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Tensile Behavior of High Volume Fly Ash Concrete with Calcium Carbonate Micro Particles

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Abstract: High volume fly ash concrete is a concrete in which at least 50% of cement is replaced by fly ash to improve the mechanical behavior in concrete with M 40 grade. The testing specimens are casted and tested for 7, 14, 28, 56 and 90 days, Cylinders of 150mm diameter and 300mm height, Prism of 100mm width, 100mm depth and 500mm length. Fly ash is replaced with cement by 50% to check the tensile behavior of High Volume Fly Ash incorporating micro Calcium carbonate. The results proves that the use of HVFA and $CaCo_3$ has significant advantage over conventional concrete also environmental impacts are to be reduced by using of supplementary cementitious materials like fly ash.

Key words: High Volume Fly ash (HVFA), Calcium Carbonate ($CaCo_3$)

1. INTRODUCTION

Cement manufacture causes environmental issues at all stages of the process like depletion of natural resources, production of greenhouse gases and energy consumption. Cement causes 7% of total greenhouse gas emission in the world. Fly ash is the common replacement material in concrete by replacing of Portland cement. Generally Fly Ash has been considered as a waste material in the past and disposal of which has posed numerous ecological and environmental problems. The HVFA concrete is beneficial for the low cost and high workability of the concrete, also has to been improving the strength and durability of the concrete. More over fly ash containing the slow pozzolanic properties to decrease the early age strength of concrete, but longer period the strength will be increased. By recycling the industrial wastes by substituting them for the virgin raw materials, supplementary cementitious materials (SCM) and set-controlling material (gypsum) for cement production. HVFA concrete with 50–60% fly ash content is used to achieve the sustainable development.

2. LITERATURE REVIEW

High volume fly ash concrete [1] is a concrete in which at least 50% of cement is replaced by flyash7. Fly ash is replaced in various replacement levels of 0, 40, 50, 55 and 60% by the weight of cement in concrete. Slump, compressive and split tensile strength of concrete mixes were evaluated. The test results indicate that the addition of high volume of fly ash improves the slump and strength properties of concrete. Fly ash replacement of 55% by the weight of cement is considered as the optimum replacement level. [2] Mechanical properties of hardened concrete (compressive strength, flexural strength and split tensile strength) have been done after 28 days of water curing. The results showed that incorporation of micro $CaCO_3$ and micro SiO_2 particles lead to increase the packing and enhance the mechanical properties and durability of concrete. A significant performance was observed in case of micro silica addition to the concrete in comparing with other micro particles. [3] High volume fly ash concrete reduces the demand for cement and gives mechanical strength appropriate for normal construction. In the present investigation Portland cement has been replaced up to 60% by Fly ash. Five concrete mixes were designed to determine the effect of fly ash on workability, compressive, tensile and flexural strengths of concrete. Portland cement was replaced with fly ash by 20%, 30%, 40% and 60% respectively, while 100% Portland cement was used as control. The mechanical properties were determined at 3, 14, 28, 56 and 90 days of hydration. [4] Engineered Cementitious Composites (ECC) is a special type of high performance fibre reinforced cementitious composite having uniquely high ductile and tensile properties. This paper focuses on characterizing the mechanical properties of an Eco–friendly ECC with High Volume Fly Ash (HVFA) content. The results show that the mechanical properties of HVFA-ECC having fly ash up to 70% are comparable with those of ECC without fly ash. [5] Fly ash is used as a mineral addition in concrete to improve its strength and durability characteristics, Cement was replaced with three percentages of fly ash. The percentages of replacements were 30, 40 and 50 % by weight of cement. Tests were performed for compressive strength, split tensile strength and modulus of elasticity. Test results showed that the compressive strength, split tensile strength and modulus of elasticity of concrete having cement replacement up to 30% was comparable to the reference concrete without fly ash.

3. SIGNIFICANCE OF THE RESEARCH

The significance of this research work is to investigation of High-volume fly ash concrete incorporated along with calcium carbonate particles in cement to obtain maximum desired strength to be used in different actual practices, the main objective of the present study is to check the hardened properties of HVFA concrete such as split tensile strength and Flexural strength ae performed for Mix 1, Mix 2, and Mix 3 under consideration.

