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Experimental Investigation on Concrete with Partial Replacement of LECA for Coarse Aggregate

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Abstract: Concrete is a material that exactly forms the basis of our modern history. It is by far the most widely used construction material today. We can hardly find any aspect of our daily lives that does not depend directly or indirectly on concrete. Our goods may be transported by trucks traveling through concrete super highways, by train that run on rails supported on concrete sleepers, by ship that moor at concrete piers in harbors protected by concrete breakwaters, or by airplanes landing and taking off on concrete runways. In this paper, Concrete is to be considered as lightweight concrete using LECA (LIGHTWEIGHT EXPANDED CLAY AGGREGATE) as a coarse aggregate, that is concrete with a density in the range 1.65 - 1.85 t/m3. In order to obtain high strength concrete, LECA was treated by solution of silica fume of concentration as10 % by weight of mixing water. Three levels of silica fume (0.5&10 %) by weight of cement and two ratios of LECA to total coarse aggregate content (50% & 75% by volume of coarse aggregate) to be used. M25 grade of concrete is used and the various tests are to be performed in the hardened state such as Compressive strength test, Splitting tensile strength test, Flexural strength test and Modulus of rupture are to be determined at 7,28days curing using by Cubes, Cylinders, Prisms and RCC Beams specimens respectively. For this purpose along with a Control Mix, 12 sets are prepared to study the mechanical properties of light weight aggregate concrete. Each set comprises of 3 cubes, 2 cylinders, 2 prisms and 2 RCC Beams. The test results will be shown an overall strength, weight reduction in various trails. Therefore, the light weight expanded clay aggregate concrete is no way inferior for construction purpose.

Key words: LECA, silica fume, Compressive strength test, Splitting tensile strength test, Flexural strength test, Modulus of rupture.

I. INTRODUCTION

Recently, with the rapid development of very tall buildings, larger-sized and long- span concrete structures, the requirements for better concrete performance are higher strength, light weight, higher toughness and others. Therefore, lightweight concrete has been used for structural purposes for several years .The density of LWC typically ranges from 1400 to 2000 kg/m3 compared with that of 2400 kg/m3 for normal-weight concrete. The use of high-strength LWC can reduce the self-weight of structures and cross-sectional areas of structural elements. However, LWC can be considered as a brittle material. The higher the compressive strength is, the higher the brittleness is. Therefore, improving the Compressive strength is the key point to popularize the application of LWC.

II. OBJECTIVE

The objective of the project is to investigate the flexural behaviour of light weight aggregate concrete (10% cured) using *LECA* with silica fume at 10% concentration with water. To find out the optimum strength with partial replacement of *LECA* aggregate in concrete and to study the mechanical properties of light weight concrete.

III.SCOPE

To study the increase in strength of concrete with different *LECA* aggregate replacement ratios with admixtures. To study the percentage reduction of foundation cost due to reduced dead loads. To study the percentage reduction in dead load to study the wide range of purposes such as panels, block production, sound barrier walls, floating homes, slope protection, wall castings and bridge deck. To study the sound insulating properties. To study the low density and thermal conductivity of light weight concrete.

IV.METHODOLOGY

The procedure of testing of materials as per proper mix design with various percentage of *LECA* and silica fume are done and the specimens are cured. Then the testing for compressive, split tensile and flexural strength are carried out.

V. EXPERIMENTAL INVESTIGATIONS

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The results of the experimental investigation on cubes, cylinders, prisms, Rcc beams are presented in this chapter. The behaviour of compression strength, tensile strength and flexural strength were observed for the specimens at ultimate load during the test.

- **M1** 0% silica fume and 50% of *LECA* replacement for coarse aggregate with admixtures
- **M2** 0% silica fume and 75% of *LECA* replacement for coarse aggregate with admixtures
- **M3** 5% silica fume and 50% of *LECA* replacement for coarse aggregate with admixtures
- **M4** 5% silica fume and 75% of *LECA* replacement for coarse aggregate with admixtures
- **M5** 10% silica fume and 50% of *LECA* replacement for coarse aggregate with admixtures
- **M6** 10% silica fume and 75% of *LECA* replacement for coarse aggregate with admixtures
- **M7** 10% silica fume and 0% of *LECA* replacement for coarse aggregate with admixtures
- **M8** 10% silica fume and 5% of *LECA* replacement for coarse aggregate with admixtures
- **M9** 10% silica fume and 10% of *LECA* replacement for coarse aggregate with admixtures
- **M10** 10% silica fume and 15% of *LECA* replacement for coarse aggregate with admixtures.

