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Comparative Analysis on Mechanical Properties of Polymer Concrete by using Various Lightweight Aggregates

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Abstract. The Polymer concrete is first established in the year of 1950s and gained popularity in 1970s repair works, building cladding and floors, as precasts components. The Polymer concrete has found applications in particularly specialised sectors due to its qualities such as high compression strength, quick curings, high specific strengths, and chemical resist. The objective of this experiment is to use destructive and non-destructive experiments to analyse the mechanical behaviour of Polymer concrete using various lightweight aggregates. Using destructive and non-destructive testing, this experiment evaluates mechanical characteristics of a lightweight polymeric concrete comprising four different types of polymeric ratios. The most important component is to reduce weight. Pumice, perlite, vermiculite, saw dust, and rice husk were utilized as light weight aggregates. Destructive tests revealed that raising the polymer ratio increased the compressive, impact strengths, and splitting-tensile, and the energy absorption of light weight polymer concrete. The properties such as ductility, impact energy, energy absorption shows decrease in efficiency. Pumice was discovered to have the best outcomes among the various lightweight aggregates. These study's findings are significant in understanding a performance of Lightweight polymer concrete and ensuring its safe deployment in a engineering applications which requires a high performance of strength to weight ratio material.

Introduction

General

Polymers concrete is a class of concrete-polymer composite that is manufactured by replacing traditional cement hydrate binders with polymer binders. At room or ambient temperature, most liquid resin, as thermosetting resins, methacrylic resin, and tar-modified resin, polymerize to produce polymeric concrete. The binder phase of polymer concrete contains no cement hydrates and is entirely composed of polymers. The aggregates are firmly held together by polymer binder. The advantage and disadvantage of a polymer binders are immediately transferred to polymer concrete. As a consequence, polymer replacement greatly enhances property such as, adhesion, abrasion, strength, chemical resist, watertightness, freeze-thaw durability, and resist in contradiction to ordinary cement concrete.

The potential of polymer concrete research was introduced as early as 1971, when the American Concrete Institute created Committees 548—Polymer in Concrete. The Committees was in charge of establishing a comprehensive database on the characteristics of polymers concrete. The Committees has also provided up-to-date literature on polymer concrete, as well as user manuals. Polymer concretes is defined as "concrete that organic polymer acts as a binder," according to the 'ACI-CT-13', ACI – Concrete Terminology-13 – An ACI Standard. Polymer concretes, to put it

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another way, is a complex material made up of aggregates linked together in matrix using a polymeric binder. It improves concrete strength by reducing porosity.

Materials

Polymer

Table.1. Properties of epoxy resin

Properties	Test methods	Units	Values
Epoxy Equivalent Weight	ASTM D1652	g/eq	185-192
Epoxy Viscosity at 25°C	ASTM D445	P	110-150
Colour	ASTM D1544	Gardner	1 max
Pounds/gallon at 25°C		lbs/gal	9.7
Density at 25°C		g/ml	1.16
Physical form			Clear liquid
Vapour pressure at 77°C		Mm Hg	0.03
Refractive index at 25°C			1.573
Specific heat		BTU/lb/°F	0.5

Table.2. Comparative physical nature of light weight aggregate

Light Weight Aggregate	Specific Gravity	Shape	Density (kg/m$^{3)}$	Bulk Density (kg/m3)	Unit Weight (kg/m3)	Compression Strength (Mpa)
Pumice	0.95	round with open textured	550-1650	350-650	1200-1600	5-15
Perlite	2.4	Round, rough surface	100-400	40-200	400-500	1.2-3
Vermiculite	2.4	cubical	100-400	60-200	300-700	1.2-3
Saw dust	2.29	Arbitrary shape	370-415	190-220	--	--
Rice husk	2.14		--	90-150	83-125	--

From this pumice is found to be more effective than any other light weight aggregates because of having high compressive strength, bulk density, density, unit weight.

Results and Methods

Workability test

Table.3. Slump cone value

Percentage of light weight aggregates	Pumice	Perlite	Vermiculite	Sawdust	Rice Husk
0.5%	52	51	53	52	53.5
1%	53.5	50.5	52.5	51.5	52
1.5%	52.5	50	51	50	51
2%	50	49	50.5	49	50.5
2.5%	49.5	48.5	49	49.5	49

This table shows the slump value of polymer concrete with various light weight light weight aggregates such as perlite, vermiculite, pumice, rice husk, sawdust. Here the slump value of polymer concrete increases when the percentage of light weight aggregates increases.