4. MATERIALS

In this present investigation (OPC- 53 Grade) Birla Super cement, Manufactured sand (M-Sand), Fly ash, Calcium Carbonate micro particles, water (ordinary potable water) and Super Plasticizer (Auramix-400).

5. TEST SPECIMENS AND TEST PROGRAM

MIX 1 = (Cement 100% + M Sand 100% + Coarse Aggregate 100%)
MIX 2 = (Cement 50% + M Sand 100% + Coarse Aggregate 100% + Fly ash 50%)
MIX 3= (Cement 50% + M Sand 100%+Coarse Aggregate 100%+Fly ash 44% + $Caco_3$ 6%)
Mechanics qualities are determined by experimental research for HVFA concrete mixes namely Mix1 (Control Mix), Mix2, and Mix3 for Compressive Strength for 7, 14, 28, 56 and 90 days and the results are tabulated.

6. RESULTS AND DISCUSSIONS

Table 1 Average Splitting tensile Strength of Mix 1

M40 GRADE CONVENTIONAL CONCRETE				
Age in Days	**No. of Samples**	**Load (kN)**	**Splitting Tensile Strength (N/mm^2)**	**Average Splitting Tensile Strength (N/mm^2)**
7 days	1	190	2.69	3.02
	2	230	3.26	
	3	220	3.11	
14 days	1	265	3.75	4.06

	2	285	4.03	
	3	310	4.39	
28 days	1	390	5.52	5.05
	2	360	5.10	
	3	320	4.53	
56 days	1	355	5.02	5.33
	2	390	5.52	
	3	385	5.45	
90 days	1	380	5.38	5.59
	2	410	5.80	
	3	395	5.59	

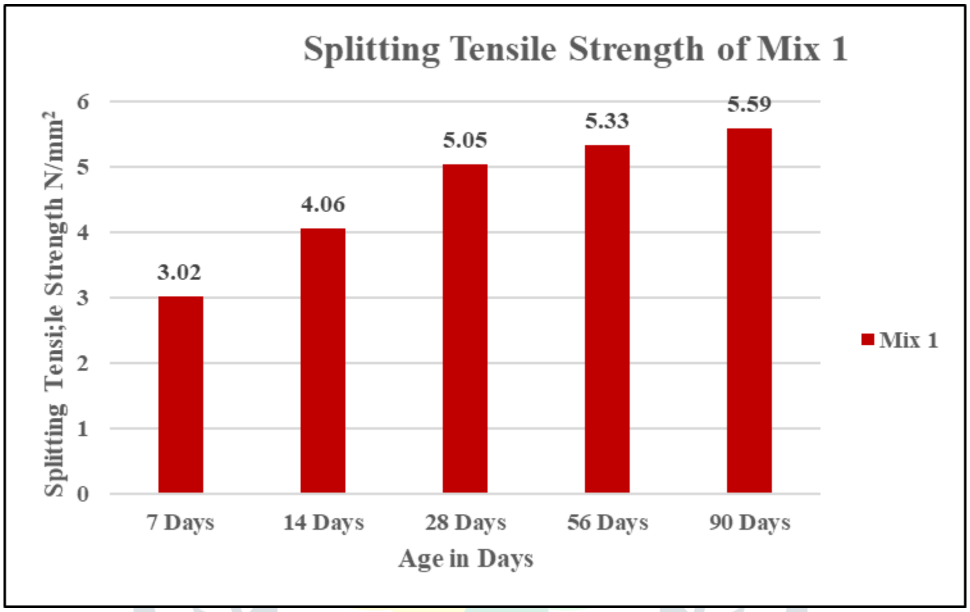

Fig: 1 Comparison of Splitting Tensile Strength of Mix 1

It is noticed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in tensile strength for Mix 1 was observed in Table 1. It is also found that the average tensile strength increases by 34%, 67%, 76% and 85% there is not much increment in strength once it reaches its maximum peak load for 28 days.

