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Residual Compressive Strength of Light Weight Concrete at Elevated Temperatures

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Abstract: The disadvantage of conventional concrete is high self-weight of it, this heavy self-weight makes it an uneconomical structural material. the most purpose of this study is to research and compare the behavior of lightweight aggregate concrete and normal weight aggregate concrete and also the study focused on influence of the Physical properties of aggregates in resistance development. The study concentrates mainly on studying the properties of residual compressive strength of LWAC for W/C ratio 0.27 at 200, 400, 600, 800, and 1000-degree temperatures. the most test parameters involved during this shows are Temperature ranges and time of Exposure. The tests were conducted for a complete of 120 specimens on W/C ratios 0.27 of sunshine Weight Aggregate Concrete at different temperatures like temperature 2000 C, 4000 C, 6000 C, 8000 C and 10000 C at 4, 8, and 12 hours.

Keywords:Light Weight Concrete, Elevated Temperatures, Pumice Aggregate, Perlite, Muffle Furnace.

I. INTRODUCTION

During the 20th century, concrete has emerged because of the material of choice for contemporary infrastructural needs. It has occupied a singular position among modern construction materials. One of the disadvantages of conventional concrete is high self -weight of it. A Density of normal concrete is in the order of 2,200 Kg/ to 2600Kg/ This heavy self-weight makes it an uneconomical structural material, and requires a larger area of cross-sections.

Lightweight pumice aggregate concrete provides a solution to these problems. Lightweight aggregates have been used worldwide to manufacture concrete over the decades. Researches show that the use of natural lightweight aggregates (e.g., diatomite, pumice, volcanic scoria, sawdust, oil palm shells, and bottom ash) instead of processed artificial aggregates (e.g., expanded shale, slate, perlite, sintered fly ash, bonded fly ash, and vermiculite) can significantly reduce the cost of such concrete. Volcanic materials such as pumice and volcanic ash (VA) can be found in many places around the world. Finding new and improved ways to build with such natural resources is becoming widespread and their use as construction materials can lead to low-cost and sustainable construction. The use of volcanic pumice (VP), pumice, and perlite as additives were found to provide excellent resistance to freezing and thawing of cement pastes, mortar, and concrete. Lightweight concrete with aggregates (such as pumice and slag) had shown its suitability of use in load-bearing structures with satisfactory resistance against salt attack/steel corrosion.

II. SCOPE OF THE PRESENTSTUDY:

The property of lightweight to concrete is achieved in actual practice by replacing the usual mineral aggregate by cellular porous or lightweight aggregate. In this study an attempt has been made to study the using of naturally available Pumice aggregates with the addition of Micro silica and Super plasticizer, to produce Lightweight aggregate concrete (LWAC).

The main purpose of this study is to investigate and compare the behavior of lightweight aggregate

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concrete (LWAC) and normal weight aggregate concrete (NWAC) and also the study focused on influence of the physical properties of the aggregates on strength development. Introducing the use of Pumice as coarse aggregate in concrete by replacing normal weight aggregate in three differing volume fractions, like M_1 Concrete mix (i.e., 0 % Pumice, 0% perlite and 0% microsilica), M_2 Concrete mix (50 % CA replaced by Pumice, 50% FA replaced by Perlite and 10% of cement replaced by microsilica).

The original conventional concrete mix design is adopted using IS methods and addition/replacement of lightweight aggregate is done on volumetric basis and trail mixes are tested. Also, to study the properties of lightweight aggregate concrete such as workability of fresh concrete and Residual Compressive strength of light weight concrete for W/B ratio 0.27 at elevated temperatures.

III. MATERIALS

- **Cement:**Ordinary Portland cement of 53 Grade (Ultra Tech Brand) available in local market conforming to IS 12269-1987 was used in the investigation. Specific gravity of cement is 3.15.
- **Fine Aggregate:**In the present investigation locally available river sand was used as fine aggregate with specific gravity 2.647.
- **Coarse Aggregate (Granite):**Machine Crushed angular granite metal of 20mm size from the local source was used as coarse aggregate with fineness modulus 7.046 and specific gravity 2.67.
- **Coarse Aggregate(Pumice):**The Lightweight coarse aggregate used in this study were all-natural pumice stone of maximum size 25mm, which is presoaking for 24hr"s in water (i.e. Pumice as partially saturated before batching the concrete), with specific gravity for oven dry pumice is 0.688, normal dry pumice is 0.931 and saturated surface dry pumice is 1.158.

