Effect Of Inclusion Of Steel Fiber, Glass Fiber, And Crumb Rubber On The Properties Of Geopolymer Concrete Composites

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Abstract- *The use of scrap tyres in construction materials has been promoted to curb the environmental exploitation caused by the open disposal of non-biodegradable waste rubber. Tyre grinds as aggregates in geopolymer concrete (GPC) would increase its sustainability value by reducing the consumption of natural aggregates. Although there is limited literature addressing the damage to GPC characteristics caused by rubber aggregates, this investigation was designed to determine the extent of possible side effects of using crumb rubber (CR) in GPC. Additionally, this investigation aims to address any resulting reduction in strength and durability using additives such as cement and fibres. Geopolymer specimens with CR replacement of fine aggregates by volume (0, 5, 10 and 15%) showed a compressive strength reduction of up to 17% when tested according to ASTM standards. Substituting the total binder by weight with Ordinary Portland cement (OPC) (0%, 5%, 10%, 15%, and 20%) improved the micro structural integrity of the rubberised geopolymer mix with the highest percentage of OPC. Despite producing new and additional binding products (CSH and CASH gels), the GPC surface readily disintegrated under acid exposure. Optimum glass fibres (GF) reinforcement (0.30%) effectively disrupted the GPC pore network, consequently reducing the acid permeability of the matrix. Further addition of steel fibres (SF) enhanced the GPC specimen's compressive and flexural strength.*

Keywords- Geopolymer, OPC, Crumb rubber, Steel fibre, Glass fibre, Sulphuric acid

I. INTRODUCTION

Introduction to Geopolymer Concrete

An overview of geopolymer concrete is given below. This kind of concrete is created by reacting aluminosilicate minerals with an alkaline activator solution. Compared to conventional Portland cement-based concrete, this novel material has a lower carbon footprint, is more durable, and is more resistant to hostile environments.

Figure no. 1 Geopolymer Concrete

Steel Fiber Reinforcement in Geopolymer Concrete

Steel fibers can be used to geopolymer concrete to greatly improve its mechanical qualities. Steel fibers enhance the concrete matrix, increasing its toughness, ductility, and tensile strength. Under varied loading circumstances, this reinforcing mechanism improves the overall performance of geopolymer concrete and helps control cracking.

Figure no. 2 Steel Fiber Reinforcement in Geopolymer Concrete

Glass Fiber Reinforcement in Geopolymer Concrete

Another popular reinforcement component in geopolymer concrete is glass fibers. These fibers are renowned for their endurance, corrosion resistance, and great tensile strength. Glass fibers have the ability to increase the flexural strength and impact resistance of geopolymer concrete compositions. Glass fibers can also improve the long-term performance of geopolymer concrete constructions by lowering shrinkage cracking.

Figure no. 3 Glass Fiber Reinforcement in Geopolymer Concrete

Crumb Rubber Modification in Geopolymer Concrete

The use of crumb rubber as a partial replacement for fine aggregates in geopolymer concrete has gained attention due to its potential environmental benefits and improved properties.

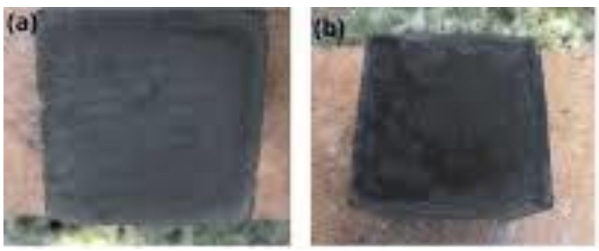

Figure no. 1.4 Crumb Rubber Modification in Geopolymer Concrete

Crumb rubber derived from recycled tires can enhance the ductility and energy absorption capacity of geopolymer concrete. The incorporation of crumb rubber particles can also lead to a reduction in density, improved thermal insulation properties, and increased resistance to impact loading.

II. OBJECTIVES OF VIEWS

The objectives of using these materials in construction projects include:

1. Objectives of Steel Fiber in Geopolymer Concrete: The objective of steel fibers in geopolymer concrete is to enhance performance by improving toughness, impact resistance, and abrasion resistance. Steel fibers also reduce sorptivity, enhance durability, and improve interfacial bond strength and mechanical behavior in polymer composites.
2. Different trial mix of Steel Fiber used as a partially replacement of Coarse aggregates by percentages of 0%,10%,20%,30% and 40%.
3. Objectives of Crumb Rubber in Geopolymer Concrete: The objectives of crumb rubber in geopolymer concrete are not explicitly mentioned in the provided context. Different trial mix of Crumb Rubber used as a partially replacement of Fine aggregates by percentages of 0%,10%,20%,30% and 40%.
4. Objectives of Glass Fiber in Geopolymer Concrete: The objective of glass fibres in geopolymer concrete is to improve density, ductility, and crack resistance. Glass fibres enhance impact strength due to increased elasticity and stiffness. They also affect workability and density negatively but significantly improve impact strength. Glass fibres used in Geopolymer Concrete with 1.5% used.
5. To determine the maximum Compressive strength of Geopolymer concrete when compared to conventional concrete at 7 and 28 days.
6. To determine the maximum Flexural strength of Geopolymer concrete when compared to conventional concrete at 28 days.

