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Study on Strength and Durability Characteristics of Light Weight Aggregate Concrete

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KEYWORDS
Light Weight Aggregates, Environmental Waste, Durability, Mechanical strength

ABSTRACT:
This study focuses on lightweight concrete (LWC), Although the majority of studies on LWC focus on "semi-lightweight" concrete, which is made with lightweight coarse aggregate and natural sand to create "totally lightweight" concrete, using waste materials in place of the fine light weight aggregate can have more positive environmental and financial effects. Synthetic lightweight aggregate made from environmental waste is a possible new supply of structural aggregate material as concerns about the overuse of natural aggregates grow. The self-load of a structure was significantly lowered when structural grade lightweight concrete was used . In this work, the mechanical and durability characteristics of a structural grade lightweight aggregate are investigated and reported. Test programme includes the test of conventional or normal weight concrete, light weight aggregate concrete for compressive strength , split tensile strength, Flexural strength and durability test after 28 and 90 days curing

I. INTRODUCTION

Investigations are conducted in the current study to examine the fundamental workability and strength characteristics of lightweight aggregate concrete. For lightweight aggregate concrete, the material qualities are established first, followed by the mix design, workability, compressive strength, and durability attributes.

Today, concrete is by far the most used construction material. Its extensive usage is partly due to the material's adaptability and moldability, high compressive strength, and the development of procedures for pre-stressing and reinforcing, which helped to compensate for its weak tensile strength.

Numerous researchers have attempted to alter the characteristics of typical concrete to meet specific requirements. On the quality of the raw materials used to make concrete, the adjustments were tested. Instead of making any initial changes to the usual materials employed, several additions and admixtures were explored. Although some technicians disapprove of the use of admixtures and additions, many, on the other hand, strongly advocate for it and support its growth since it gives concrete many desirable properties and promotes economy.

The low density of light weight aggregate concrete is a clear distinguishing feature. Having low density has a lot of benefits. It aids in reducing dead load, accelerates construction, and decreases transportation and handling expenses. Construction of towering, weighty structures on weak soils has been made possible by the use of lightweight materials. Lightweight concrete floors and walls will result in significant cost savings in framed constructions. The use of light weight aggregate concrete with low thermal conductivity will be of great benefit from the point of view of thermal

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comforts and lower power consumption in extreme climatic conditions as well as in the case of buildings with air conditioning. This property improves with decreasing density, making it one of the most significant characteristics of light weight aggregate concrete. When low weight aggregate concrete is used, industrial wastes like cinder, fly ash, slag, and others that are difficult to dispose of have a place to go.All these tend to show that structural light weight concrete can provide an alternative construction material both in terms of economic cost and engineering performance.

AIM OF THE PRESENT STUDY:

In real use, the lightweight quality of concrete is obtained by substituting cellular porous or lightweight aggregate for the typical mineral aggregate. This study aims to investigate the production of Lightweight Aggregate Concrete utilizing naturally occurring Pumice aggregates with the addition of Micro silica, Perlite, and Super plasticizer.

The investigation and comparison of the behaviors of lightweight aggregate concrete (LWAC) and normal weight aggregate concrete (NWAC) is the primary goal of this study. The study also focused on the impact of the physical characteristics of the aggregates on the development of strength. By substituting normal weight aggregate and fine aggregate in varying volume fractions, such as M1 Concrete Mix (i.e., 0% Pumice, Perlite, and Micro silica), and M2 Concrete Mix (i.e., 50% Granite + 50% Pumice, 50% Fine Aggregate + 50% Perlite, and 10% Micro silica), we can introduce the use of pumice as coarse aggregate and perlite as fine aggregate in concrete.

Natural Light Weight Aggregates:

There are several natural light weight aggregates available, prominent among them are:

Pumice, Diatomite, Volcanic cinders, Saw dust.

Artificial Light Weight Aggregates:

There are some artificial light weight aggregates produced. Some of them are :

Artificial cinder, Clinker, Foamed slag, expanded Clay, expanded Shale.

II. EXPERIMENTATION:

Varying the percentage of Micro Silica, Pumice and perlite content, 2 mixes were tried to study the effect of replacement of crushed stone aggregate and fine aggregate with pumice and perlite respectively on the properties of concrete. For each mix 27 Big cubes,27 Small cubes, 18 cylinders and 18 beams were casted and were tested after 28 days, 90 days and 360 days curing.

Test programme includes the test of conventional or normal weight concrete, light weight aggregate concrete for compressive strength , split tensile strength, Flexural strength and durability test after 28 and 90 days curing.

Specimens: The specimens consisted of:

1. Compressive strength –cubes of 150x150x150 mm size
2. Split tensile strength – cylinders of 150x300 mm size
3. Flexure strength – beams of 100x100x500 mm size
4. Durability test– cubes of 100x100x100 mm size
5. Concrete Mix proportion

OBJECTIVES OF THE EXPERIMENTAL STUDY:

i) To create lightweight aggregate concrete mixes with a desired compressive strength while using the least amount of cement possible.
ii) To create light weight aggregate concrete mixes with the lowest feasible water/binder ratio.
iii) To research the fundamental strength and workability characteristics of lightweight aggregate concrete

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III. RESULTS AND DISCUSSION

3.1. DESIGN MIX

3.1.1.Mix Proportions of Concrete mixes in NWAC &LWAC

Type of Concrete	W/BRatio	Binder		F.A		C.A	
		Cement	Microsilica	Riversand	Perlite	20mmHBG metal	Pumice
NWAC (100% Granite)	0.27	1	0	1.137		2.206	
Design Mix (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	0.27	0.90	0.10	0.5685	0.5685	1.103	1.103