Table 2 Average Splitting tensile Strength of Mix 2

M40 GRADE 50% FLY ASH CONCRETE				
Age in Days	**No. of Samples**	**Load (kN)**	**Splitting Tensile Strength (N/mm^2)**	**Average Splitting Tensile Strength (N/mm^2)**
7 days	1	110	1.56	2.08
	2	140	1.98	
	3	190	2.69	
14 days	1	210	2.97	2.69
	2	170	2.41	
	3	190	2.69	
28 days	1	260	3.68	4.03
	2	300	4.25	
	3	295	4.18	
56 days	1	310	4.39	4.62

	2	350	4.95	
	3	320	4.53	
90 days	1	390	5.52	5.14
	2	360	5.10	
	3	340	4.81	

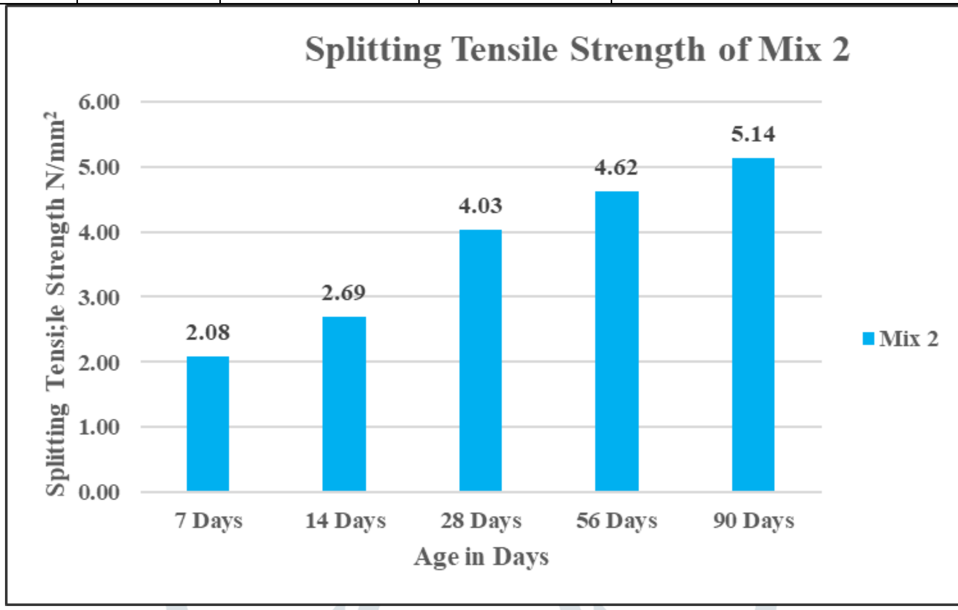

Fig: 2 Comparison of Splitting Tensile Strength of Mix 2

It noticed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in tensile strength for Mix 2 was observed in Table 2. It is also found that the average tensile strength increases by 29%, 93%, 122% and 147% there is not much increment in strength once it reaches its maximum peak load for 28 days.

Table 3 Average Splitting tensile Strength of Mix 3

M40 GRADE FLY ASH CONCRETE (44% FA + 6% $CaCO_3$)				
Age in Days	**No. of Samples**	**Load (kN)**	**Splitting Tensile Strength (N/mm^2)**	**Average Splitting Tensile Strength (N/mm^2)**
7 days	1	210	2.97	2.90
	2	225	3.18	
	3	180	2.55	
14 days	1	275	3.89	3.63
	2	215	3.04	
	3	280	3.96	
28 days	1	320	4.53	4.53
	2	340	4.81	
	3	300	4.25	
56 days	1	385	5.45	5.07
	2	360	5.10	
	3	330	4.67	
90 days	1	450	6.37	5.87
	2	415	5.87	
	3	380	5.38	

