Experimental studies on Micro Particles induced High Volume Fly Ash (HVFA) Slabs under Static Loading

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Abstract - *This study aims to the effect of using micro particles as addition to cementitious materials on the properties of fly ash concrete. Binary combination of (micro $CaCO_3$ + micro SiO_2) different contents were applied to investigate their combined effect. Mechanical properties (compressive strength, split tensile strength and flexural strength) and Static loading tests on slabs were done after 28 days of water curing.*

*Results of mechanical strength tests manifested that the mix with 8% Micro particles addition to 50% fly ash replaced concrete showed considerable results compared with the conventional mix of M40 grade concrete. Six slab specimens of 600mm*600mm*60mm consisting of a control mix, a mix with 50% fly ash replacement of cementitious materials and a mix with 50% fly ash replacement of cementitious with 8% micro particles addition were investigated with fixed ends and static loading conditions to obtain load-deflection curves and was found to be comparable with theoretical values for the same.*

Key Words: High volume fly ash concrete, Micro calcium carbonate, micro silica, fixed end conditions, Load deflection behaviour

1. INTRODUCTION

Use of fly ash as partial replacement of OPC in concrete is persistent for many decades. Fly ash acts as Pozzolanic material which reacts with Calcium Hydroxide (CH) of cement hydration due to the presence of amorphous SiO_2 and $Al2O_3$. However, the reaction of fly ash in the hydration reaction is slow and affects the early age properties of concrete. Moreover, its use in concrete is also limited to approximately 15-25% by mass (ACI 226.4R). In view of sustainability of concrete the maximisation of the use of fly ash or other SCMs in concrete is the key priority and also researched extensively specially on high volume fly ash (HVFA) concrete.

The mechanical behaviour of concrete materials depends to a great extent on their structural constituents and phenomenon which are functional on a Nano - and micro scale. The capability to target material development at the primary structural level promises to gain the optimization of material behaviour and performance.

Significant advancements have been made in the application of micro-technology in cement and concrete science. There have been lots of improvements in understanding the characteristics of the hydration products of Portland cement (particularly C-S-H) at the micro-scale. This makes possible the development of better concrete that can address specific durability and environmental issues. Developing these structures in concrete give results in higher compressive, split tensile and flexural strength; lower set time and permeability of water and higher resistance to chemical attacks.

2 Experimental programme

Cement concrete aimed to have 28 compressive strength of 40Mpa was used as a reference mix. In addition to reference mix, two other mixes were studied with incorporation of 50% fly ash replacement to cement and 50% fly ash replacement and 8% micro particles addition to cement respectively.

2.1 Materials used

2.1.1 Cement

Ordinary Portland cement of 53 grade [Birla super plus] confirming to IS: 12269-1987 has been used.

2.1.2 Fly Ash

Locally available class F fly ash was used for the studies.

2.1.3 Fine aggregates

M sand passing through IS sieve 4.75 mm was used .the specific gravity and fineness modulus was 2.60 and 4.31

2.1.4 Course aggregates

Crushed angular aggregates passing through 20 mm and retained on 10 mm sieve was used the specific gravity was 2.65.

2.1.5 Superplasticizer

The super plasticizer based on poly-carboxylic ether polymer with long lateral chains “AUR MIX” confining with BIS 9103-1999 was used

2.1.6 Micro silica

Micro silica purchased from M L A Industries of 0.18(g/cc) bulk density was used.

2.1.7 Micro calcium carbonate

Micro Calcium carbonate purchased from Yamuna calcium with 0.44(g/cc) bulk density was used.

2.2 Basic test results.

Table -1: Basic material test results

Materials	Test	Result
Cement	Standard consistency test Initial setting time Soundness Fineness Specific gravity	28% 135 mins 1.2mm 7% 3.15
Fly ash	Specific gravity Particle size	2.33 0.1-30microns
M-Sand	Specific gravity Fineness modulus Bulk density Loose Zone	2.60 4.34 1550Kg/m3 2
Coarse aggregates	Specific gravity Water absorption value (by weight %) Bulk density Loose rodded Elongation index Flakiness index Crushing Value	2.65 0.5% 1400 Kg/m3 6.5% 5.1% 22%
Micro Silica (As provided by the manufacturer)	Appearance Surface area Average particle size (µm) Bulk density (gm/cc) pH	Snow white 123 11.18 0.18 6.8
Micro Calcium carbonate (As provided by the manufacturer)	Appearance Bulk density (gm/ml) pH	Snow white 0.44 9.5