3.1.2 Quantities of Materials required per 1 m^3 of NWAC & LWAC

Type of Concrete	W/B Ratio	Waterin Kg	Binder		Super Plasticizerin Kg	F.A		C.A	
			Cement	Micro Silica		Riversand	Perlite	20mmHBG metal	Pumice
NWAC (100% Granite)	0.27	155.00	575.00	0	0	653.00	0	1268.00	0
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	0.27	155.00	518.00	57.00	12.00	5.00	6.00	10.788	11.984

3.2 TRAIL MIXES

3.2.1 Percentages of Admixtures of Concrete Mixes in Trail Mixes

Mix	W/B Ratio	Binder		Fine aggregate		Coarse Aggregate		Super Plasticizer
		% of Cement	% of Micro Silica	% ofRiver Sand	% of Perlite	% ofC.A	% of Pumice	
TrailMix-1 NWAC	0.30	100.00	0.00	100.00	0.00	100.00	0.00	0.00
Trail Mix-2 LWAC	0.30	0.900	0.10	50.00	50.00	50.00	50.00	0.00

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Trail Mix-3 NWAC	0.27	100.00	0.00	100.00	0.00	100.00	0.00	2.00
Trail Mix-4 LWAC	0.27	0.900	0.10	50.00	50.00	50.00	50.00	2.00

3.3.2 Test Results of Concrete mixes in Trail Mixes

Type of Concrete	W/BRatio	% of Cement	%of Microsilica	% of Super plasticizer(Master Glenium SKY8233 v2)
NWAC (100% Granite)	0.27	100	0	0
Design Mix-LWAC (50% C.A&50% Pumiceand 50%F.A& 50% Perlite)	0.27	90	10	2%

Mix	Type of Concrete	Slump	Unit Weight	28 Days CompressiveStrength(Mpa)
Trail Mix-1	NWAC	20mm	2300	56.50
Trail Mix-2	LWAC	17mm	2030	30.50
Trail Mix-3	NWAC	11mm	2280	77.23
Trail Mix-4	LWAC	10mm	2000	36.42

3.3 Mix Proportions

3.3.1 Percentages of Mineral Admixtures of NWAC & LWAC

3.3.2 Mix Proportions of Concrete mixes in NWAC & LWAC

Type of Concrete	W/BRatio	Binder		F.A		C.A	
		Cement	Microsilica	Riversand	Perlite	20mmHBG metal	Pumice
NWAC (100% Granite)	0.27	1	0	1.137		2.206	

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Design Mix (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	0.27	0.90	0.10	0.5685	0.5685	1.103	1.103

3.3.3 Quantities of Materials required per 1 m^3 of NWAC(Normal Weight AggregateConcrete)&LWAC (Light Weight Aggregate concrete)

Type of Concrete	**W/B Ratio**	**Water in Kg**	**Binder**		**Super Plasticizer in Kg**	**F.A**		**C.A**	
			Cement	**Micro Silica**		**Riversand**	**Perlite**	**20mmHBG metal**	**Pumice**
NWAC (100% Granite)	0.27	155.00	575.00	0	0	653.00	0	1268.00	0
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	0.27	155.00	518.00	57.00	12.00	5.00	6.00	10.788	11.984

3.4 Fresh Concrete properties of Concrete Mixes

3.4.1 Workability of fresh concrete mixes in NWAC (Normal Weight AggregateConcrete)&LWAC (Light Weight Aggregate concrete)

Type of Concrete	**Slump value in mm**
NWAC (100% Granite)	10mm
LWAC (50% C.A&50% Pumice and50%F.A& 50% Perlite)	10mm

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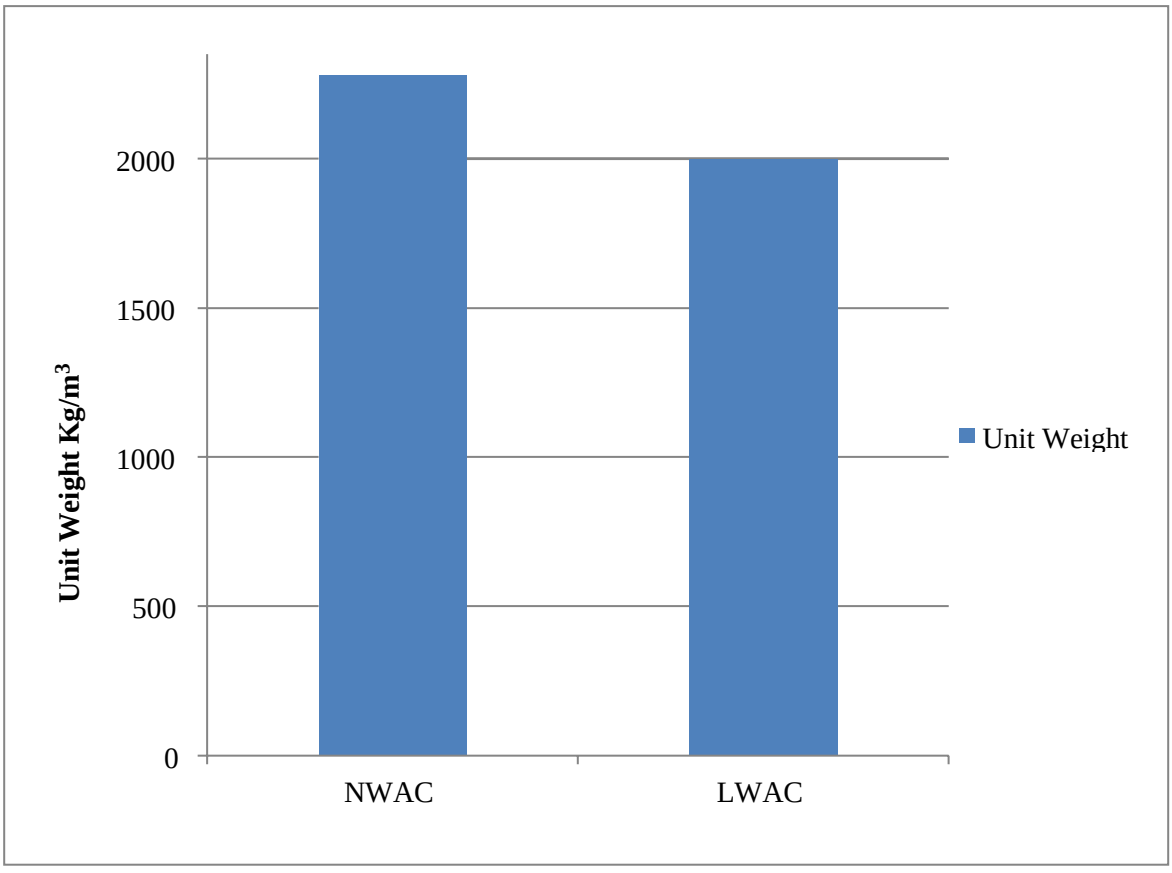
3.4.2Unit Weight of NWAC & LWAC