Mechanical properties

Table.4. Compressive strength of polymer concrete

Percentage of light weight aggregates	Pumice	Perlite	Vermiculite	Sawdust	Rice Husk
0.5%	16.52	16.20	16.38	16.32	16.35
1%	18.89	18.56	18.26	18.35	18.78
1.5%	21.67	21.32	21.59	21.65	21.56
2%	23.45	22.98	22.81	22.92	22.87
2.5%	22.5	22.54	22.35	22.25	22.15

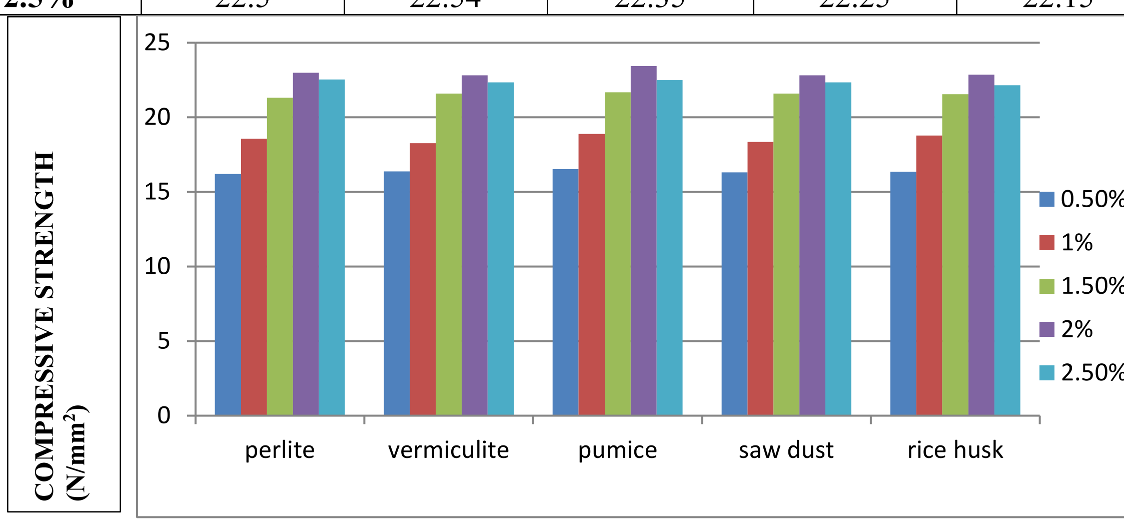


Figure.1. Compression strength of polymer concrete

This table shows the comparative representation of compression strength of a polymeric concrete with light weight aggregate perlite, vermiculite, pumice, sawdust, rice husk. The polymer concrete with pumice aggregates shows higher compressive strength than any other light weight aggregates. The value keeps on increasing as the light weight aggregate percentage increases. The compressive strength of 23.45(N/mm^2) shows when the percentage of light weight aggregates is 2% then it starts slightly to decreases. Then the polymer concrete with light weight aggregates such as perlite, vermiculite, saw dust, rice husk, shows decrease in the compression strength.

Table.5. Split-tensile strength of polymer concrete

Percentage of light weight aggregates	Pumice	Perlite	Vermiculite	Sawdust	Rice Husk
0.5%	2.5	2.45	2.31	2.30	2.25
1%	2.7	2.67	2.51	2.38	2.28
1.5%	3.1	3.1	2.98	2.83	2.75
2%	3.0	2.95	2.79	2.71	2.67
2.5%	2.9	2.88	2.81	2.72	2.66