Fig.3.1 Pumice Stone

- **Perlite:**Water trapped in the structure of the material vaporizes and escapes, and this causes the expansion of the material to 7–16 times its original volume. The expanded material is a brilliant white, due to the reflectivity of the trapped bubbles. Unexpanded ("raw") perlite has a bulk density around 1100 kg/m^3 (1.1 g/cm^3), while typical expanded perlite has a bulk density of about 30– 150 kg/m^3(0.03–0.150g/cm^3).

Fig. 3.2 Perlite

IV. EXPERIMENTAL INVESTIGATION:

Compressive strength of concrete can be defined as the measured maximum resistance of a concrete to axial loading. Compression test is the most common test used to test the hardened concrete specimens because the testing is easy to make. Generally, specimen of 150 x 150 x 150 mm size is used to determine the compressive strength. The determination of compressive strength has received a large amount of attention because the concrete is primarily meant to withstand compressive stresses.

TABLE: 4.1 Compressive Strength of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^0C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration

S.No	Type of Concrete	W/C Ratio	Compressive Strength (Mpa)			
			Duration (hours)			
			Room Temp.	4 hrs.	8 hrs.	12 hrs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	NWAC	0.27	66.109	65.95	57.93	53.84
2	LWAC	0.27	43.214	43.00	41.20	26.81
3	NWAC	0.27	66.109	56.563	52.256	50.159
4	LWAC	0.27	43.214	33.519	29.745	25.224
5	NWAC	0.27	66.109	42.636	31.281	20.748
6	LWAC	0.27	43.214	25.434	15.693	12.077
7	NWAC	0.27	66.109	28.166	24.57	17.55
8	LWAC	0.27	43.214	15.05	12.23	11.20
9	NWAC	0.27	66.109	24.18	13.61	8.64
10	LWAC	0.27	43.214	14.05	6.23	3.557

TABLE: 4.2 Percentage Decrease in Compressive Strength of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^0 C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration

S.No	Type of Concrete	W/C Ratio	Temperature	Percentage Decrease ofCompressive Strength (MPa)		
				Duration (hours)		
				4 hrs.	8 hrs.	12 hrs.
1	2	3	4	6	7	8
1	NWAC	0.27	200^0 C	0.24	12.37	18.56
2	LWAC	0.27	200^0 C	0.50	4.66	37.96
3	NWAC	0.27	400^0 C	14.44	20.95	24.13
4	LWAC	0.27	400^0 C	22.43	31.17	41.63
5	NWAC	0.27	600^0 C	35.51	52.68	68.62
6	LWAC	0.27	600^0 C	41.14	63.69	72.05
7	NWAC	0.27	800^0 C	57.39	62.83	73.45
8	LWAC	0.27	800^0 C	65.17	71.70	74.08
9	NWAC	0.27	1000^0 C	63.42	79.41	86.93
10	LWAC	0.27	1000^0 C	67.49	85.58	91.77

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TABLE: 4.3 Percentage Weight Loss of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^{0}C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration

S.No	Type of Concrete	W/C Ratio	Temperature	Percentage Weight Loss		
				Duration (hours)		
				4 hrs.	8 hrs.	12 hrs.
1	2	3	4	6	7	8
1	NWAC	0.27	200^0 C	0.53	1.08	1.74
2	LWAC	0.27	200^0 C	1.33	1.94	2.89
3	NWAC	0.27	400^0 C	3.05	3.68	3.75
4	LWAC	0.27	400^0 C	6.81	7.12	8.1
5	NWAC	0.27	600^0 C	7.95	7.65	7.3
6	LWAC	0.27	600^0 C	4.57	5.2	5.15
7	NWAC	0.27	800^0 C	5.61	7.43	8.21
8	LWAC	0.27	800^0 C	9	11.47	14.21
9	NWAC	0.27	1000^0 C	63.42	79.41	86.93
10	LWAC	0.27	1000^0 C	67.49	85.58	91.77

TABLE: 4.4 Pulse Velocity (m/sec) of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^{0}C, 600^0 C, 800^0 C at 4,8,12 Hours Duration

S.No	Type of Concrete	W/C Ratio	Tempera ture	Pulse velocity (m/sec)			
				Duration (hours)			
				0hrs	4 hrs.	8 hrs.	12 hrs.
1	2	3	4	5	6	7	8
1	NWAC	0.27	200^0 C	4320	3310	2940	2729
2	LWAC	0.27	200^0 C	4056	2962	2614	2301
3	NWAC	0.27	400^0 C	4320	2962	2510	2447
4	LWAC	0.27	400^0 C	4056	2687	2380	2094
5	NWAC	0.27	600^0 C	4320	2484	1474	1126
6	LWAC	0.27	600^0 C	4056	1146	900	634