Type of Concrete	Unit Weight (Kg/m^3)
NWAC (100% Granite)	2280.00
LWAC (50% C.A&50% Pumice and50%F.A& 50% Perlite)	2000.00



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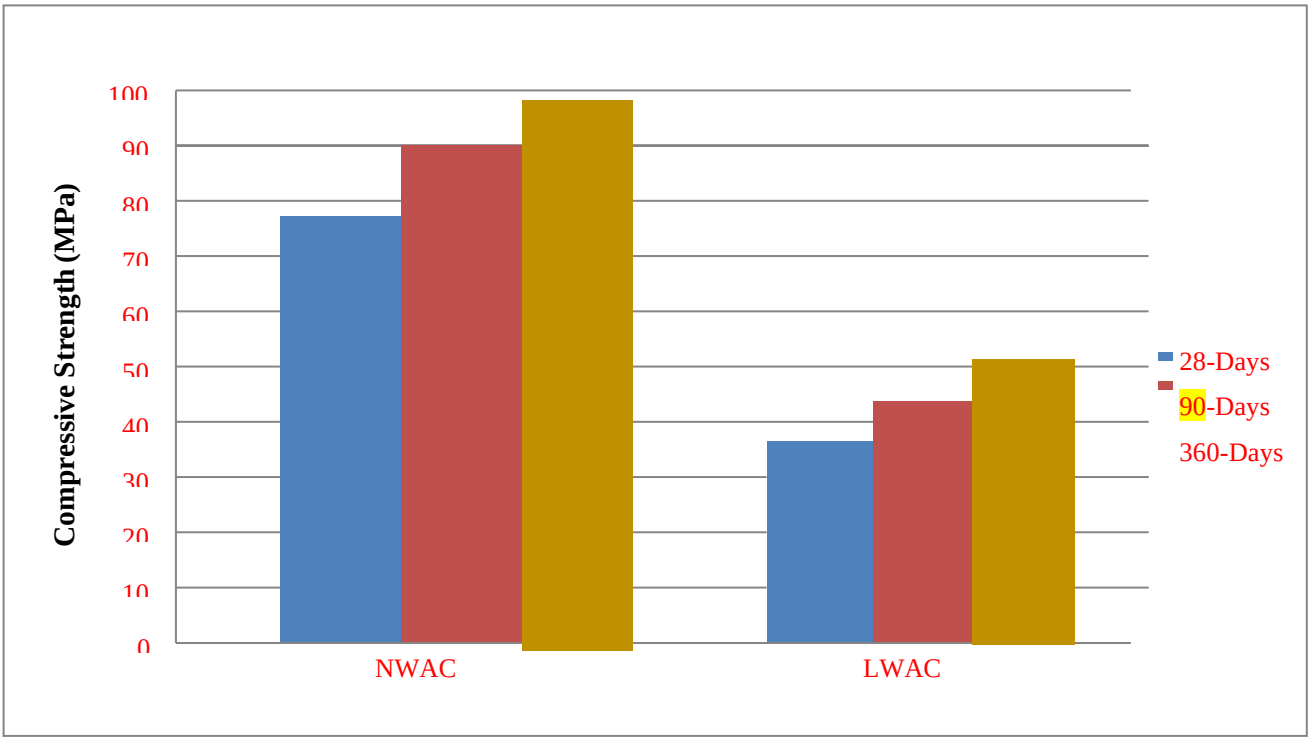
3.5 Compressive strength of NWAC(Normal Weight AggregateConcrete)&LWAC (Light Weight Aggregate concrete)

3.5.1 Compressive strength of NWAC(Normal Weight Aggregate Concrete)&LWAC(Light Weight Aggregate concrete)at Age of 28 & 90 Days&360 Days

Type of Concrete	28-Days Compressive Strength (MPa)	90-Days Compressive Strength (MPa)	easeof strength
NWAC (100 % Granite)	77.23	90.05	16.60%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	36.42	43.70	20.00%



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3.6 Split Tensile strength of Concrete Mixes

3.6.1 Split Tensile strength of NWAC(Normal Weight Aggregate Concrete)&LWAC (Light Weight Aggregate concrete) at Age of 28 & 90 Days

