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STRENGTH AND DURABILITY TEST (SULPHATE ATTACK) ON LIGHT WEIGHT CONCRETE BY PARTIAL REPLACEMENT OF VERMICULITE FOR FINE AGGREGATE AND SILICA FUME FOR CEMENT

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Abstract- The present study focuses on the preparation of M30 grade concrete by replacing fine aggregate with 0%,5%,10%,15%,20%,25% of vermiculite and cement with 0% and 10% of constant silica fume to improve the performance of concrete. Via experimentation, the impact of acid exposure on concrete strength and weight is investigated in the current report. Concrete cubes of different mixes(12no.'s) are casted and exposed to Sulphuric acid of (pH=3). Cubes with dimensions of 100mm x 100mm x 100mm are cast with M30 concrete and then immersed (cured) in water for 28 days. The cubes are then soaked in 4 percent concentrated Sulphuric acid for 7 days. The compressive strength of the cured cubes is then measured using a compressive measuring machine.

Key Words: **- Vermiculite, Sulfuric Acid, Light weight concrete, Durability, Strength, Silica fume**

I. INTRODUCTION

The innovative construction development is the largest buyer of unprocessed (raw material) materials present day. To withstand further requirements, it is necessary to reduce the present consumption of valuables (raw materials) which in turn enlightens us to utilize of lightweight concrete (LWC) which in turn shrink the dead load. Which is achievable by reducing density of aggregates with is possible by replacement with light weight aggregates like perlite, pumice, expanded clay, vermiculite dolomite scoria etc. which on contrarily develops appreciable mechanical and durable concrete. This research desires to evaluate durability aspects of light weight concrete (LWC) using vermiculite as aggregate which possess the strength as mandatory.

II. LITERATURE REVIEW

Chandra Shekar, Hemanth Kumar Ch, V Manikanta and M Simhachalam(2016) Light weight vermiculite is one of the innovative category of light weight concrete. Vermiculite is a light mass and inexpensive product due to its thermal resistance which made it very valuable insulating material. The bulk density of concrete ranges from 750 (Kg/m3) to 2050 (kg/m3). This less density provides reduction of dead load which in turn improves the economical design of structures. The study of consequences of fly ash as partial replacement for cement in light weight vermiculite concrete were examined by replacing 0%, 10%, 20% and 30% of cement content with fly ash, for which to 20% has given best result.

P. Sundar Kumar, M.J .Ratna Kanth Babu , K. Sundara Kumar1 and K. Satish Kumar (2010)

The mechanical aspects of a structural grade lightweight aggregate made with fly ash and clay were examined using fly ash and silica fume to increase mechanical properties. In present investigation it was found that 10% replacement of fly ash and S.F. will increase the mechanical properties. When FA & SF was increased to 20% the is hydration reaction is delayed. And the addition of SF used in our test has high specific surface, high amorphous SiO_2 and small particle size which in turn increases the physical and chemical aspects phenomenon due to which SF reacts and hydrates the cement making it more a strong adhesive. And also by encouraging cement hydration and improving concrete uniformity, it creates a synergistic effect. The addition of SF increases the longevity and strength of concrete by increasing CSH gel hydrates, which makes it stronger and more robust.

Shaik Naseeruddin, Dumpa Venkateswarlu, Alamanda Sai Kumar (2019) the impact of an acidic curing environment on the strength and durability of M40 grade concrete cured in water containing various percentages of Hydro chloric acid (HCL) and Sulphuric acid at various ages is examined (H_2SO_4) and concluded that the strength of concrete decreased as the curing time and acid concentration in the curing water increased, and that

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NovolacEpoxy floor resins, which protect the structure against hundreds of different chemicals and acids and provide the highest level of protection, be given to make the structure durable and acid resistant mechanical aspects will be decreased.