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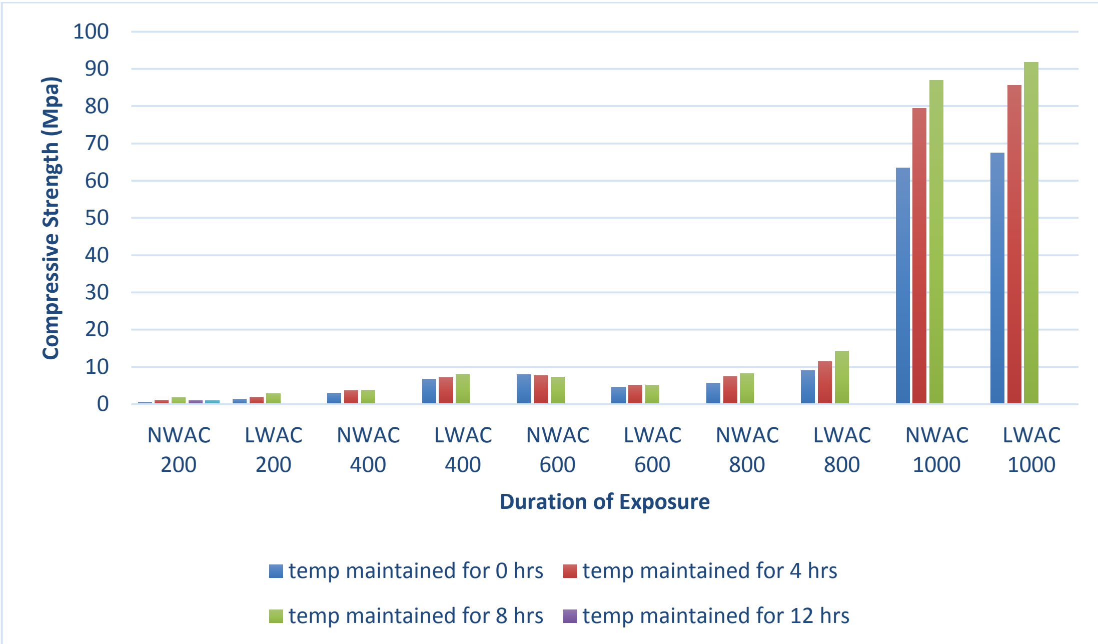
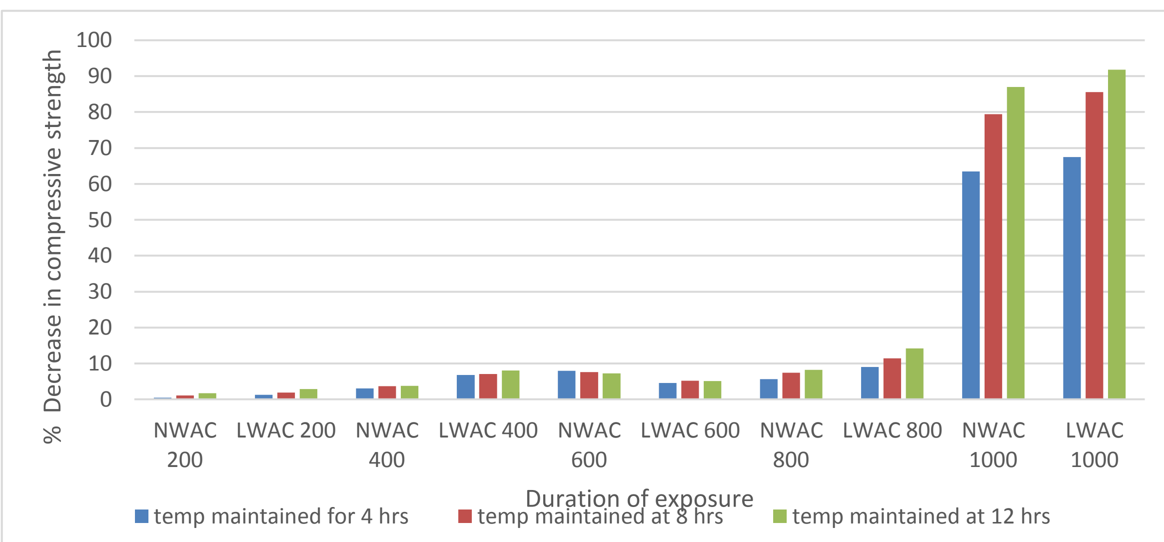
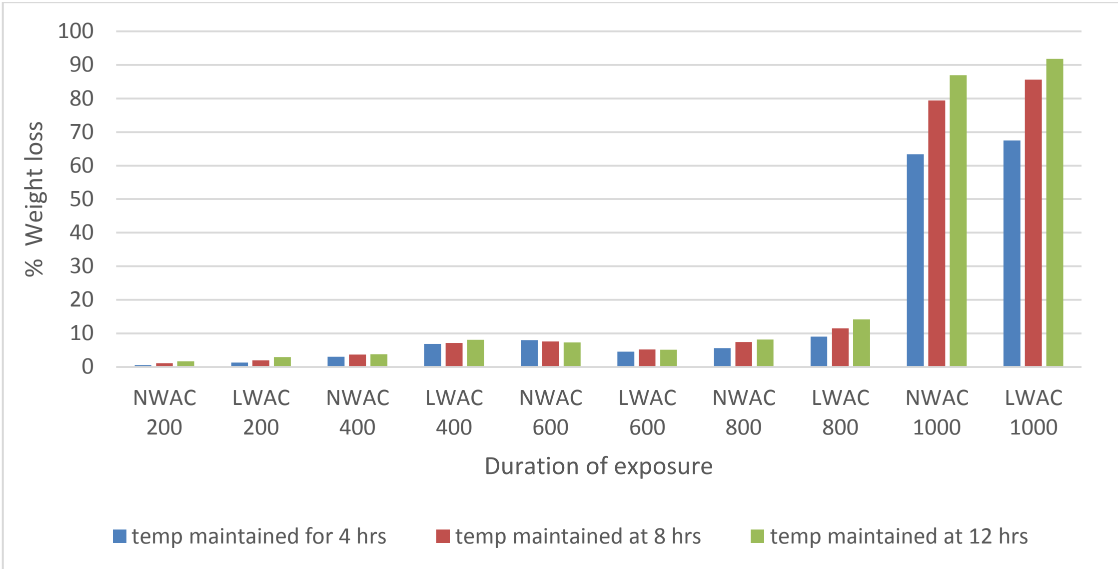