Type of Concrete	28-Days Compressive Strength (MPa)	360-Days Compressive Strength (MPa)	Increase of strength
NWAC (100 % Granite)	77.23	92.67	19.99%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	36.42	47.42	30.20%

Type of Concrete	28-Days Split Tensile Strength (MPa)	90-Days Split Tensile Strength (MPa)	Increase of strength
NWAC (100 % Granite)	3.32	4.01	20.78%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	2.75	3.12	13.45%

Type of Concrete	28-Days Split Tensile Strength (MPa)	360-Days Split Tensile Strength (MPa)	Increaseof strength
NWAC (100 % Granite)	3.32	4.10	23.50%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	2.75	3.60	30.90%

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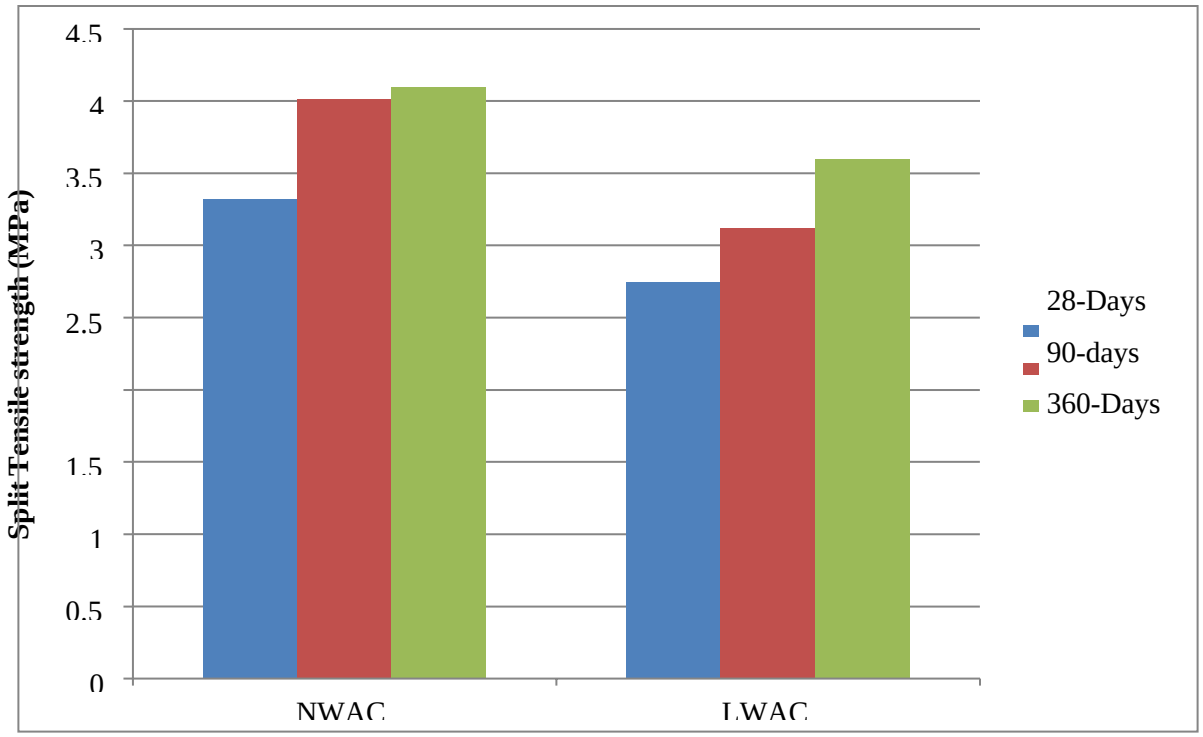

3.7 Flexural strength of Concrete Mixes

3.7.1 Flexural strength of NWAC(Normal Weight Aggregate Concrete)&LWAC(Light Weight Aggregate concrete) at Age of 28 & 90 Days

Type of Concrete	**28-DaysFlexural Strength (MPa)**	**90-DaysFlexural Strength (MPa)**	**easeof strength**
NWAC (100 % Granite)	6.90	8.35	21.00%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	4.46	5.00	12.10%

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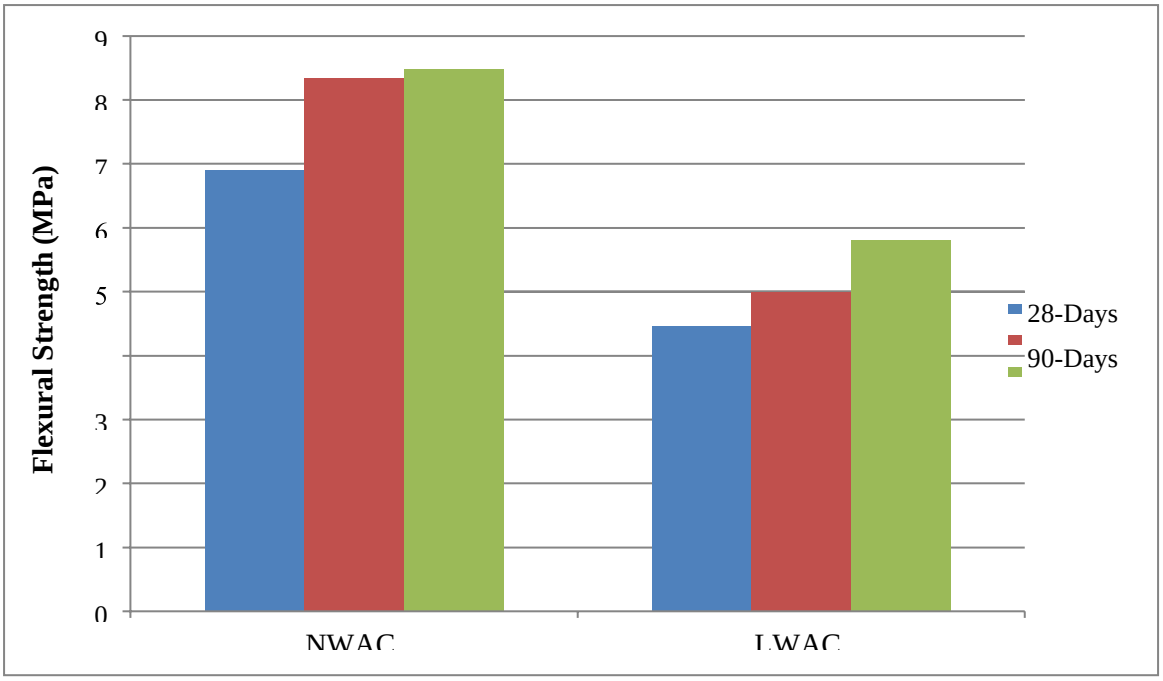
Type of Concrete	28-Days Flexural Strength (MPa)	360-Days Flexural Strength (MPa)	Increaseof strength
NWAC (100 % Granite)	6.90	8.48	22.90%
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	4.46	5.80	30.00%