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		1	40	1.78		7.395	128	5.69		7.36
M 1 (50%)		2	42	1.87	2.22333	7.58	130	5.78	5.82333	7.5
	0%	3	68	3.02		7.374	134	6		7.48
		1	40	1.78		7.25	120	5.33		7.27
		2	40.5	1.8	1.83	7.26	122	5.42	5.45	7.26
M2(75%)		3	43	1.91		7.26	125	5.6		7.27
		1	41	1.82		7.34	122	5.42		7.48
		2	42	1.87	1.86667	7.39	125	5.56	5.61667	7.5
M 3(50%)	5%	3	43	1.91		7.46	132	5.87		7.49
		1	40	1.78		7.23	119	5.29		7.29
		2	39	1.73	1.73333	7.31	110	4.89	5.24667	7.28
M 4(75%)		3	38	1.69		7.28	125	5.56		7.27
		1	43	1.91		7.39	122	5.42		7.38
		2	45	2	2.31	7.41	123	5.47	5.26	7.39
M 5(50%)	10%	3	68	3.02		7.53	110	4.89		7.5
		1	42	1.87		7.36	115	4.89		7.25
		2	41	1.82	1.82333	7.38	121	4.89	4.89	7.27
M 6(75%)		3	40	1.78		7.21	119	4.89		7.3
		1	310	13.77		7.51	520	4.89		7.31
		2	295	13.11	13.8	7.51	510	4.89		7.35
M7(0%)		3	305	13.55		7.51	530	4.89	23.1	7.29
		1	290	12.88		7.51	490	4.89		7.32
		2	295	13.11	12.9	7.51	495	4.89		7.41
M8(5%)		3	285	12.7		7.51	495	4.89	21.7	7.38
		1	300	13.33		7.51	495	4.89		7.33
		2	305	13.55	13.4	7.51	480	4.89		7.37
M9(10%)		3	295	13.11		7.51	510	4.89	22	7.39
		1	305	13.55		7.51	500	4.89		7.37
		2	290	12.88	13.57	7.51	490	4.89		7.3
M10(15%)	10%	3	315	14		7.51	510	4.89	22.2	7.25

Fig: 5.1 Compressive strength test result of M0, M1, M3

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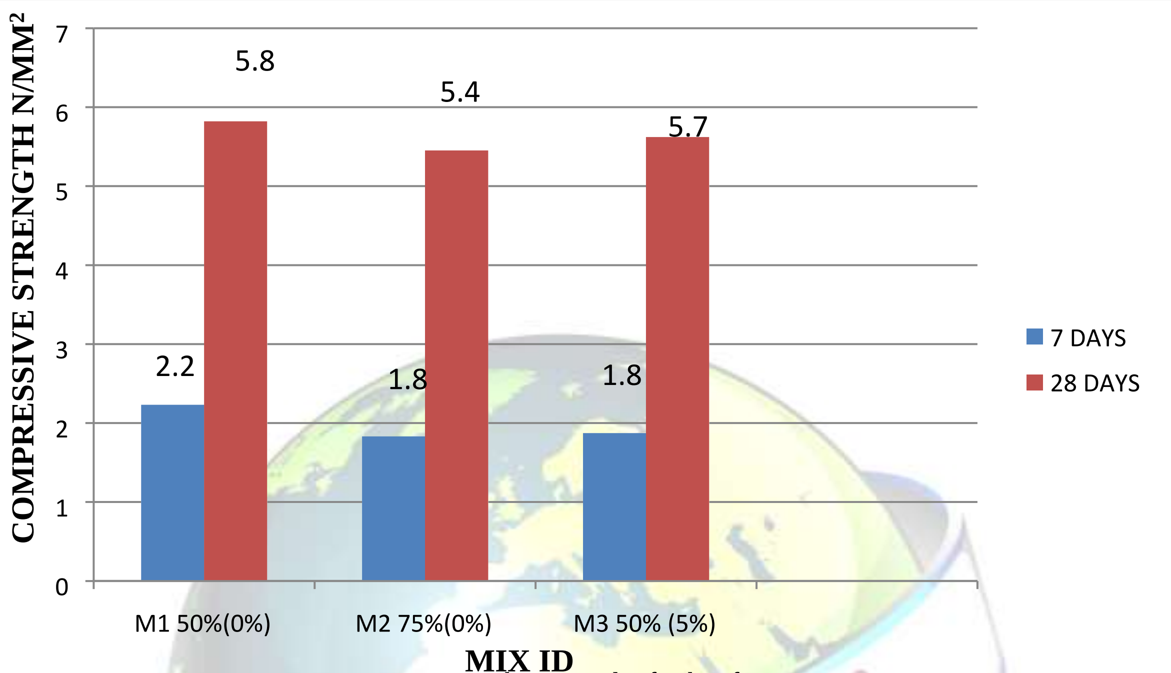
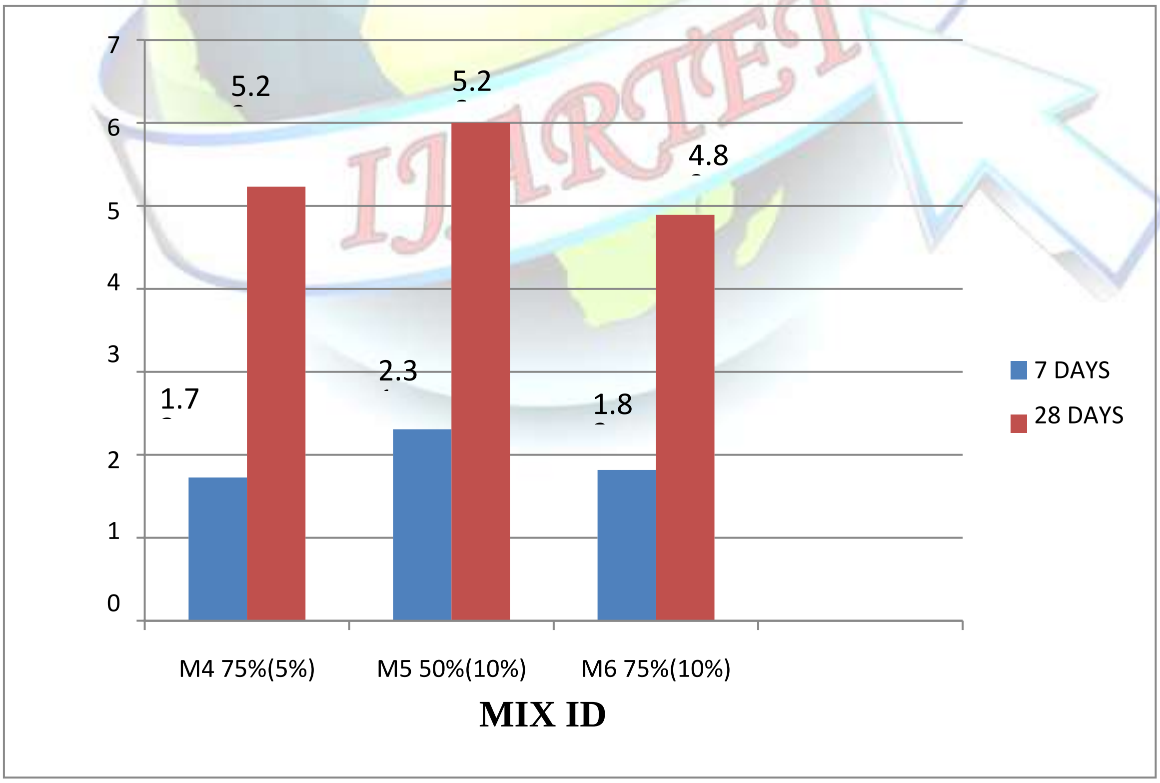