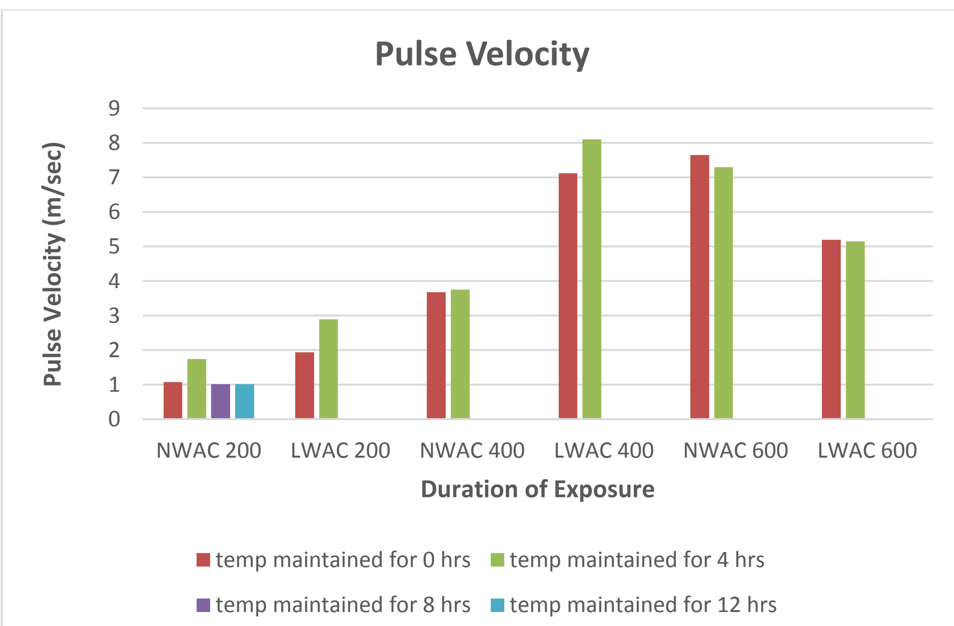
Compressive Strength of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^{0}C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration