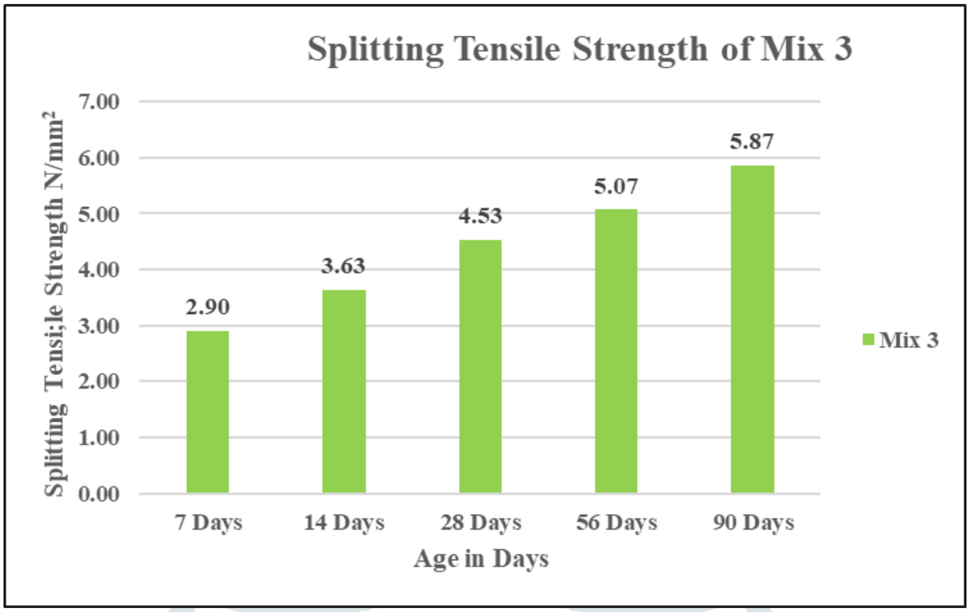

Fig: 3 Comparison of Splitting Tensile Strength of Mix 3

It is observed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in tensile strength for Mix 3 was observed in Table 3. It is also found that the average tensile strength increases by 25%, 56%, 74% and 102% there is not much increment in strength once it reaches its maximum peak load for 28 days.

6.1 Flexural Strength

Table 5 Average Flexural Strength of Mix 1

M40 GRADE CONVENTIONAL CONCRETE				
Age in Days	**No. of Samples**	**Load (kN)**	**Flexural Strength (N/mm^2)**	**Average Flexural Strength (N/mm^2)**
7 days	1	8	3.2	3.13
	2	7.5	3	
	3	8	3.2	
14 days	1	10	4	4.20
	2	10.5	4.2	
	3	11	4.4	
28 days	1	12	4.8	5.27
	2	13	5.2	
	3	14.5	5.8	
56 days	1	13	5.2	5.47
	2	13.5	5.4	
	3	14.5	5.8	
90 days	1	13.5	5.4	5.73
	2	14.5	5.8	
	3	15	6	