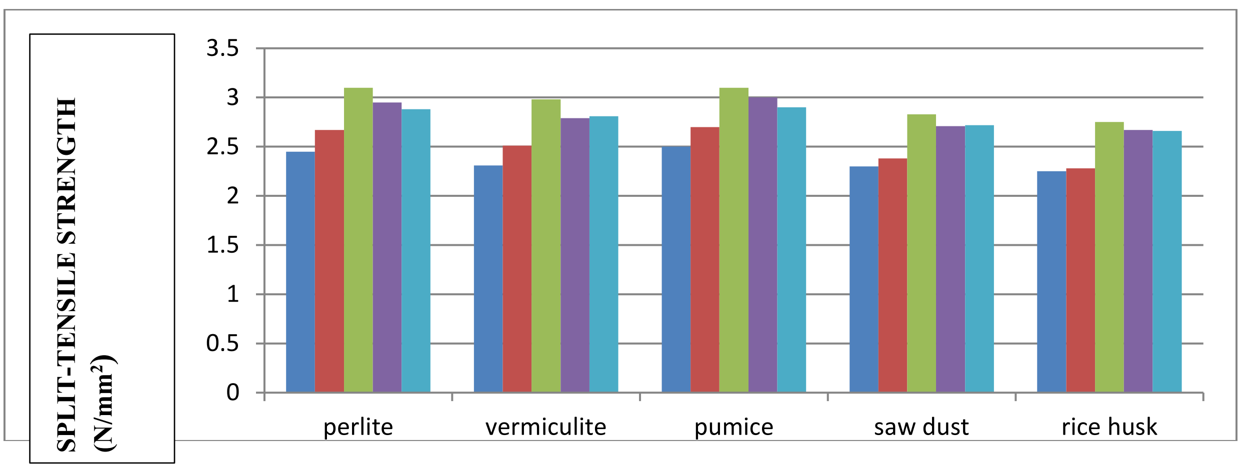
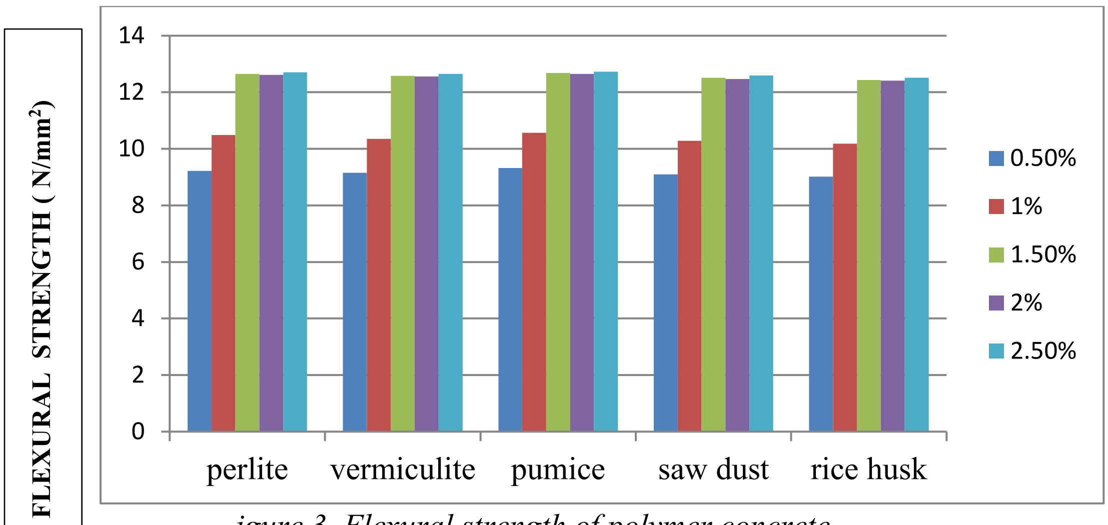


Figure.2. Split-tensile strength of polymer concrete

This table shows the properties of the Split-Tensile strength of a polymer concretes with light weight aggregate perlite, vermiculite, pumice, sawdust, rice husk. The polymer concrete with pumice aggregates shows higher Split-Tensile strength than any other light weight aggregates. The value keeps on increasing as the light weight aggregate percentage increases. The split-Tensile strength of 3.0(N/mm^2) shows when the percentage of light weight aggregates is 2% then it starts slightly to decreases. Then the polymer concrete with light weight aggregates such as perlite, vermiculite, saw dust, rice husk, shows decreases in the Split-tensile strength.

Table.6. Flexural strength of polymer concrete

Percentage of light weight aggregates	Pumice	Perlite	Vermiculite	Sawdust	Rice Husk
0.5%	9.32	9.22	9.15	9.10	9.02
1%	10.57	10.49	10.35	10.28	10.18
1.5%	12.68	12.65	12.58	12.51	12.43
2%	12.65	12.61	12.56	12.47	12.41
2.5%	12.73	12.71	12.65	12.59	12.51



igure.3. Flexural strength of polymer concrete

This table shows a value of flexural strength of a polymeric concrete with the light weight aggregate perlite, vermiculite, pumice, sawdust, rice husk. The polymer concrete with pumice aggregates shows higher flexural strength than any other light weight aggregates. The value keeps on increasing as the light weight aggregate percentage increases. The flexural strength of 12.73(N/mm^2) shows when the percentage of light weight aggregates is 2.5%. Then the polymer concrete with light weight aggregates such as perlite, vermiculite, saw dust, rice husk, shows a gradual decrease in the flexural strength