Fig :5.2 Compressive strength test result of cubes for M4,M5.M6



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		1	40	0.567		7.395	128	1.81		7.36
M 1 (50%)		2	44	0.622	0.60867	7.58	130	1.84	1.85	7.5
	0%	3	45	0.637		7.374	134	1.9		7.48
		1	45	0.637		7.25	125	1.77		7.27
		2	46	0.65	0.66	7.26	127	1.8	1.80333	7.26
M2(75%)		3	49	0.693		7.26	130	1.84		7.27
		1	42	0.594		7.34	134	1.9		7.48
		2	43	0.608	0.60333	7.39	132	1.87	1.84	7.5
M 3(50%)	5%	3	43	0.608		7.46	124	1.75		7.49
		1	40	0.565		7.23	128	1.81		7.29
		2	44	0.622	0.608	7.31	130	1.84	1.85	7.28
M 4(75%)		3	45	0.637		7.28	134	1.9		7.27
		1	45	0.637		7.39	134	1.9		7.38
		2	46	0.65	0.66	7.41	122	1.73	1.79	7.39
M 5(50%)	10%	3	49	0.693		7.53	123	1.74		7.5
		1	68	0.962		7.36	110	1.55		7.25
		2	42	0.594	0.72133	7.38	127	1.8	1.72	7.27
M 6(75%)		3	43	0.608		7.21	128	1.81		7.3
		1	100	1.414		7.51	210	2.97		7.31
		2	105	1.49	1.41	7.51	205	2.9		7.35
M7(0%)		3	95	1.34		7.51	215	3.04	2.97	7.29
		1	120	1.7		7.51	200	2.83		7.32
		2	115	1.63	1.7	7.51	202	2.85		7.41
M8(5%)		3	125	1.77		7.51	198	2.8	2.83	7.38
		1	95	1.34		7.51	195	2.75		7.33
		2	100	1.414	1.34	7.51	200	2.83		7.37
M9(10%)		3	90	1.27		7.51	190	2.69	2.7	7.39
		1	100	1.414		7.51	210	2.97		7.37
		2	105	1.49	1.42	7.51	200	2.83		7.3
M10(15%)	10%	3	95	1.34		7.51	220	3.11	2.97	7.25

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Fig : 5.3 Tensile strength results of cylinder for M1,M2,M3