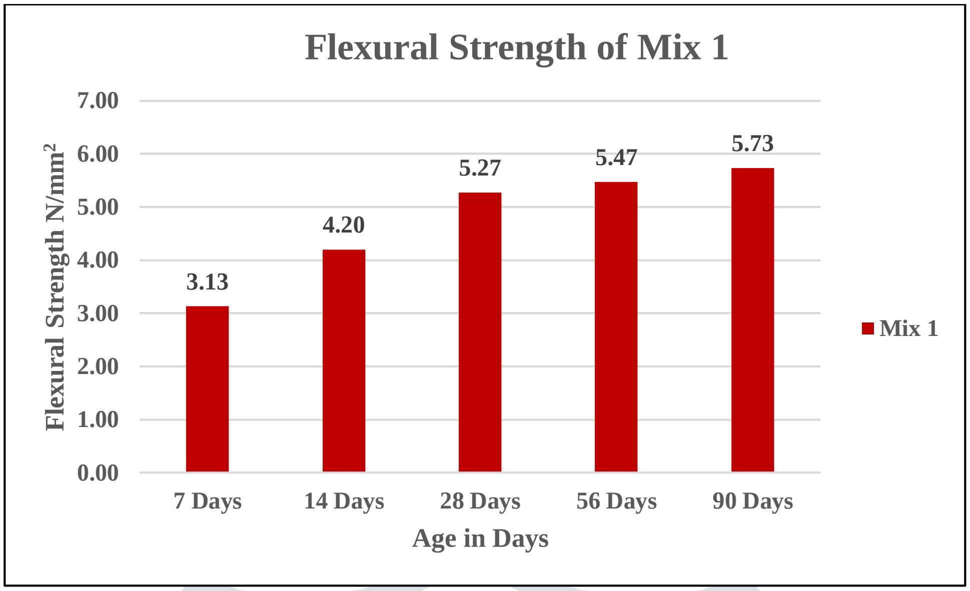

Fig: 5 Comparison of Flexural Strength of Mix 1

It is noticed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in flexural strength for Mix 1 was observed in Table 5. It is also found that the average flexural strength increases by 34%, 68%, 74% and 83% there is not much increment in strength once it reaches its maximum peak load for 28 days.

Table 6 Average Flexural Strength of Mix 2

M40 GRADE 50% FLY ASH CONCRETE				
Age in Days	**No. of Samples**	**Load (kN)**	**Flexural Strength (N/mm^2)**	**Average Flexural Strength (N/mm^2)**
7 days	1	4	1.6	2.13
	2	5.5	2.2	
	3	6.5	2.6	
14 days	1	6	2.4	2.87
	2	7.5	3	
	3	8	3.2	
28 days	1	9.5	3.8	4.33
	2	10	4	
	3	13	5.2	
56 days	1	5.5	2.2	4.73
	2	14.5	5.8	
	3	15.5	6.2	
90 days	1	11	4.4	5.33
	2	13.5	5.4	
	3	15.5	6.2	

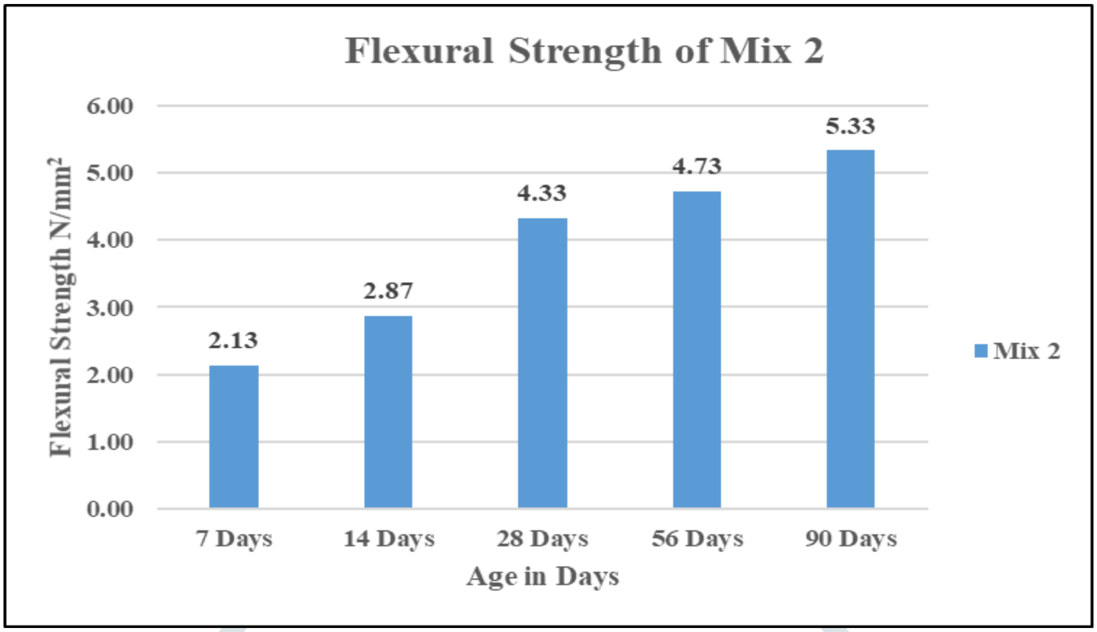

Fig: 6 Comparison of Flexural Strength of Mix 2

It is noticed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in flexural strength for Mix 1 was observed in Table 6. It is also found that the average flexural strength increases by 34%, 103%, 122% and 150% there is not much increment in strength once it reaches its maximum peak load for 28 days.