3.8 Durability properties of NWAC (Normal Weight Aggregate Concrete)&LWAC (Light Weight Aggregate concrete) at 28 days

Table: 3.8.1

Type of Concrete	Average weightWithout Chemical immersion	f Chemical(5%)	Reduction in weight After 28 days Chemical immersion
NWAC (100 % Granite)	2.18 Kg	HCL	2.56 Kg
	2.563 kg	H_2SO_4	2.32 kg

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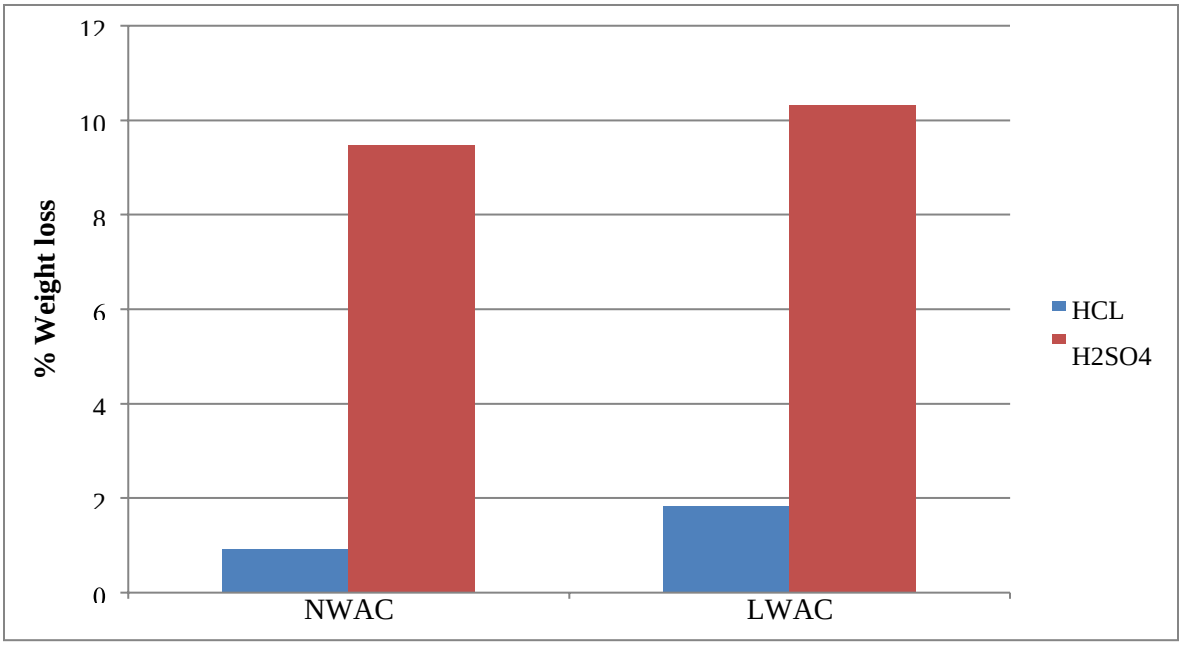
Table: 3.8.2

Type of Concrete	Average weightWithout Chemical immersion	sage of Chemical(5%)	Reduction in weightAfter 28 days Chemical immersion
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	2.18 kg	HCL	2.14 kg
	2.23 kg	H_2SO_4	2.00 kg

3.8.3 Comparison of percentage weigh loss of concrete mixes after 28-daysimmersion in chemicals

Age	28-Days	
Chemical	**HCL**	**H_2SO_4**
NWAC (100% Granite)	0.92 %	9.48 %
LWAC (50% C.A&50% Pumice and50%F.A& 50% Perlite)	1.83 %	10.31 %



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3.8.4 Compressive Strength of Normal Weight Aggregate Concrete at 28 DaysWith & Without Chemical immersion

3.8.5 Compressive strength of Specimen at 28 Days Without & With Different Chemical immersion Light Weight Aggregate Concrete Mix (50 % Granite & 50% pumiceand 50%River sand&50%pumice)

Type of Concrete	Compressivestrength Without Chemical immersion	sage of Chemical(5%)	Reduction of Compressive strength After 28 days Chemical immersion
NWAC (100% Granite)	77.23 N/mm^2	HCL	67.54 N/mm^2
	77.23 N/mm^2	H_2SO_4	29.35 N/mm^2