2.3 Mix proportions.

Table -2: Mix proportions

Mix symbol	Cement	Fly ash	Micro silica	Micro calcium carbonate	Cement (kg/m3)	Fly ash (kg/m3)	Fine aggregates (kg/m3)	Coarse aggregate (kg/m3)	W/c ratio
M-0	100%	Nil	Nil	Nil	448.03	Nil	882.62	1170	0.4
M-1	50%	50%	Nil	Nil	231.48	231.48	875	1160.04	0.4
M-2	50%	50%	4%	4%	231.48	231.48	875	1160.04	0.4

3. Preparation and Testing Of Slab Specimens

3.1 Casting of Slab Specimens.

The form work used for casting of specimens was of wooden fabricated with accurate dimensions especially for the study as a first step installation of reinforcements into the formwork was completed. And then the Individual materials were batched in an electronic weighing balance. The materials were properly hand mixed in the mixer. Firstly, the aggregates, micro particles and cementitious materials were mixed randomly in the dry state and thoroughly mixed concrete was poured in layers and vibrated. The top surface of the slab was finished using a trowel. The concrete was allowed to set for 24 hours and then the formwork was removed carefully and the specimens were allowed for a curing period of 28 days.

3.2 Design of Slab Specimens.

The slab specimens are designed as two way slabs by treating all four edges fixed. The live load considered for this study is 10 KN/m2 as per IS 875: Part 2 -1987 and the test slab specimens are designed using IS-456:2000 codal provisions.

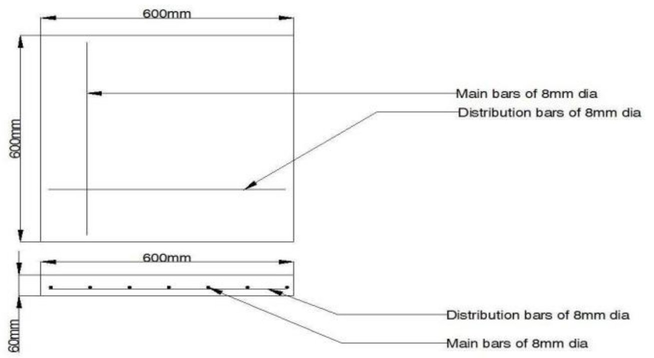

Figure -1: Plan and C/S of test slab

4. Results

4.1 Compressive strength development

Table -3: Cube compressive strength

Age days	Control mix N/mm2	M-1 50% Cement Replacement N/mm2	M-2 50% Cement Replacement + 8% micro particles addition. N/mm2
7	29.33	14.22	Nil
14	37.18	18.07	Nil
28	45.92	21.11	29.04