M. Preethi, Md. Hamraj, P.Ashveen Kumar (2021) studied M30 grade concrete by partial replacement of fine aggregate with 0% to 25% of vermiculite with an increment of 5% and cement with 0% and 10% of constant silica fume to promote the achievements of concrete. In this experimental work an effort is made to know the effect of HCL acid exposure on strength and weight of concrete. Concrete cubes of different mix proportions are prepared and exposed to Hydrochloric acid of (pH=5). Cubes of size 100mm x 100mm x 100mm are cast for M30 grade of concrete, following which the cubes are cured in water for 28 days. Next, the cubes are immersed with 4% concentrated Hydrochloric acid for 7 days in curing drum maintaining a pH of 5. The cured cubes are then tested for weight and to determine their compressive strength. Find the resistance against acid attack of silica fume concrete increases as silica fume content increases from 0% to 10%

Table 1: Mix Proportions

MIX PROPORTIONS						
Sample	Cement	S.F.	F.A.	Ver	C.A.	w/c
1	8.4705	0	12.02	0	14.06	0.4
2	8.4705	0	11.43	0.6	14.06	0.4
3	8.4705	0	10.83	1.2	14.06	0.4
4	8.4705	0	1022	1.8	14.06	0.4
5	8.4705	0	9.62	2.4	14.06	0.4
6	8.4705	0	9.02	3	14.06	0.4
7	7.6234	0.847	12.02	0	14.06	0.4
8	7.6234	0.847	11.43	0.6	14.06	0.4
9	7.6234	0.847	10.83	1.2	14.06	0.4
10	7.6234	0.847	10.22	1.8	14.06	0.4
11	7.6234	0.847	9.62	2.4	1.06	0.4
12	7.6234	0.847	9.02	3	14.06	0.4

III. EXPERIMENTAL RESULTS

Acid resistance test is done by the concrete cube specimens were immersed in Sulphur acid solution. The specimens were immersed in acid solution for a period of 7 days in room temperature. After the specified duration, the specimens were taken out, wiped off and left to dry in room temperature for away. Then all the specimens were weighed again and the weight losses were noted and plotted. After that, the weighed specimens were tested for their compressive strength under CTM as per IS 516-1959. Substituting the values of applied load and cross- sectional area in the Equation, the values of compressive strength were obtained. To compare their results, the mean values of strength were reported and plotted as a graph. At standard exposures, the mean compressive strength of traditional and CCW cube specimens was 31.50 and 37.5 N/mm2, respectively.

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Table 2: Compressive strength at 7 days

Compressive strength at 7 days						
Sample	**Weight (Kg)**	**Avg Wt (Kg)**	**Force (kN)**	**Area (mm^2)**	**Stg (N/mm^2)**	**Avg Strg (N/mm^2)**
1	2.423	2.421	250	10000	25	25.8
	2.42		260	10000	26	
	2.421		265	10000	26.5	
2	2.418	2.416	180	10000	18	19
	2.416		200	10000	20	
	2.415		190	10000	19	
3	2.3	2.31	140	10000	14	15
	2.31		150	10000	15	
	2.32		160	10000	16	
4	2.29	2.276	120	10000	12	12
	2.26		110	10000	11	
	2.28		130	10000	13	
5	2.2	2.2	50	10000	5	5.11
	2.204		52.5	10000	5.25	
	2.2		51	10000	5.1	
6	2.05	2.01	45	10000	4.5	4.23
	1.99		40	10000	4	
	2		42	10000	4.2	
7	2.4	2.4	350	10000	35	34.5
	2.39		340	10000	34	
	2.41		345	10000	34.5	
8	2.35	2.36	327.5	10000	32.75	32
	2.36		302.5	10000	30.25	
	2.38		330	10000	33	
9	2.3	2.28	230	10000	23	22
	2.28		220	10000	22	
	2.27		210	10000	21	
10	2.22	2.21	200	10000	20	19.5
	2.21		190	10000	19	
	2.2		195	10000	19.5	
11	2.18	2.18	150	10000	15	14
	2.19		140	10000	14	
	2.17		130	10000	13	
12	2.15	2.14	100	10000	10	10
	2.13		90	10000	9	
	2.14		110	10000	11	