III. EXPERIMENTAL WORK OF MATERIALS

Test performs of Fine Aggregates

Fineness modulus of Fine Aggregates

Table No. 1: Sieve analysis of fine aggregate (Experimental work)

S. No.	IS Sieve Size	Weight retained (gm)	percentage weight retained	Cumulative percentage weight retained	Cumulative percentage passing	
					Fine aggregate	Grading Zone III
1	10mm	0	0.00	0.00	100.00	100
2	4.75mm	10	1.00	1.00	99.00	90-100
3	2.36mm	20	2.00	3.00	97.00	85-100
4	1.18mm	110	11.00	14.00	86.00	75-100
5	600u	415	41.50	55.50	44.50	60-79
6	300u	325	32.50	88.00	12.00	12--40
7	150u	120	12.00	100.00	0.00	0-10
Total Weight retained		1000		261.50		

Specific gravity of fine aggregate

Table No. 2:% Absorbed of fine aggregate

Trial	Wet Weight	Dry Weight	Wet - Dry	% Absorbed
1	118.11	117.42	0.69	0.59
2	158.10	157.13	0.97	0.62
3	172.81	171.12	1.09	0.64

Table No. 3:Bulk SSD of fine aggregate

Trial	S	A	B	C	B + S - C	B + A - C
1	500.05	497.10	670.70	983.80	186.90	184.00
2	499.77	496.70	679.60	992.40	187.00	183.90
3	499.61	496.50	671.60	984.10	187.10	184.00

Trial	Bulk SSD S/B+S-C	Bulk A/B+S-C	APPARENT A/B+A-C
1	2.68	2.66	2.70
2	2.67	2.66	2.70
3	2.67	2.65	2.70
Average	2.67	2.66	2.70

Test performs of Crumb rubber

Fineness modulus and grain size distribution of Crumb rubber

Table No. 4:Fineness modulus of Crumb rubber

S. No.	IS Sieve Size	Weight retained (gm)	percentage weight retained	Cumulative percentage weight retained
1	10mm	0.00	0.00	0.00
2	4.75mm	9.70	9.70	0.97
3	2.36mm	41.40	51.10	5.11
4	1.18mm	157.60	208.70	20.87
5	600 microns	321.60	530.30	53.03
6	300 microns	301.20	831.50	83.15
7	150 microns	141.20	972.70	97.27
Total Weight retained		1000		260.00

Specific gravity of Crumb rubber

Specific gravity of Crumb rubber

Sample No.I

Weight of empty Pycnometer (in gm) W1= 681 gm

Weight of Pycnometer + Sample (in gm) W2=1385 gm

Weight of Pycnometer + Sample + Water (in gm) W3=1961 gm

Weight of Pycnometer + Water (in gm) W4=1534 gm

Specific Gravity 2.54

MIX DESIGN – (for the grade M30 plain concrete))The mix design is carried out according to (Mix design code) IS code 10262:2009 Through following step – As per IS Code 10262:2009 (New revised code)

Table 5 Mix proportion

Cement	Water	Fine aggregate	Coarse aggregate
414	186	711.21	1099.90
1	0.45	1.72	2.65

Table 6 The final trial batches quantities of per cubic meter of concrete M30

Mix designation	Cement kg/m3	Fine Agg. kg/m³	Crumb Rubber kg/m3	Coarse Agg. kg/m³	Steel Slag kg/m3	Water kg/m	Glass Fiber kg/m³
NM-30	414	711.21	0	1099.90	0	186	0
M-CS-10	248.4	640.089	71.121	989.91	109.99	186	5
M-CS-20	248.4	568.968	142.242	879.92	219.98	186	5
M-CS-30	248.4	497.847	213.363	769.93	329.97	186	5
M-CS-40	248.4	426.726	284.484	659.94	439.96	186	5

IV. RESULT & DISSCUSSION

Workability of concrete mixes design for slump cone test

Table no. 7Slump Cone Test

Mix designation	Slump Value Vibrators not used (in mm)	Slump Value Vibrators used (in mm)
NM-30	**74**	**30**
G-CS-10	**77**	**31**
G-CS-20	**79**	**33**
G-CS-30	**82**	**35**
G-CS-40	**76**	**32**

Result ;

Mix designation G-CS-30 ,Slump Value Vibrators not used 82mm ,Slump Value Vibrators used 35 mm

Compressive Strength

Table No. 8: Compressive strength for M30 at 7 days.

S. No.	Mix designation	Compressive Strength (in MPa)
1	NM-30	27.80
2	G-CS-10	28.92
3	G-CS-20	31.75
4	G-CS-30	33.60
5	G-CS-40	30.65

Table No. 9; Compressive strength for M30 at 28 days

S. No.	Mix designation	Compressive Strength (in MPa)
1	NM-30	38.65
2	G-CS-10	39.95
3	G-CS-20	42.95
4	G-CS-30	44.15
5	G-CS-40	41.55

Flexural Strength

Table No. 10; Flexural strength for M30 at 28 days.

S. No.	Mix designation	Flexural Strength (in MPa)
1	NM-30	4.33
2	G-BS-10	5.15
3	G-BS-20	5.80
4	G-BS-30	6.90
5	G-BS-40	5.55

V. CONCLUSIONS

The following conclusions are made from the study:

1. The workability of concrete for different percentage replacement of the coarse aggregate in M30 grade concrete with steel Fiber and the fine aggregate with crumb rubber were evaluated in comparison to traditional concrete between Glass Fiber concrete.
2. Mix designationG-CS-30 ,Slump Value Vibrators not used 82mm ,Slump Value Vibrators used 35 mm
3. compressive strength of hardened concrete at 7 & 28 days of curing & compare various mixes.
4. Compressive Strength results is Mix designationM-CS-30, Strength 32.58 MPa Increase strength in 16.99%at 7 days.
5. Compressive Strength results is Mix designation M-CS-30, Strength 44.15MPa at 28days.
6. Flexural strength at 28 days of curing & compare various mixes in the process of testing. FlexuralStrength results isMix designation G-BS-30, Strength 6.90 MPa in at 28 days.

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