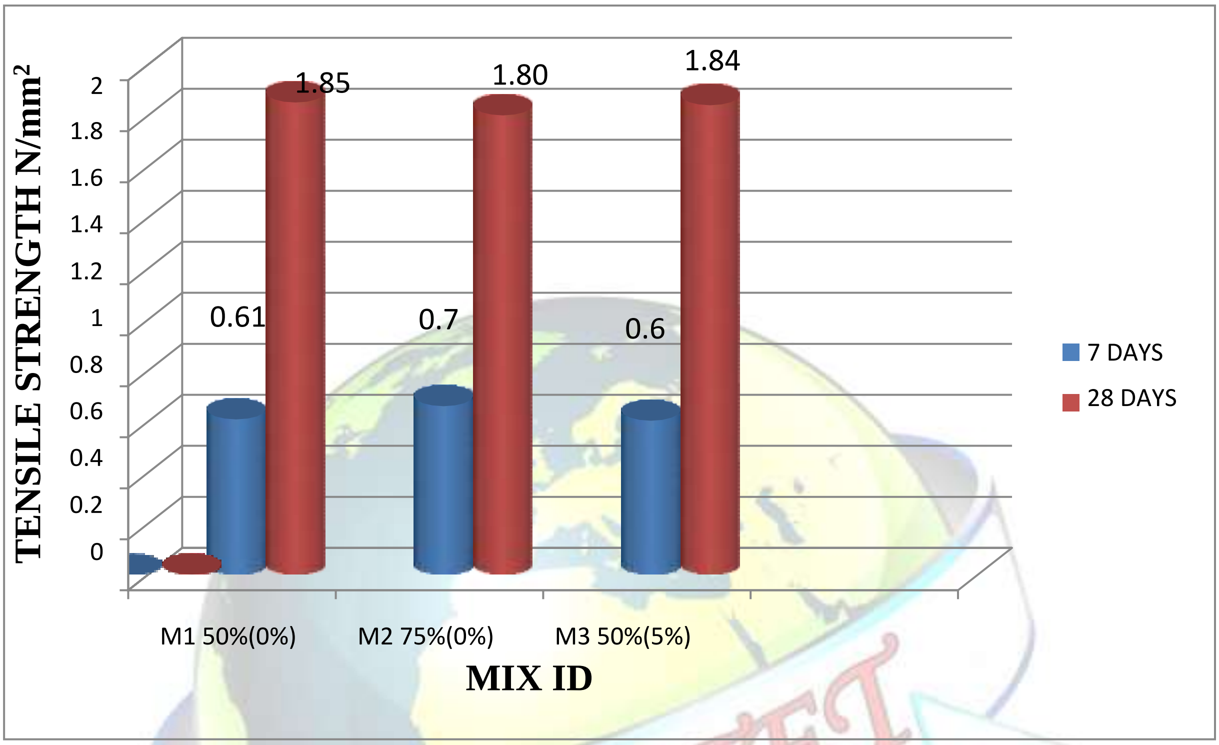
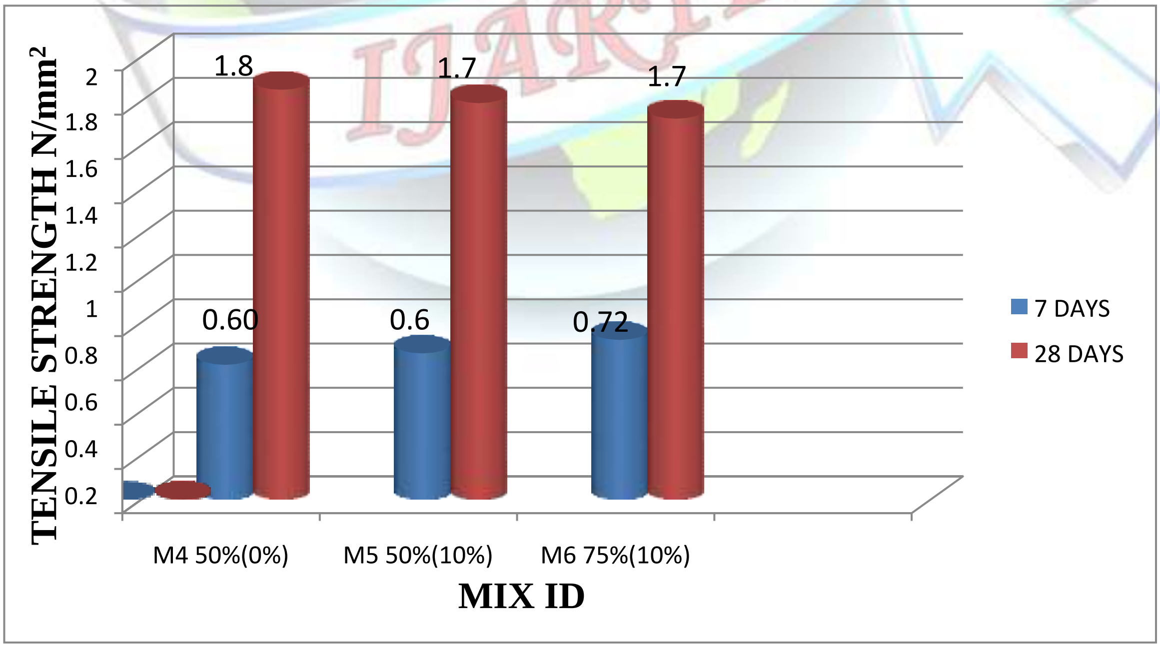


Fig : 5.4Tensile strength results of cylinder for M4,M5,M6



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TEST AGE	SOLUTION CONCENTRATION %	S.NO	7 DAYS LOAD TAKEN	RESULT	AVERAGE	WEIGHT Kg	28 DAYS LOAD TAKEN	RESULT	AVERAGE	WEIGHT Kg
M 1 (50%)	0%	1	40	0.267	0.28667	7.395	128	0.85	0.87	7.36
		2	44	0.293		7.58	130	0.87		7.5
		3	45	0.3		7.374	134	0.89		7.48
M2(75%)		1	45	0.3	0.31	7.25	125	0.83	0.85	7.27
		2	46	0.3		7.26	127	0.85		7.26
		3	49	0.33		7.26	130	0.87		7.27
M 3(50%)	5%	1	42	0.28	0.28667	7.34	134	0.89	0.86667	7.48
		2	43	0.29		7.39	132	0.88		7.5
		3	43	0.29		7.46	124	0.83		7.49
M 4(75%)		1	40	0.27	0.28667	7.23	128	0.85	0.87	7.29
		2	44	0.29		7.31	130	0.87		7.28
		3	45	0.3		7.28	134	0.89		7.27
M 5(50%)	10%	1	45	0.3	0.31333	7.39	134	0.89	0.84	7.38
		2	46	0.31		7.41	122	0.81		7.39
		3	49	0.33		7.53	123	0.82		7.5
M 6(75%)		1	68	0.45	0.34	7.36	110	0.73	0.81333	7.25
		2	42	0.28		7.38	127	0.85		7.27
		3	43	0.29		7.21	128	0.86		7.3
M7(0%)	10%	1	100	0.67	0.67	7.51	210	1.4	1.4	7.31
		2	105	0.7		7.51	205	1.37		7.35
		3	95	0.63		7.51	215	1.43		7.29
M8(5%)		1	120	0.8	0.8	7.51	200	1.33	1.33	7.32
		2	115	0.77		7.51	202	1.35		7.41
		3	125	0.83		7.51	198	1.32		7.38
M9(10%)		1	95	0.63	0.63	7.51	195	1.3	1.3	7.33
		2	100	0.67		7.51	200	1.33		7.37
		3	90	0.6		7.51	190	1.27		7.39
M10(15%)		1	100	0.67	0.67	7.51	210	1.4	1.4	7.37
		2	105	0.7		7.51	200	1.33		7.3
		3	95	0.65		7.51	220	1.47		7.25

