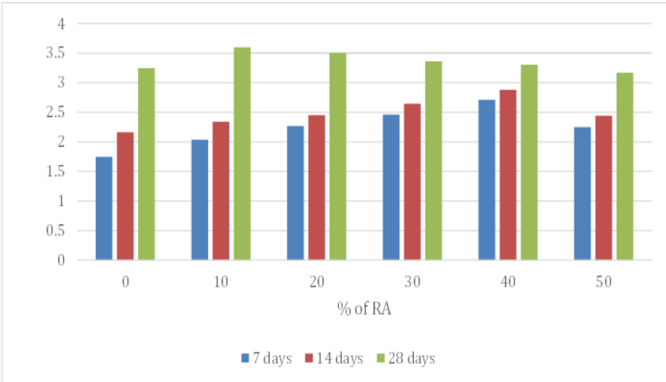

Fig -4 Flexural Strength for Different % of RA

Table -8 Slump Cone Values for Different % Of RCF

Grade of concrete	% Of RCF	Slump (mm)
M25	0	56
	5	60
	10	67
	15	72
	20	63

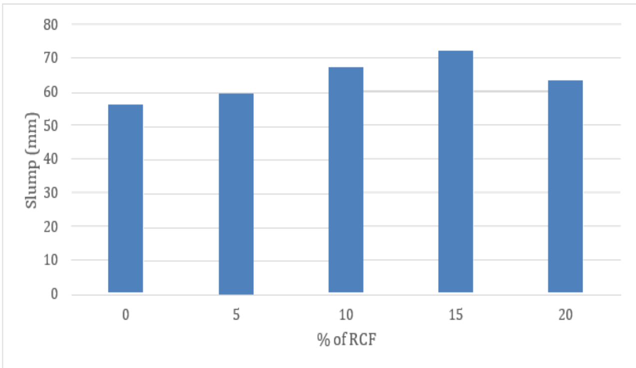

Fig -5 Slump Cone Results for Different % Of RCF

Table -9 Compressive Strength for Different % of RCF

% of RCF	7 days	14 days	28 days
0	19	23	30.23
5	21	24.5	32.56
10	21.5	26.5	35.5
15	20	26	37.01
20	19.5	23.5	31.5

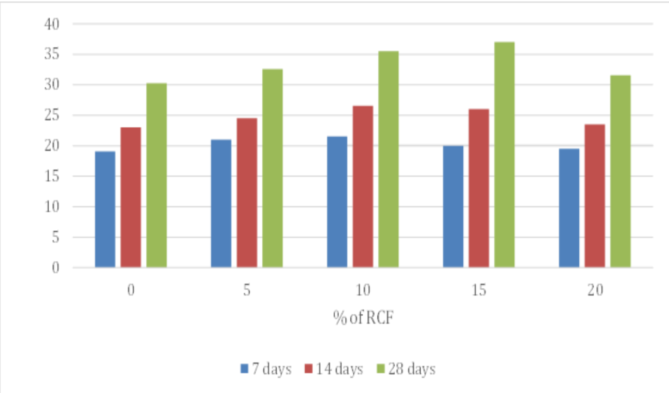

Fig -6 Compressive Strength for Different % of RCF

Table -10 Flexural Strength for Different % of RCF

% of RCF	7 days	14 days	28 days
0	1.65	2.28	3.62
5	1.45	2.73	3.90
10	2.10	2.41	4.26
15	2.23	2.87	4.44
20	2.09	2.46	3.78

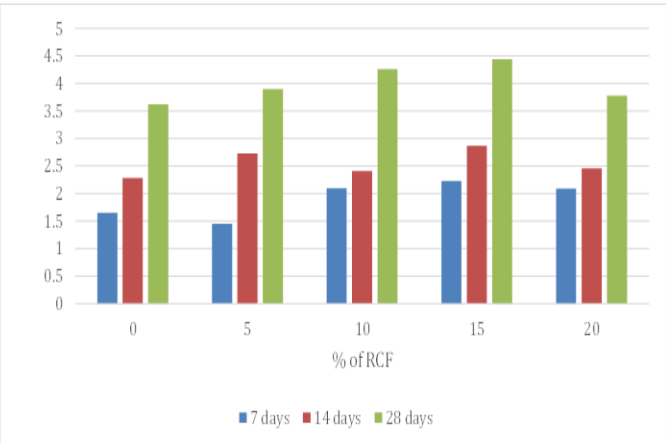

Fig -7 Flexural Strength for Different % of RCF

Table -11 Slump Cone Values for Different % of RCF and RCF

Grade of concrete	% of RA & RCF	Slump (mm)
M25	0	59
	10 & 5	63
	20 & 10	69
	30 & 15	75
	40 & 20	64