Type of Concrete	Compressivestrength Without Chemical immersion	sage of Chemical(5%)	Reduction Compressive strength After 28 days Chemical immersion
LWAC (50% C.A&50% Pumice and 50%F.A& 50% Perlite)	36.42 N/mm^2	HCL	33.37 N/mm^2
	36.42 N/mm^3	H_2SO_4	22.36 N/mm^3

3.8.6 Comparison of percentage Compressive Strength loss for concrete mixesafter 28 days immersion in HCI & H_2SO_4

Age	**28 Days**	
Chemical	**HCL**	**H_2SO_4**
NWAC (100% Granite)	12.54%	61.99%
LWAC (50% C.A&50% Pumice and50%F.A& 50% Perlite)	8.37%	38.60%

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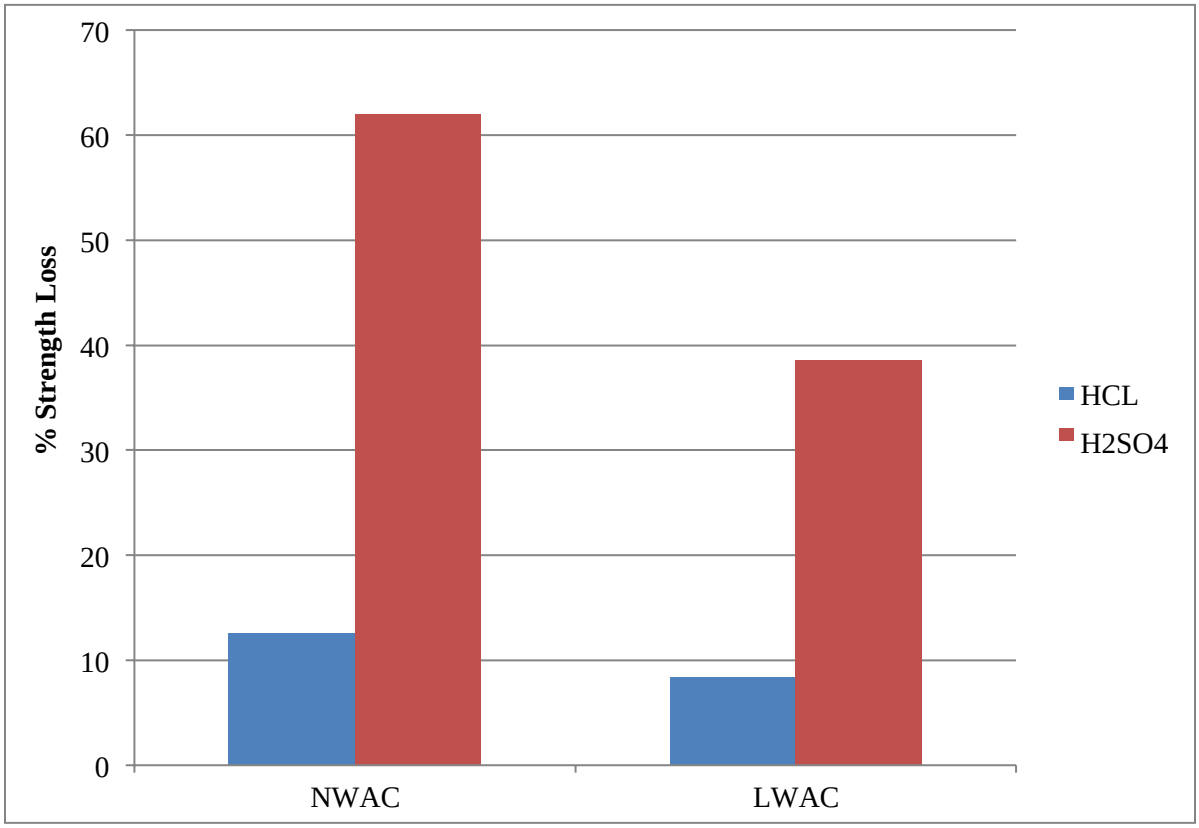

3.9 Durability properties of Concrete mixes at 90 days

3.9.1 Average Weight of Specimen at 90 Days With and Without DifferentChemical immersion for NWAC

Type of Concrete	Average weightWithout Chemical immersion	osage of Chemical(5%)	Reduction in weight After 90 days Chemical immersion
NWAC (100 % Granite)	2.632 Kg	HCL	2.583 Kg
	2.613 kg	H_2SO_4	2.166 kg