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Fig ; 5.5 flexural strength results of prism for M1,M2,M3

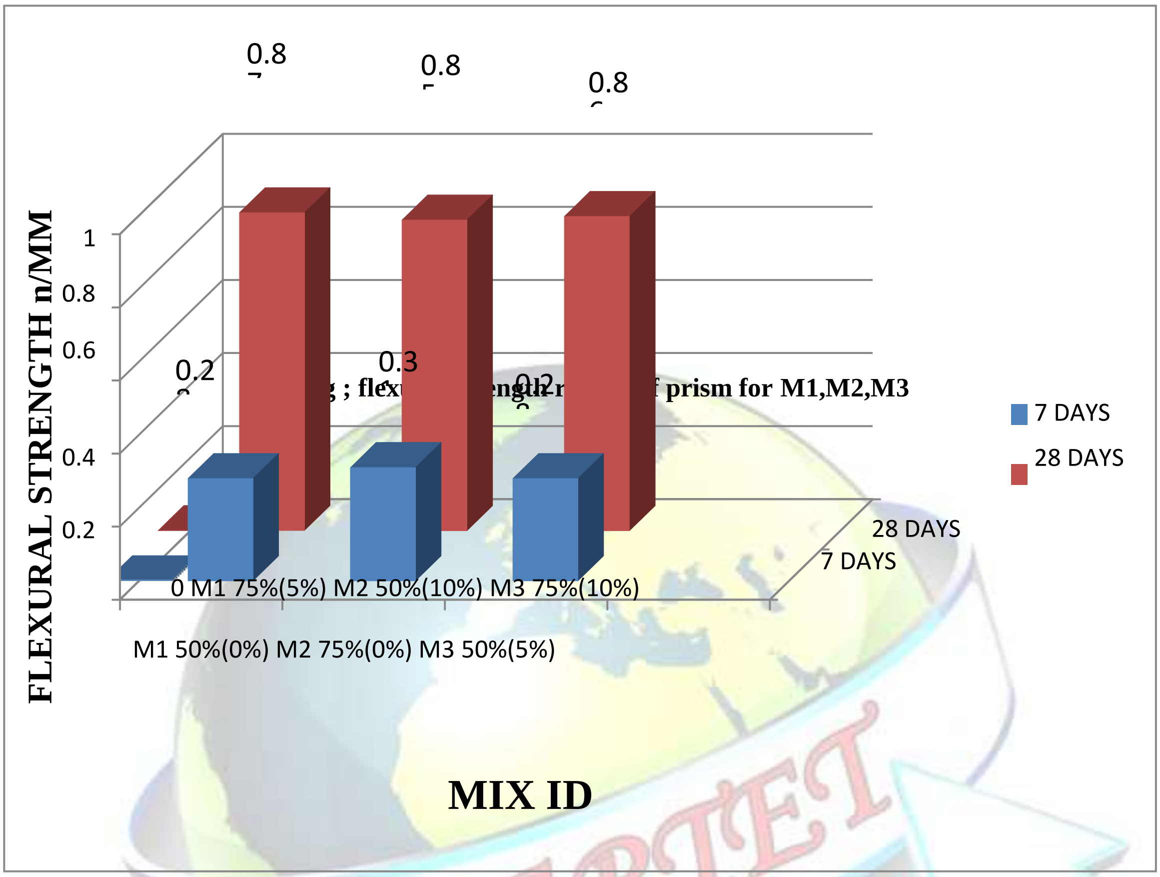

Fig ; 5.6 flexural strength results of prism for M4,M5,M6

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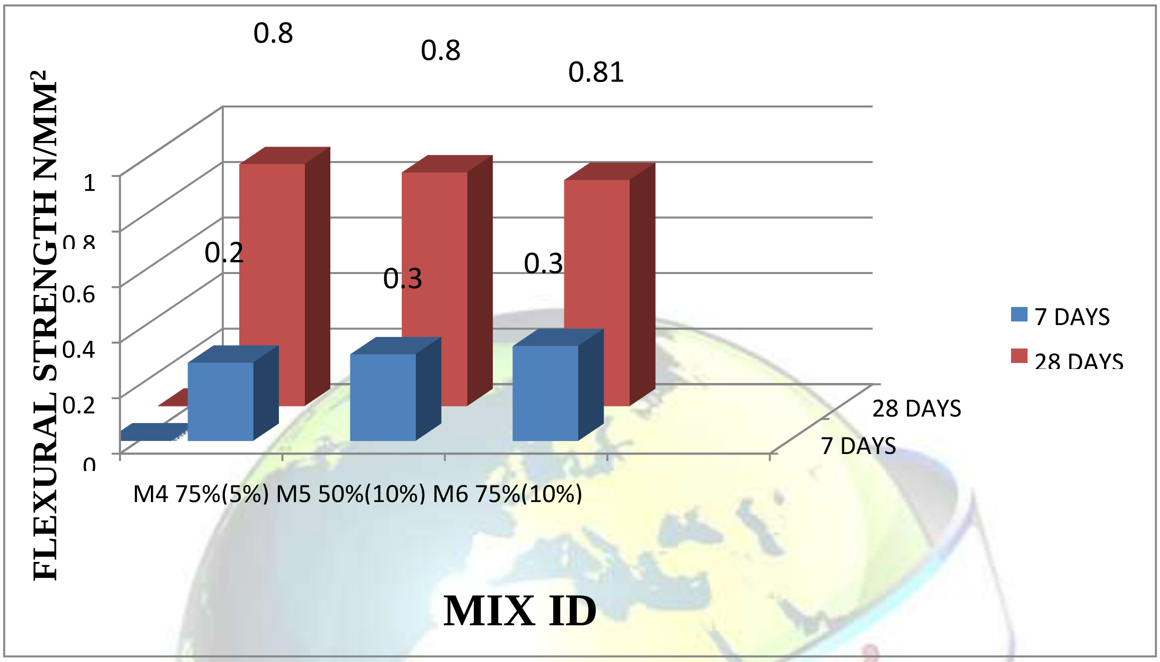