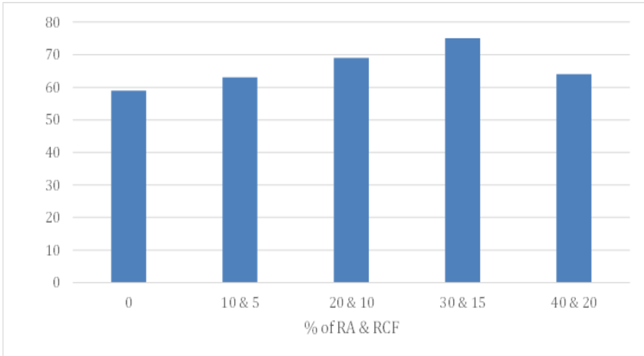

Fig -8 Slump Cone Values for Different % Of RA And RCF

Table -12 Compressive Strength for Different % of RA and RCF

% Of RA & RCF	7 days	14 days	28 days
0	20.5	25	32.5
10 & 5	21.10	27.5	34.4
20 & 10	22.00	29	35.67
30 & 15	23.45	30.5	38.12
40 & 20	22.5	29.5	36.88

Fig -9 Compressive Strength for Different % Of RA and RCF

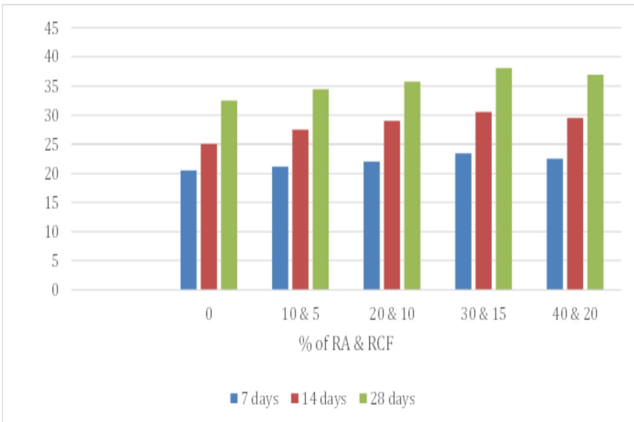

Table -13 Flexural strength for Different % Of RA and RCF

% of RA & RCF	7days	14days	28days
0	2.89	3.28	3.90
10&5	3.04	3.41	4.128
20&10	3.14	3.44	4.28
30&15	3.19	3.51	4.57
40&20	2.97	3.25	4.42

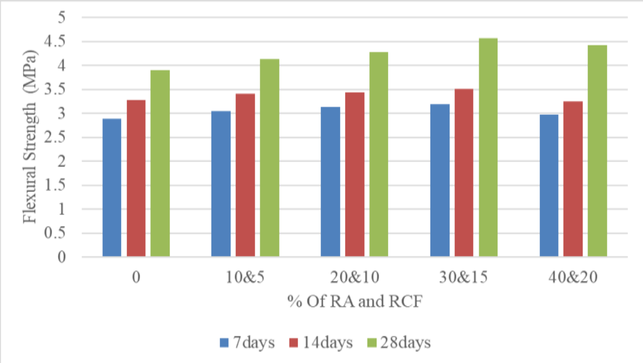

Fig -10 Flexural strength for Different % Of RA and RCF

6. CONCLUSIONS

Effect of Recycled Aggregate (RA) Content:

- Slump Test (M25 Grade): The addition of RA up to 40% results in an increase in slump, indicating improved workability. However, at 50% RA the slump decreases, suggesting a less workable mix.
- Compressive Strength (M25 Grade): Compressive strength generally increases with RA content up to 40%. Beyond 40%, there is a slight decrease in strength at 50% RA, indicating an optimum RA content for enhancing compressive strength.
- Flexural Strength (M25 Grade): Flexural strength shows an increasing trend with RA content up to 40%, with a slight decrease at 50% RA. This suggests that 40% RA content is optimal for achieving maximum flexural strength in M25 grade concrete.

Effect of Recycled Carbon Fiber (RCF) Content:

- Slump Test (M25 Grade): Slump increases with RCF content up to 20%, indicating improved workability. However, at 20%, there is a slight decrease in slump, suggesting a less workable mix.
- Compressive Strength (M25 Grade): Compressive strength increases with RCF content up to 15%, beyond which there is a slight decrease at 20%. This implies that 15% RCF content is optimal for enhancing compressive strength in M25 grade concrete.
- Flexural Strength (M25 Grade): Flexural strength shows an increasing trend with RCF content up to 15%, beyond which there is a slight decrease at 20%. This indicates that 15% RCF content is optimal for achieving maximum flexural strength in M25 grade concrete.

Effect of Combined RCF and RA Content:

- Slump Test (M25 Grade): Slump increases with the combined addition of RCF and RA up to 30%, beyond which there is a slight decrease at 40%. This suggests that a combination of 30% RA and 15% RCF provides optimal workability in M25 grade concrete.
- Compressive Strength (M25 Grade): Compressive strength increases with the combined addition of RA and RCF up to 30% and 15% respectively, beyond which there is a slight decrease at 40% RA and 20% RCF. This implies that a combination of 30% RA and 15% RCF content is optimal for enhancing compressive strength in M25 grade concrete.
- Flexural Strength (M25 Grade): Flexural strength shows an increasing trend with the combined addition of RA and RCF up to 30% and 15% respectively, beyond which there is a slight decrease at 40% RA

and 20% RCF. This indicates that a combination of 30% RA and 15% RCF content is optimal for achieving maximum flexural strength in M25 grade concrete.

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