Table.6. Pulse velocity of polymer concrete

Percentage of light weight aggregates	Pumice	Perlite	Vermiculite	Sawdust	Rice Husk
0.5%	4.23	4.21	4.16	4.11	4.01
1%	6.72	6.67	6.52	6.48	6.42
1.5%	6.78	6.73	6.68	6.61	6.53
2%	5.37	5.35	5.31	5.27	5.21
2.5%	5.29	5.24	5.21	5.18	5.15

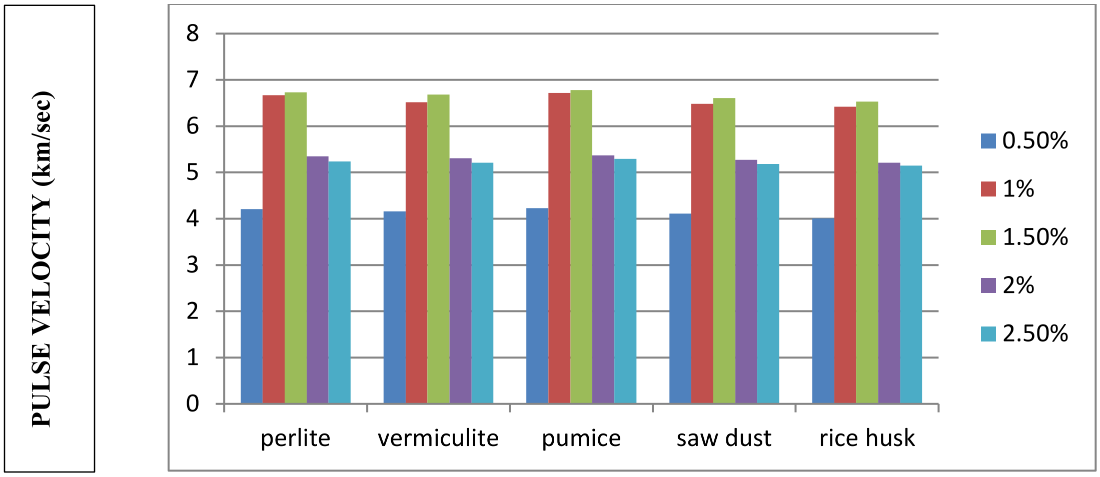


Figure.4. Pulse velocity of polymer concrete

This table shows a value of a pulse velocity of a polymer concrete with a light weight aggregate perlite, vermiculite, pumice, sawdust, rice husk. The polymer concrete with pumice having the pulse velocity greater than any other light weight aggregates. The value keeps on increasing as the light weight aggregate percentage increases. The pulse velocity of 6.78(km/sec) shows when the percentage of light weight aggregates is 1.5% then it starts slightly to decreases. Then the polymer concrete with light weight aggregates such as perlite, vermiculite, saw dust, rice husk, shows decrease in the value of pulse velocity.

Conclusion

- The physical property of pumice shows that the it has better density, bulk density, unit weight and the compression strength.
- The use of pumice in the polymer concrete reduces the density by 20% compared to normal polymer concrete.
- Compression strength is find as maximum for polymer concrete with the pumice aggregate of 1.5% as the substitution of fine aggregate.
- Split-tensile strength is find to be maximum for the polymer concrete with the pumice aggregate of 1.5% as the substitution t of fine aggregate.
- Flexural strength is found to be maximum for the polymer concrete with the pumice aggregate of 1.5% as the substitution t of fine aggregate.
- Pulse velocity is found to be maximum for the polymer concrete with the pumice aggregate of 1.5% as the substitution of fine aggregate**.**
- When compare to a Portland cement, polymer concretes has high compression and flexural strength. Compressive strengths of 70 to 120 Mpa have been noted.
- LWPC has a lesser density than PC, around 20% lower. This can improve to lower the total cost of construction as well as the structural damage caused by particular types of loads (eg. earthquakes).
- Increase the polymers content of LWPC specimens ranges from 11% to 14% improves mechanical characteristics, ductility, and energy absorption, with improvements of 56% in splitt tensile strength, 34% in compressive strengths, 68% in energy absorptions, and 53% in flexural strengths,
- As a polymer content increases, rate of increase in a compression strength reduces, and the compression strength of 14% polymer content show only a little difference. The porosity

of specimens decreases as polymeric content rises, according to non-destructive examinations.

- It's well known that polymer concretes has considerably superior mechanical characteristics and durabilities than traditional Portland cement concretes. Because of its superior mechanical qualities and a durability, polymer concretes has been prove to be a promising material.
- The mechanical characteristics of LWPC and their fluctuation with temperature were discussed in this work. Although the findings are encouraging, they also highlight the significance of careful LWPC design and execution, as the material's mechanical characteristics can deteriorate dramatically under specific situations.

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