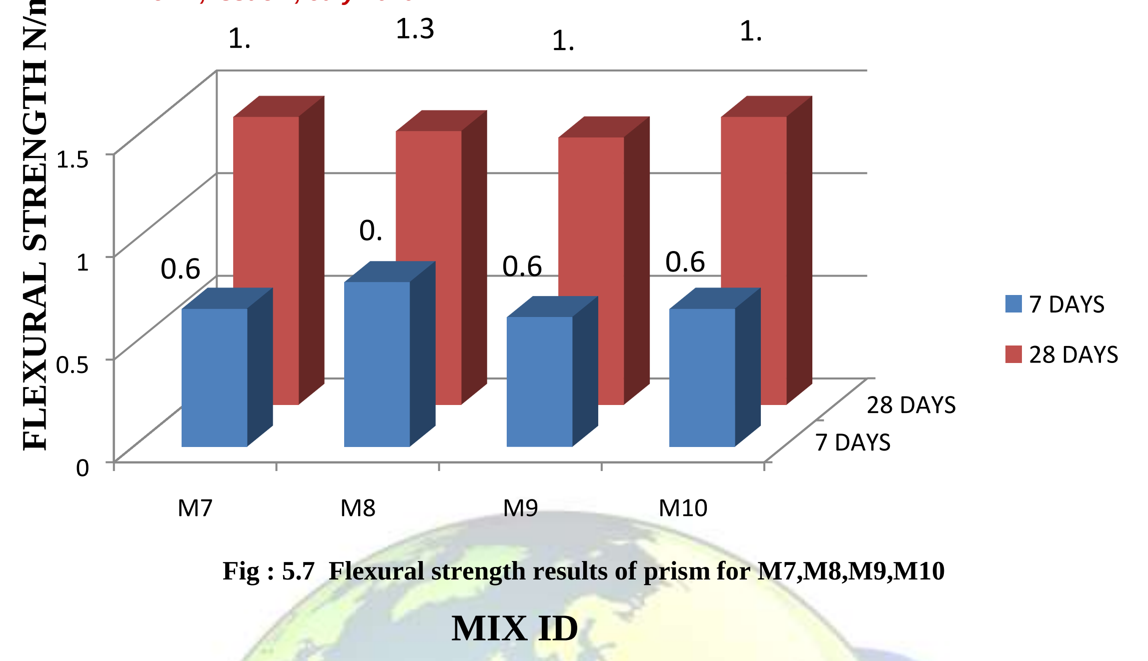

Fig : 5.7 Flexural strength results of prism for M7,M8,M9,M10

5.5 FLEXURAL STRENGTH RESULTS OF RCC BEAM

The results of the experimental investigation on Rcc beam specimens are presented below. The behavior of the Rcc beam specimens in terms of crack development, Failure mode and ultimate loads were observed during the test.

Beam details

M1- 150×155×1000 Size Beam + 50% replacement of leca + 0 % silica fume+3% reinforcement ratio

M2- 150×155×1000 Size Beam + 75% replacement of leca + 0 % silica fume+3% reinforcement ratio

M3- 150×155×1000 Size Beam + 50% replacement of leca + 5 % silica fume+3% reinforcement ratio

M4- 150×155×1000 Size Beam + 75% replacement of leca + 5 % silica fume+3% reinforcement ratio

M5- 150×155×1000 Size Beam + 50% replacement of leca + 10 % silica fume+3% reinforcement ratio

M6- 150×155×1000 Size Beam + 75% replacement of leca + 10 % silica fume+3% reinforcement ratio

M7-150×155×1000 Size Beam+0% replacement of leca+10%silica fume+3% reinforcement ratio

M8-150×155×1000 Size Beam+5% replacement of leca+10%silica fume+3% reinforcement ratio

M9-150×155×1000 Size Beam+10% replacement of leca+10%silica fume+3% reinforcement ratio

M10-150×155×1000 Size Beam+15% replacement of leca+10%silica fume+3% reinforcement ratio