Percentage Decrease in Compressive Strength of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^0 C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration



Percentage Weight Loss of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^0C, 600^0 C, 800^0 C and 1000^0 C at 4,8,12 Hours Duration



ThePulse Velocity (m/sec) of Normal Weight Aggregate Concrete (NWAC) and Light Weight Aggregate Concrete (LWAC) for 28 days at Room Temperature 200^0 C, 400^0C, 600^0 C, 800^0 C at 4,8,12 Hours Duration

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V. CONCLUSIONS

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

1. The Unit weight values of NWAC (100 % Granite), and LWAC (50 % Pumice+50% Perlite) concrete mixes are 2340 Kg/m^3, 1940 Kg/m^3respectively.
2. The Unit Weight of Lightweight aggregate concrete (LWAC) mix with 50 % pumice and 50% perlite were found to be 17.09 % less than Normal Weight Aggregate Concrete (NWAC) mix.
3. The compressive strength of Ordinary Concrete Specimen with the replacement of micro silica was found to be better than the normal - grade concrete specimen in terms of cube compressivestrength.
4. The maximum compressive strength obtained for replacement of micro silica was found to be of 66.109 MPa and for light weight concrete the compressive strength was found to be decreased and the value obtained was 43.21 MPa and the percentage decrease in compressive strength was found to be34.63%.
5. Also, the compressive strength was found to be decreased with the increase of the temperatures as well as the exposure time from 200^0C to 1000^0C and time exposure of 4 hours, 8 hours and 12 hoursrespectively.
6. The percentage weight loss of light weight pumice and perlite aggregate concrete mixes was found to be higher than when compared with the normal weight aggregateconcrete.
7. As the exposure time of the specimen for both normal and light weight aggregate increases the % decrease in compressive strength was found to be decreased from 200^0C to 1000^0C.This is due to decrease in compressive strength of concrete for both normal and light weight aggregateconcrete.
8. The percentage decrease in compressive strength ranges from a maximum value of 56.23% at 8 hours of exposure at 200^0 C to a minimum value of 5.13% at 12 hours of exposure at 1000^0C but whereas the compressive strength is more in the case of 8 hours of exposure and very less when compared to it in the case of 12 hours ofexposure.
9. The percentage loss of weight was found to be increased for both normal weight and light weight aggregate concrete at a temperature and it ranged from minimum value of 0.535% at 4 hours of exposure at 200^0C to 14.318% at 12 hours of exposure at1000^0C.
10. From the above study, it can be concluded that as the exposure of temperature and also time increases, the compressive strength of the concrete decreases apparently.
11. When the specimen were tested to non-destructive testing i.e., Ultrasonic pulse Velocity Test, the specimen which were cured under room temperature shown better performance in the terms of compressive strength when compared with the specimen subjected to elevatedtemperatures.
12. As the extent of elevated temperatures was increased, the compressive strength was found to be decreased and also with the time of exposuresimilarly.
13. Ultrasonic pulse velocity test was used up to an elevated temperature of 600^0C for an exposure

duration of 12 hours, and for later temperatures it was found difficult to use NDT testing for the specimens which were exposed to 800^{0}C and 10000C at 4 hours, 8 hours and 12 hours ofduration.

14. From the above study, it is recommended that Lightweight aggregate concrete (LWAC) will be suitable for partition walls, floor screens / roofing and panel material in auditoriumsetc.
15. Because of Lightweight aggregate concrete (LWAC) Lighter than Normal Weight Aggregate Concrete (NWAC), it is also useful in design of earthquake resistant structures.
16. The colour change observed on broken specimen at 800^0 C for 4 hours duration from light yellowish to at 800^0 C for 12 hours duration to dark yellowishcolour.
17. The colour change observed on broken specimen at 800^0 C for 12 hours duration from dark yellowish to at 1000^0 C for 12 hours duration to brick redcolour.
18. Crack pattern is also observed at same temperature for the same duration number of cracks on LWAC is quite higher thanNWAC.

VI. SCOPE FOR FUTUREINVESTIGATION:

1. The study can be further extended with replacement of 100 % River Sand by Light Weight Fine Aggregate (Perlite) to Know Residual Compressive Strength of Light Weight Aggregate Concrete at ElevatedTemperatures

2. The study can be further extended with replacement of 100 % Coarse Aggregate by Light Weight Aggregate (pumice) to Know Residual Compressive Strength of Light Weight Aggregate Concrete at ElevatedTemperatures

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