Table 3: Compressive strength at 14 days

Compressive strength at 14 days						
Sample	**Weight (Kg)**	**Avg Wt (Kg)**	**Force (KN)**	**Area (mm^2)**	**Stg (N/mm^2)**	**Avg Strg (N/mm^2)**
1	2.42	2.42	270	10000	27	27
	2.421		280	10000	28	
	2.419		260	10000	26	
2	2.415	2.416	200	10000	20	21
	2.417		210	10000	21	
	2.418		220	10000	22	
3	2.31	2.308	160	10000	16	17
	2.3		180	10000	18	
	2.316		170	10000	17	
4	2.28	2.25	150	10000	15	15
	2.25		160	10000	16	
	2.23		140	10000	14	
5	2.18	2.19	60	10000	8	8.25
	2.2		67.5	10000	9.75	
	2.21		70	10000	7	
6	2.1	2.05	75	10000	7.5	7.25
	2.05		72.5	10000	7.25	
	2		70	10000	7	
7	2.42	2.4	360	10000	36	36.5
	2.41		362.5	10000	36.25	
	2.39		370	10000	37	
8	2.36	2.37	336	10000	33.6	33.75
	2.38		337.5	10000	33.75	
	2.39		340	10000	34	
9	2.31	2.29	250	10000	25	24.5
	2.29		240	10000	24	
	2.28		245	10000	24.5	
10	2.23	2.23	225	10000	22.5	22.25
	2.22		220	10000	22	
	2.24		222.5	10000	22.25	
11	2.19	2.19	190	10000	19	9.6
	2.2		195.5	10000	19.55	
	2.18		202.5	10000	20.25	
12	2.16	2.15	125	10000	12.5	12.75
	2.14		130	10000	13	
	2.15		127.5	10000	12.75	

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Table 4: Compressive strength at 28 days

Compressive strength at 28 days						
Sam	**Weight (Kg)**	**Avg Wt (Kg)**	**Force (KN)**	**Area (mm^2)**	**Stg (N/mm^2)**	**Avg Strg (N/mm^2)**
1	2.45	2.43	300	10000	37	37
	2.42		320	10000	38	
	2.43		320	10000	36	
2	2.39	2.39	300	10000	30	30
	2.4		290	10000	29	
	2.38		310	10000	31	
3	2.32	2.325	270	10000	27	26.83
	2.315		275	10000	27.5	
	2.34		260	10000	26	
4	2.29	2.26	225	10000	22.5	22.08
	2.26		220	10000	22	
	2.24		217.5	10000	21.75	
5	2.19	2.20	190	10000	19	18.18
	2.21		180	10000	18	
	2.22		175.5	10000	17.55	
6	2.12	2.09	130	10000	13	12
	2.1		120	10000	12	
	2.05		110	10000	11	
7	2.28	2.29	480	10000	48	50.33
	2.29		520	10000	52	
	2.31		510	10000	51	
8	2.27	2.26	480	10000	48	46.33
	2.26		440	10000	44	
	2.25		470	10000	47	
9	2.23	2.21	340	10000	34	35.66
	2.22		380	10000	38	
	2.19		350	10000	35	
10	2.18	2.166	260	10000	26	27.18
	2.17		280	10000	28	
	2.15		275.5	10000	27.55	
11	2.14	2.148	220	10000	22	21.25
	2.15		200	10000	20	
	2.155		217.5	10000	21.75	
12	2.13	2.12	130	10000	13	13.18
	2.11		130	10000	13	
	2.12		135.5	10000	13.55	