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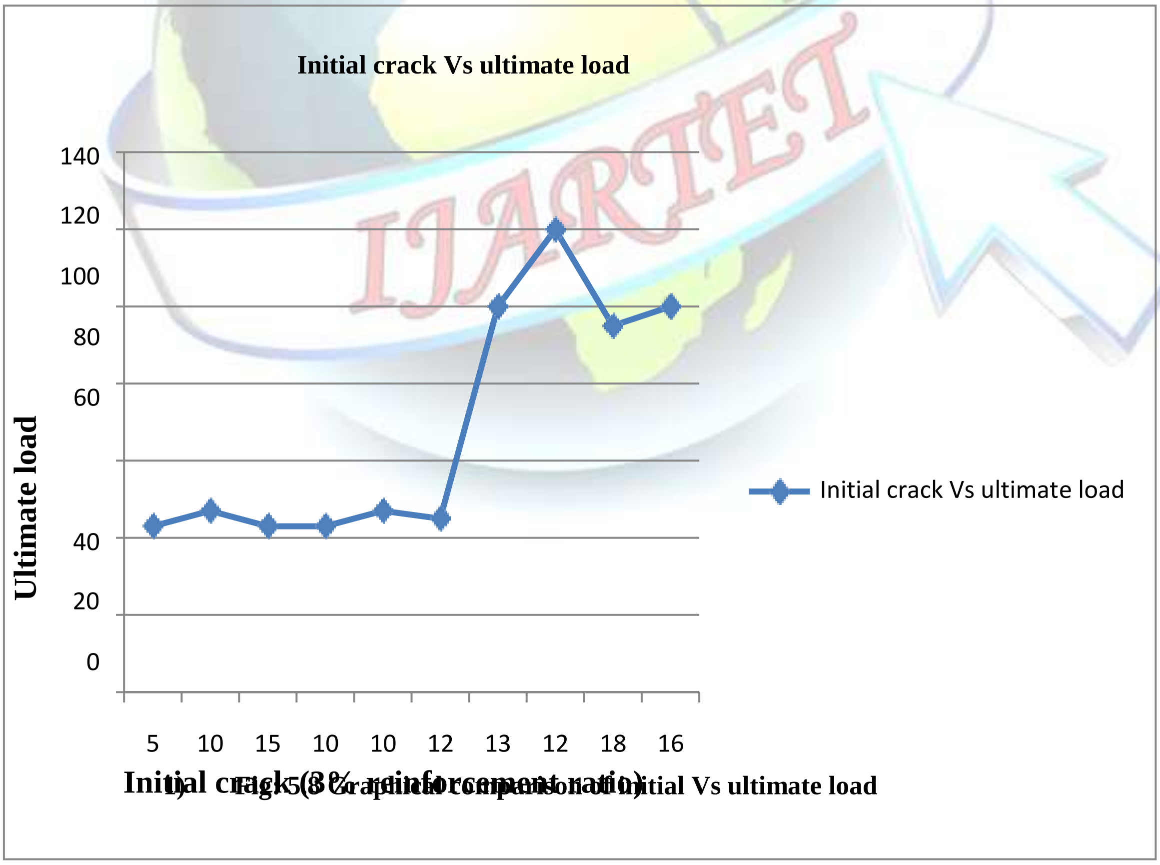
Table : 5.4 Flexural strength test results

S.No	Specimen Type	Initial Crack	Ultimate Load
1	M1	5	43
2	M2	10	47
3	M3	15	43
4	M4	10	43
5	M5	10	47
6	M6	12	45
7	M7	13	100
8	M8	12	120
9	M9	18	95
10	M10	16	100



1) Fig.5 Graphical comparison of Initial Vs ultimate load

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Table 5.5 Comparison of deflection and ductility index

Beam designation	Deflection at first crack(mm)	Deflection at ultimate load (mm)	Ductility index D.I=$\delta u/\delta y$
M1	0.52	2.78	5.35
M2	0.79	3.25	4.11
M3	1.14	3.12	2.74
M4	0.82	5.7	6.95
M5	0.73	4.58	6.27
M6	1.32	4.82	3.7
M7	0.94	4.85	5.17
M8	2.22	5.39	2.43
M9	0.74	3.88	5.24
M10	0.98	4.78	4.87

Table 5.6 Stiffness value at first crack load

Beam designation	First crack load (kN)	First crack deflection (mm)	Stiffness kN/mm
M1	5	0.52	9.61
M2	10	0.79	12.7
M3	15	1.14	13.17
M4	10	0.82	12.2
M5	10	0.73	13.89
M6	12	1.32	9.09
M7	13	0.94	13.83
M8	12	0.74	24.32
M9	18	2.22	5.41
M10	16	0.98	16.32

Fig 5.9 first crack load Vs stiffness

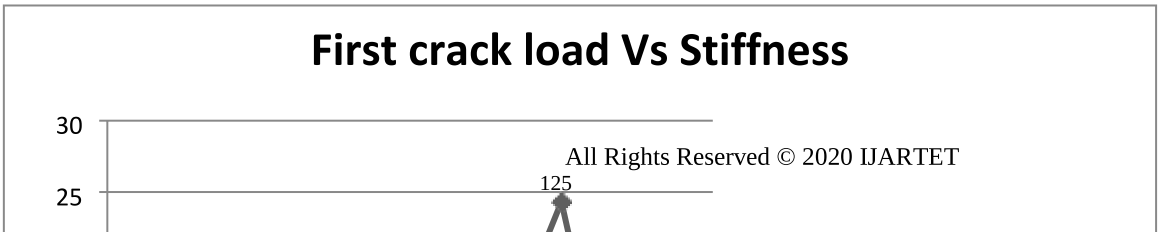

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Table 5.7 ultimate load Vs stiffness

Beam designation	Ultimate load (kN)	Deflection at ultimate load (mm)	Stiffness kN/mm
M1	43	2.78	15.7
M2	47	3.25	14.47
M3	43	3.12	13.78
M4	43	5.7	7.54
M5	47	4.58	1.27
M6	45	4.82	9.34
M7	100	4.85	20.62
M8	120	3.88	24.48
M9	95	5.39	22.26
M10	100	4.78	20.92