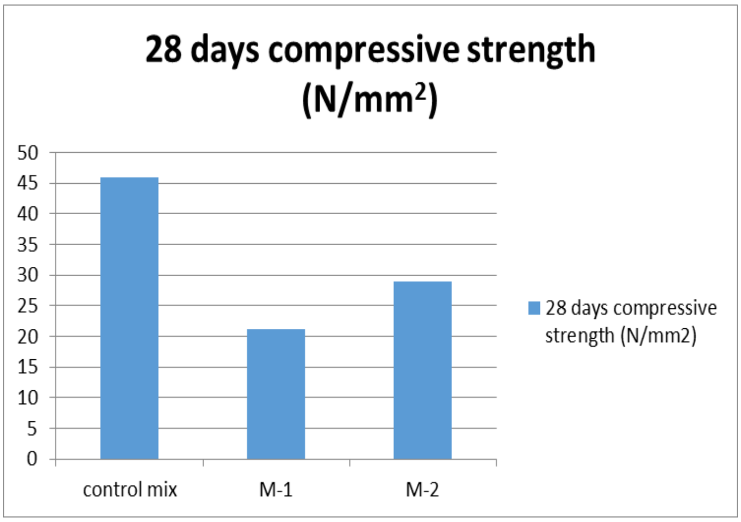

Figure-2: 28 days Compressive strength comparison

4.2 Static Test on slabs

4.2.1 Results of load deflection curve (P- δ curve)

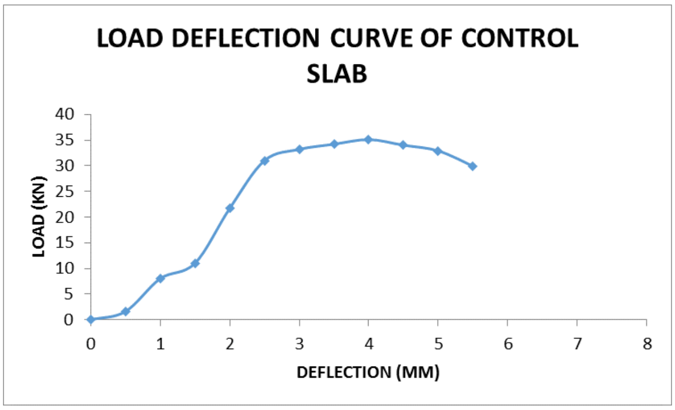

Figure-3: Load - Deflection curve for Control slab

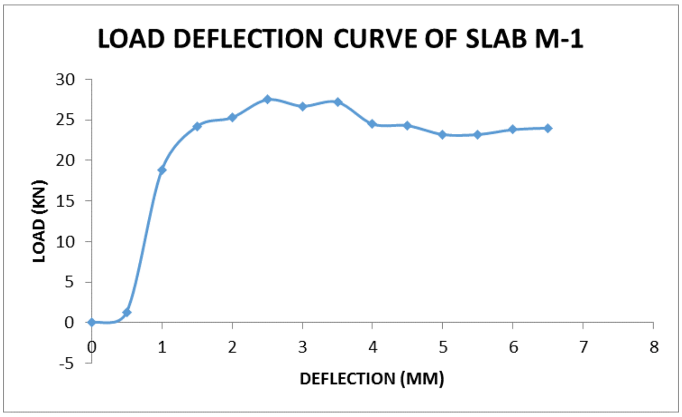

Figure-4: Load - Deflection curve for SLAB M-1

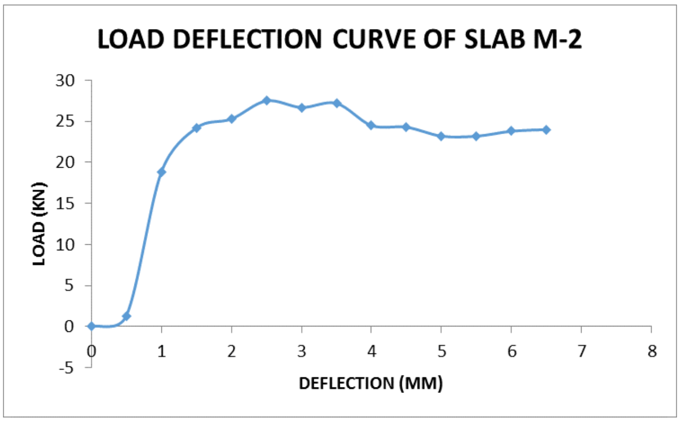

Figure-5: Load - Deflection curve for SLAB M-2

4.2.1.1 First crack load

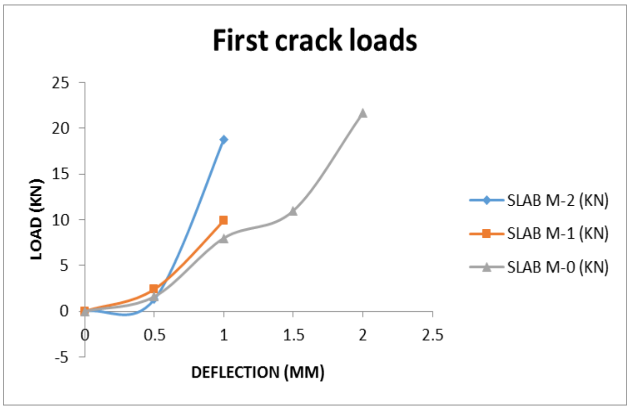

Figure-6: First crack loads of all slabs

4.2.1.2 Ultimate load

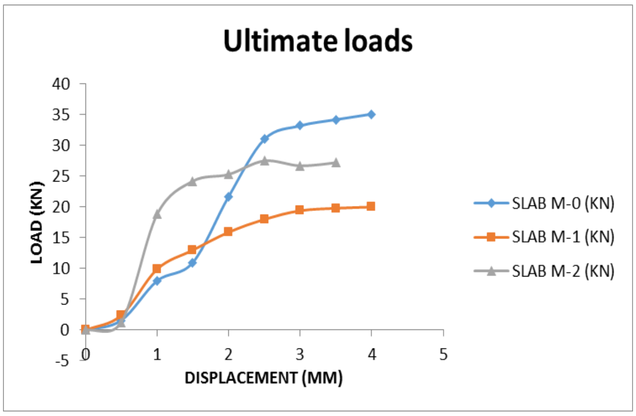

Figure-7: Ultimate loads for all slabs

4.2.2 Ductility index

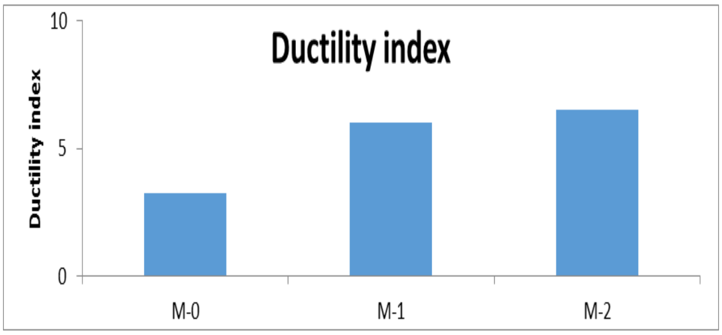

Figure-8: Ductility Index

4.2.3 Energy absorption capacity

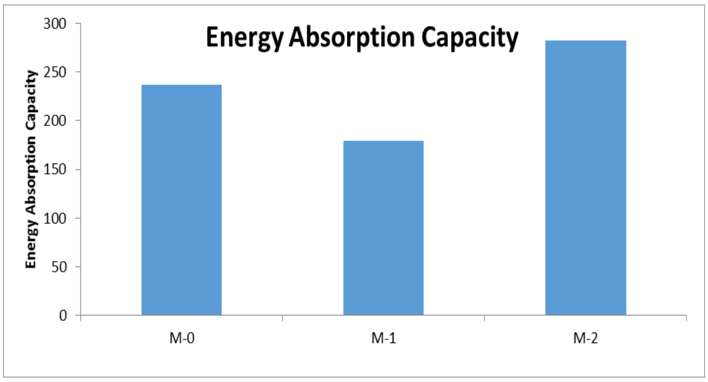

Figure-9: Energy Absorption Capacity

4.2.4 Punching shear strength

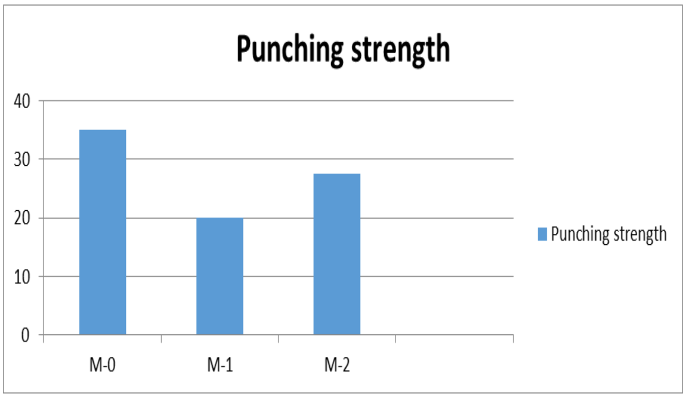

Figure-10: punching shear strength

4.2.4 Cracking moment

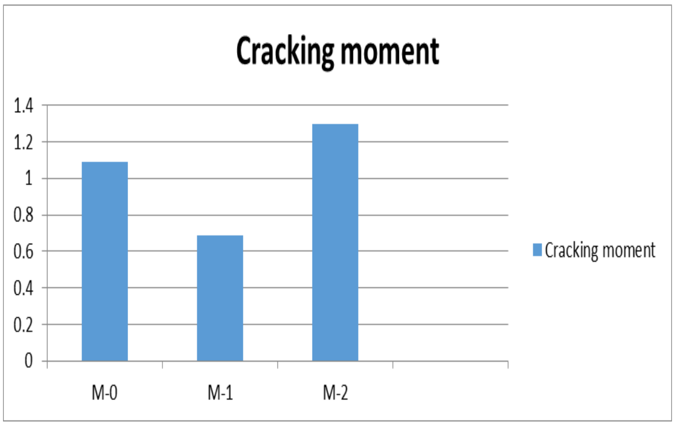

Figure-11: cracking moment

4.3 Cracking pattern

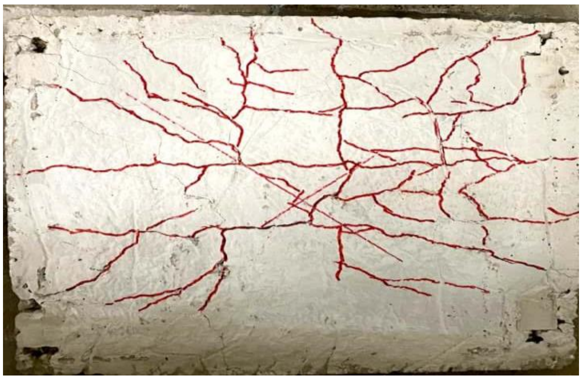

Figure-12: Crack Pattern of M-0

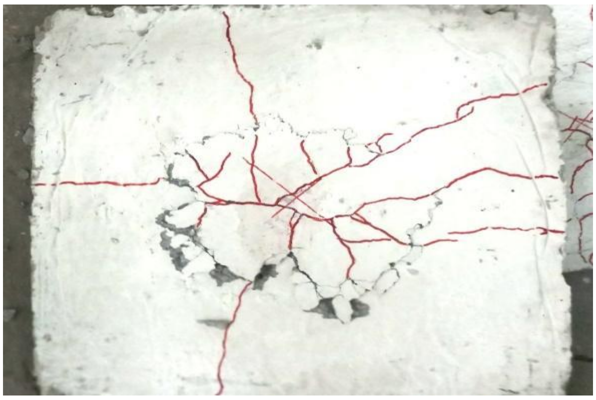

Figure-13: Crack Pattern of M-1

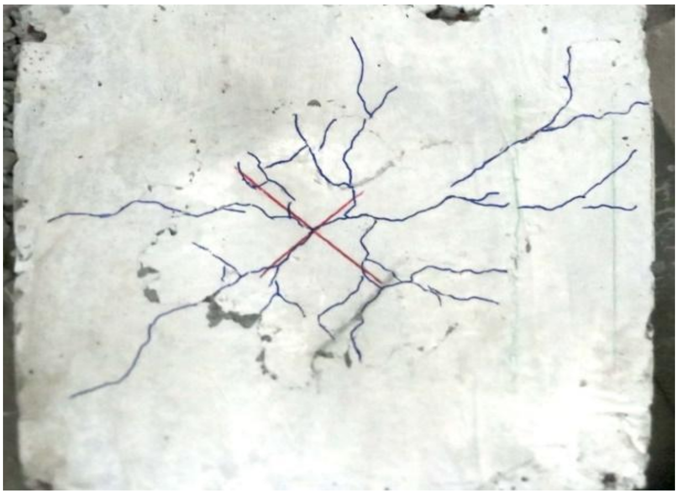

Figure-14: Crack Pattern of M-2