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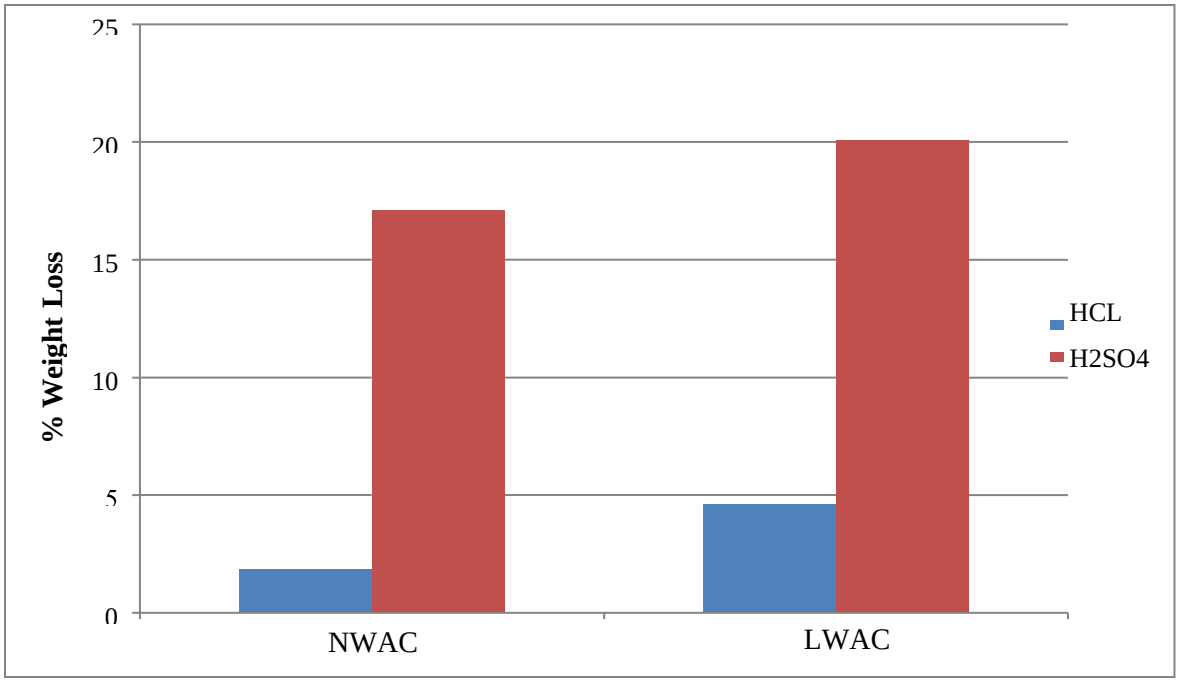
3.9.2 Average Weight of Specimen at 90 Days Without & With Different Chemicalimmersion of Light Weight Aggregate Concrete

Type of Concrete	Average weightWithout Chemical immersion	f Chemical(5%)	Reduction in weight After 90 days Chemical immersion
LWAC (50% C.A&50% Pumice and	2.184 Kg	HCL	2.083 Kg
50%F.A& 50% Perlite)	2.193 kg	H_2SO_4	1.753 kg

3.9.3 Comparison of percentage weigh loss results of concrete mixes after 90 daysimmersion in HCI & H_2SO_4

Age	90 Days	
Chemical	HCL	H_2SO_4
NWAC (100% Granite)	1.86 %	17.10%
LWAC(50% C.A&50% Pumice and50%F.A& 50% Perlite)	4.62%	20.06 %



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3.9.4 Compressive Strength of Specimen at 90 Days Without & With DifferentChemical immersion for Normal Weight Aggregate Concrete

Age	**90-Days**	
Chemical	HCL	H_2SO_4
NWAC (100% Granite)	20.00 %	71.66 %
LWAC (50% C.A&50% Pumice and50%F.A& 50% Perlite)	18.94 %	66.01 %

Type of Concrete	**Compressivestrength Without Chemical immersion**	**Dosage of Chemical(5%)**	**Reduction in Compressive strength After 90 days Chemical immersion**
NWAC (100% Granite)	90.05 N/mm^2	HCL	72.04 N/mm^2
	90.05 N/mm^2	H_2SO_4	25.52 N/mm^2

3.9.5 Compressive Strength of Specimen at 90 Days Without & With DifferentChemical immersion for Light Weight Aggregate Concrete(LWAC)

Type of Concrete	**Compressive strength Without Chemical immersion**	**f Chemical(5%)**	**Reduction in Compressive strength After 90 days Chemical immersion**
LWAC (50% C.A&50% Pumice and	43.70 N/mm^2	HCL	35.42 N/mm^2
50%F.A& 50% Perlite)	43.70 N/mm^2	H_2SO_4	14.85 N/mm^2

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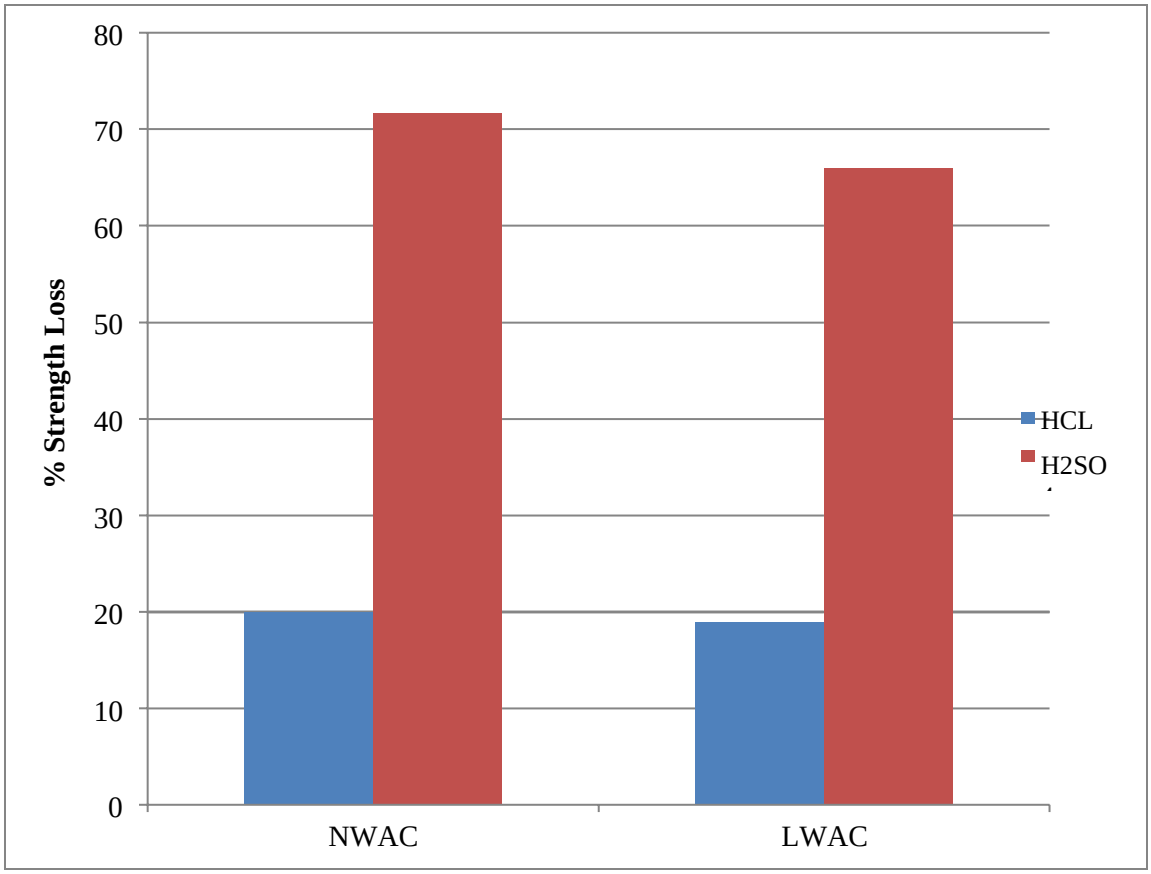
3.9.6 Comparison of percentage Compressive Strength loss results for concretemixes after 90 days Curing in HCI & H_2SO_4