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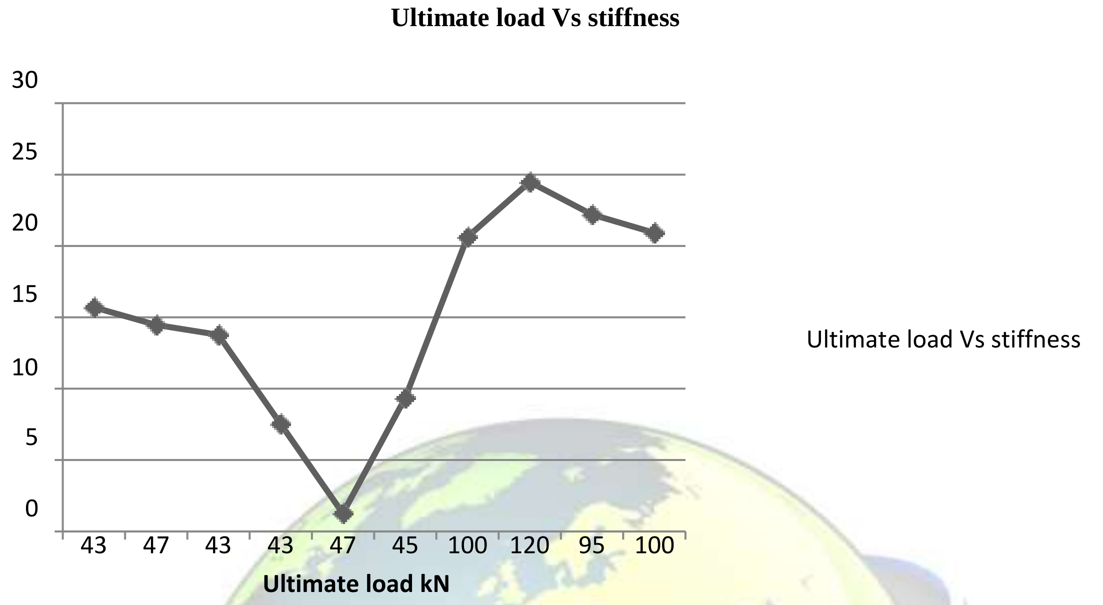

2) FIG5.10 ultimate load Vs stiffness

5.7 ENERGY ABSORPTION CAPACITY

Energy absorption is the energy absorbed or stored by a member when work is done on it to deform it and is called strain energy or resilience. Energy absorption is calculated as the area under the load versus deflection curve up to first crack load. The energy absorption values of control beam and reinforced concrete beams are shown in below table.

Beam designation	First crack load (kN)	First crack deflection (mm)	Energy Absorption (kN-mm)
M1	5	0.52	1.3
M2	10	0.79	3.95
M3	15	1.14	8.55
M4	10	0.82	4.1
M5	10	0.73	3.65
M6	12	1.32	7.92
M7	13	0.94	6.11
M8	12	2.22	13.32
M9	18	0.74	6.66
M10	16	0.98	7.84

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Table5.8 Energy absorption for various specimen at first crack load

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Table 5.9 Energy absorption for various specimens at ultimate load

Beam designation	Ultimate load (kN)	Deflection at ultimate load (mm)	Energy absorption ratio kN-mm
M1	43	2.78	59.77
M2	47	3.25	76.375
M3	43	3.12	67.08
M4	43	5.7	125.55
M5	47	4.58	107.63
M6	45	4.82	108.45
M7	100	4.85	242.5
M8	120	5.39	323.4
M9	95	3.88	184.3
M10	100	4.78	239

3) ENERGY DUCTILITY

Beam designation	Energy absorption at First crack load (kN-mm)	Energy absorption up to ultimate load (kN-mm)	Energy Absorption ratio I=B/A
M1	1.3	59.77	45.98
M2	3.95	76.375	19.34
M3	8.55	67.08	7.85
M4	4.1	125.55	30.2
M5	3.65	107.63	29.49
M6	7.92	108.45	13.69
M7	6.11	242.5	39.69
M8	13.32	323.4	24.28
M9	6.66	184.3	27.67
M10	7.84	239	30.48

Table : 5.10 Energy ductility for various specimens

The aboveTable shows that the energy ductility of various beams. It shows that M1 higher energy ductility than that of control beam. Due to the good bonding between steel and concrete, it shows performance of ductility.

VI. CONCLUSION

The following conclusions were arrived from the experimental works carried out on various percentage of LECA (light expandable clay aggregate) for partial replacement of coarse aggregates.

- The flexural strength of M8 concrete beam attains a max load of 120 N.
- The main aim of the project is to reduce the density of concrete without affecting the strength.

- Cube compressive strengths achieved for M20 grade of LWAC are 20.19N/mm^2 for 28 days.
- The cube Compressive strength, Split tensile strength of cylinder and beam Flexural strength of light

- weight aggregate concrete is reduced as compared to conventional concrete.
- The Workability of Lightweight aggregate concrete gets considerably increased when LECA is used as coarse aggregate.
- The result show that 5% replacement of LECA for coarse aggregate with admixtures was found to be good performance in compression strength, split tensile strength and flexural strength of prisms and Rcc beams when compared with 28 days strength.
- Initial cost of leca is high compared to the normal coarse aggregate.
- Due to the demand of coarse aggregate we can use LECA as coarse aggregate material because it is available in large amount.
- From the compressive strength results, it was found that partially replacement of LECA concrete has given same strength as that of conventionally curved concrete.
- From the spilt tensile strength results, flexural strength result it was found that partially replacement of LECA concrete has given same strength as that of conventionally cured concrete.

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