5. CONCLUSIONS

5.1 Compressive strength

The experimentally obtained values of the compressive strength at 28 days for M-0, M-1 and M-2 are found to be 45.92 N/mm2, 21.11 N/mm2 and 29.04 N/mm2 respectively. It is experimentally evident that compressive strength of M-1 and M-2 are comparable with the compressive strength of conventional concrete.

5.2 Load deflection curve

It can be observed that both Normal concrete slabs and Fly ash concrete slabs showed a linear behaviour at initial stages and beyond this a nonlinear behaviour was observed. The experiments show that in most of the cases fly ash concrete slabs showed more deflection than the Normal concrete slabs at a given load.

i. First crack load

The experimentally obtained values of first crack load for M-0 is 15.7 kN whereas for M-1 and M-2 are 9.9 kN, and 18.8 kN respectively. It is observed that from experimental results, first crack load for other slabs has been achieved up to 63%, and 120% with respect to control slab M-0.

ii. Ultimate load

The experimentally obtained values of ultimate load for M-0 is 35.1 kN whereas for M-1 and M-2 are 20 kN, and 27.5 kN respectively. It is observed that from experimental results, ultimate load for other slabs has been achieved up to 57% and 78.3% with respect to control slab M-0.

6.2.2 Ductility index

The experimentally obtained values of Ductility Index for Slab M-0 is 3.25 whereas for M-1 and M-2 is 6 and 6.5 respectively. From the results it can be seen that Ductility Index for M-1 and M-2 is achieved upto 184.6% and 200% w.r.t beam M-0 respectively.

6.2.3 Energy Absorption Capacity

The experimentally obtained values of Energy absorption capacity M-0, M-1 and M-2 concrete test slab specimens are 237 kN-mm, 179.6 kN-mm and 282 kN-mm respectively. It is observed from experimental results, energy absorption capacity for M-1 and M-2 has been achieved up to 70.8% and 119% respectively with respect to M-0.

6.2.4 Cracking Moment

The experimentally obtained values of cracking moment for M-0 are 1.09 kN-mm whereas for M-1 and M-2 are 0.69 kN-mm and 1.3 kN-mm respectively. It is observed that from experimental results, cracking moment for other Slab is 63.3% and 119.2% with respect to control slab M-0.

6.2.5 Punching shear strength

The experimentally obtained values of punching shear strength for M-0 are 35.1 kN whereas for M-1 and M-2 are 20 kN and 20.7 kN respectively. It is observed that from experimental results, punching shear strength for other Slab is 60% and 78.35% with respect to control slab M-0.

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