IV. CONCLUSION

The following conclusions are drawn from the Experimental Investigation in present thesis:

- The Unit weight values of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 2280 Kg/m^3 and 2000 Kg/m^3 respectively.
- The Unit Weight of Lightweight Aggregate Concrete (LWAC) mixes with 50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite is found to be 14.00 % less than Normal Weight Aggregate Concrete (NWAC) mix.
- The compressive strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 77.23MPa and 36.42MPa at 28 days respectively.
- The compressive strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 90.05MPa and 43.70 MPa at 90 days respectively.
- The compressive strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 92.67MPa and 47.42MPa at 360 days respectively.
- The development of compressive strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 90 days increased by 16.60 % and 20.00 % compared to 28 days respectively.

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- The development of compressive strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 360 days increased by 19.99 % and 30.20 % compared to 28 days respectively.
- The percentage increase of compressive strength of Lightweight Aggregate Concrete (LWAC) mixes with 50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite is similar to Normal Weight Aggregate Concrete (NWAC) mix.
- The split tensile strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 3.32MPa and 2.75MPaat 28 days respectively.
- The split tensile strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 4.01MPa and 3.12 MPa at 90 days respectively.
- The split tensile strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 4.10MPa and 3.60MPaat 360 days respectively.
- The development of split tensile strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 90 days increased by 20.78 % and 13.45 % compared to 28 days respectively.
- The development of split tensile strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 360 days increased by 23.50 % and 30.90 % compared to 28 days respectively.
- The Flexural strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 6.90MPa and 4.46MPaat 28 days respectively.
- The Flexural strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 8.35MPa and 5.00MPaat 90 days respectively.
- The Flexural strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) concrete mixes are 8.48MPa and 5.80MPaat 360 days respectively.
- The development of Flexural strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 90 days increased by 21.00 % and 12.10 % compared to 28 days respectively.
- The development of Flexural strength of NWAC (100 % Granite) and LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) mixes at 360 days increased by 22.90 % and 30.00 % compared to 28 days respectively.
- The percentage increase of Flexural Strength of Lightweight Aggregate Concrete (LWAC) mixes with 50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite is similar Normal Weight Aggregate Concrete (NWAC) mix.
- The percentage weigh loss of Lightweight Aggregate Concrete (LWAC) mixes with 50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite was higher while compare with Normal Weight Aggregate Concrete (NWAC) mix in 5 % HCL & H_2SO_4 solutions.
- The Compressive Strength of NWAC (100 % Granite) specimen after 28 days immersed in HCL & H_2SO_4 are 67.54MPa and 29.35MPa respectively.
- The Compressive Strength of LWAC (50% Granite+50% Pumice & 50%Fine Aggregate+50% Perlite) specimen after 28 days immersed in HCL & H_2SO_4 are 33.37MPa and 22.36MPa respectively.
- The Compressive Strength of NWAC (100 % Granite) specimen after 90 days immersed in HCL & H_2SO_4 are 72.04MPa and 25.52MPa respectively.
- The Compressive Strength of LWAC (50% Granite+50 % Pumice & 50%Fine Aggregate+50% Perlite) specimen after 90 days immersed in HCL & H_2SO_4 are 35.42MPa and 14.85 MPa respectively.
- The percentage compressive strength loss of Lightweight Aggregate Concrete (LWAC) mixes with 50 % Pumice and 50% Perlite is lesser while compare with Normal Weight Aggregate Concrete (NWAC) mix in 5 % HCL & H_2SO_4

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solutions, because of the improved interfacial zone between the mortar matrix and pumice aggregates.

From the above study, it is recommend that Light Weight Aggregate Concrete (LWAC) will be suitable for partition walls, floor screens / roofing and panel material in auditoriums etc.

Because of Light Weight Aggregate Concrete (LWAC) Lighter than Normal Weight Aggregate Concrete (NWAC), it is also useful in design of earthquake resistant structure

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