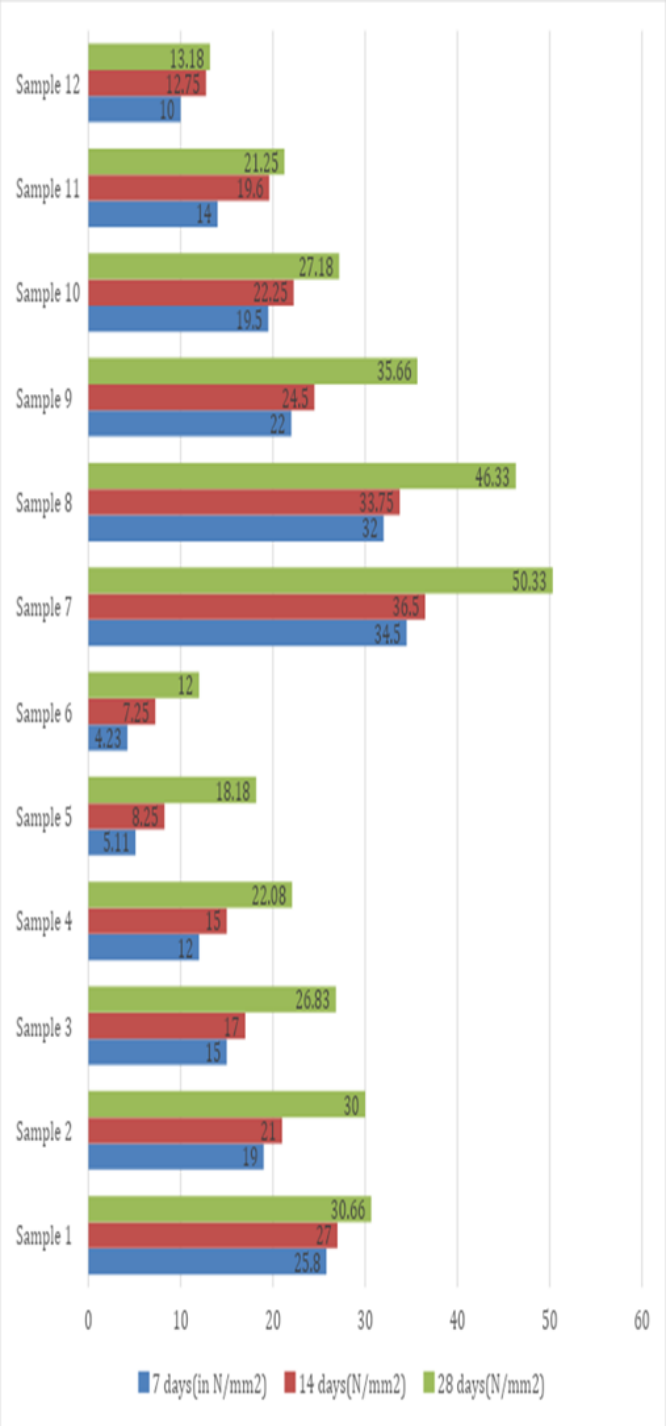

Figure 1: Compressive strength at 7, 14 and 28 days

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Table 5: Compressive strength at 7 days cured in acid

Compressive strength at 7 days cured in acid					
sample	Wt (kg)	Force (KN)	Area(mm2)	Strength(N/mm2)	average strength(N/mm2)
1	2.25	445	10000	44.5	33.575
	2.4	450	10000	45	
	2.3	448	10000	44.8	
2	2.45	180	10000	18	19
	2.45	200	10000	20	
	2.45	190	10000	19	
3	2.33	230	10000	23	24.23
	2.3	255	10000	25.5	
	2.32	243	10000	24.3	
4	2.29	145	10000	14.5	16.25
	2.31	180	10000	18	
	2.3	163	10000	16.25	
5	2.2	55	10000	5.5	7
	2.14	85	10000	8.5	
	2.17	70	10000	7	
6	2.3	108	10000	10.8	10.9
	2.3	110	10000	11	
	2.3	109	10000	10.9	
7	2.36	475	10000	47.5	46.25
	2.35	450	10000	45	
	2.34	463	10000	46.25	
8	2.36	360	10000	36	37
	2.34	380	10000	38	
	2.35	370	10000	37	
9	2.31	255	10000	25.5	26.75
	2.38	280	10000	28	
	2.28	268	10000	26.75	
10	2.17	175	10000	17.5	22.35
	2.2	272	10000	27.2	
	2.18	224	10000	22.35	
11	2.2	205	10000	20.5	20.6
	2.24	207	10000	20.7	
	2.23	206	10000	20.6	
12	2.16	125	10000	12.5	11.5
	2.19	107	10000	10.7	
	2.14	116	10000	11.6	

Figure.2 Deterioration of Cubes after 7 days in Acid

Figure.3 Cubes cured in Acid

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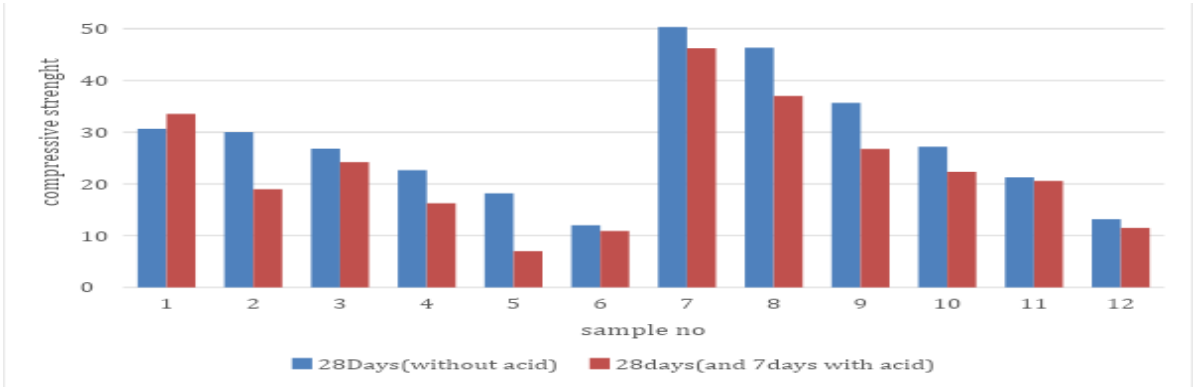

Figure 4: Comparison Compressive Strength with and without acid.