Table 7 Average Flexural Strength of Mix 3

M40 GRADE FLY ASH CONCRETE (44% FA + 6% $CaCO_3$)				
Age in Days	**No. of Samples**	**Load (kN)**	**Flexural Strength (N/mm^2)**	**Average Flexural Strength (N/mm^2)**
7 days	1	7.5	3	2.93
	2	8	3.2	
	3	6.5	2.6	
14 days	1	9	3.6	3.87
	2	8.5	3.4	
	3	11.5	4.6	
28 days	1	13	5.2	4.73
	2	12.5	5	
	3	10	4	
56 days	1	12.5	5	5.60
	2	13.5	5.4	
	3	16	6.4	
90 days	1	14	5.6	6.27
	2	17.5	7	
	3	15.5	6.2	

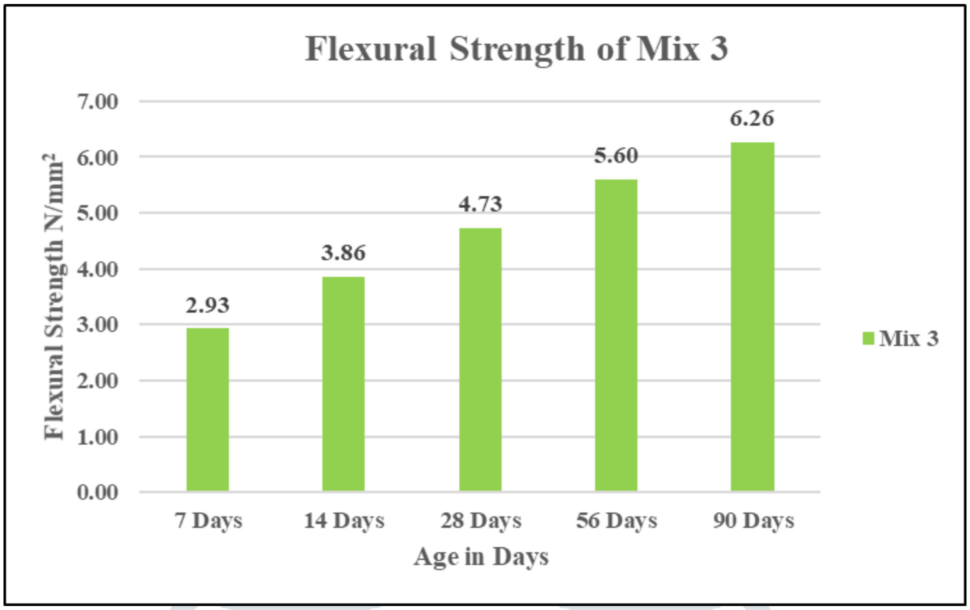

Fig: 7 Comparison of Flexural Strength of Mix 3

It is observed that for 7 days, 14 days, 28 days, 56 days and 90 days increase in flexural strength for Mix 1 was observed in Table 6. It is also found that the average flexural strength increases by 34%, 103%, 122% and 150% there is not much increment in strength once it reaches its maximum peak load for 28 days.

7. CONCLUSION

- The average tensile strength for Mix 1 increases by 34%, 67%, 76% and 85% and Mix 2 29%, 93%, 122% and 147% also for Mix 3 25%, 56%, 74% and 102% respectively, there is not much increment in strength once it reaches its maximum peak load for 28 days.
- The average flexural strength for Mix 1 increases by 34%, 68%, 74% and 83%, for Mix 2 34%, 103%, 122% and 150% and for Mix 3 34%, 103%, 122% and 150% respectively.
- The Tensile strength of Mix 2 decreases by 7% and Tensile strength of Mix 3 increases by 9% as compared to Mix 1.
- By using the Fly ash in concrete, the cost of concrete can be reduced by 35% and eco system can be balanced.