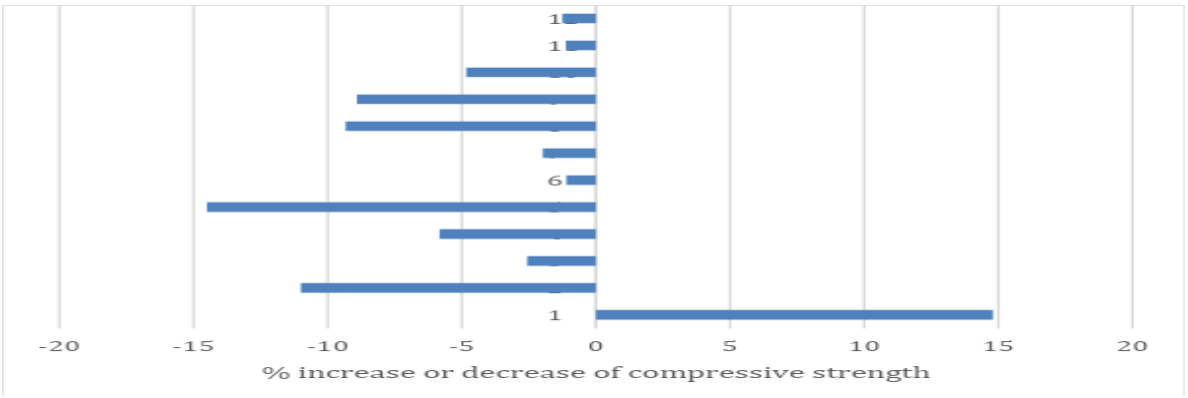

Figure 5: Comparing of %of increase or decrease of comp. strength with and without acid

Table6. Comparison Compressive Strength with and without acid

	Compressive strength before acid			Strength after acid test			%loss or gain		
	-1	-2	-3	-1	-2	-3	-1	-2	-3
1	30	30	32	44.5	45	44.8	14.5	15	14.8
2	30	29	31	18	20	19	-12	-9	-12
3	27	27.5	26	23	25.5	24.3	-4	-2	-1.7
4	23	22	21.5	14.5	18	16.25	-8	-4	-5.5
5	19	18	17.55	5.5	8.5	7	- 13.5	-9.5	-10.6
6	13	12	11	10.8	11	10.9	-2.2	-1	-0.1
7	48	52	51	47.5	45	46.25	-0.5	-7	-4.75
8	48	44	47	36	38	37	-12	-6	-10
9	34	38	35	25.5	28	26.75	-8.5	-10	-8.25
10	26	28	27.55	17.5	27.2	22.35	- 8.48	-0.8	-5.2
11	22	20	21,5	20.5	20.7	20.6	-1.5	0.7	-1.15
12	13	13	13.55	12.5	10.7	11.6	-0.5	-2.3	-1.95

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IV. CONCLUSION

- Upon analysis of results it was found that compressive strength with 10% replacement of Silica Fume levels were significantly higher than 0%. With increasing vermiculite percentage, silica fume replacement and compressive strength decreased.
- Power decreased as vermiculite percentage was increased as a partial substitution of fine aggregate with 0% silica fume.
- Minimum strength obtained without silica fume is 11N/mm^2 and with replacement of silica fume the minimum strength is 13N/mm^2.The compressive strength at 7,14,28 days for 10% Silica Fume replacement was found to be very high
- The maximum compressive strength was achieved for sample 7 i.e. by replacing cement with 10% of Silica, at 28 days.
- The compressive strength was found to be increased compared to conventional concrete
- On comparison of water and acid curing, it was found that maximum compressive strength in acid curing was substantially more than water curing at 7 days and lesser than 28 days water curing
- The maximum compressive strength at 28 days in water curing was found to be 52 N/mm^2 , while in acid curing it was found to be 47.5N/mm^2
- The maximum compressive strength at 7 days in water curing was obtained at 10% Silica fume replacement while in acid curing it was obtained by replacing cement with 10% Silica fume and fine aggregate with 5% vermiculite.
- The resistance of silica fume concrete to alkaline attack increases as the percentage of silica fume increases from 0% to 10%.

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