Analysis of High Performance of Concrete Loading Beam Column Joint

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Abstract- *High performance concrete appears to be a better choice for a strong and durable structure. In this project, investigations were carried out on strength properties and durability properties such as compressive strength, split tensile strength, flexural strength, saturated water absorption test, acid attack, carbonation and alkalinity measurement of M75 grade of HPC mixes with different % replacement of 10%, 20%, and 30% of foundry sand with fine aggregate and 10%, 20%, and 30% of cement by fly ash by adopting water-binder ratio of 0.3. Conplast SP430 is based on Sulphonated Napthalene Polymers can be used as a super plasticiser for better workability for high performance concrete. The HPC mix, grade M75 concrete is designed as per ACI 211.4R-08 "Guide for selecting proportions for high strength concrete with Pozzolana Portland cement and other cementitious materials". Mechanical characteristics like Compressive strength, Split-tensile strength, Flexural strength was examined. The durability study was done by conducting the tests such as saturated water absorption test, acid attack, carbonation and alkalinity measurement. A mathematical model was conducted using ANSYS 10.0 software. The predicted mathematical model for beam column joint produced accurate results for the respective ages when compared with the experimental results. Based on the results obtained, the replacement of 30% foundry sand and fly ash with 3% of super plasticiser which superior characteristics was arrived. The details of the investigations along with the results are presented in this report.*

I. INTRODUCTION

High performance concrete (HPC) is a concrete that meets special combinations of performance and uniformity requirements which cannot always be achieved routinely using conventional constituents and normal mixing and placing and curing practices. There are many materials like fly ash, furnace slag, foundry sand and silica fume etc. One among these special concrete is the foundry sand which is new emerging as one of new generation construction material in producing high strength and performance concrete for special structures.

HIGH PERFORMANCE CONCRETE (HPC)

High performance concrete is widely used throughout the world and to produce them it is necessary to reduce the water/binder ratio and increase the binder content. Super plasticisers are used in these concretes to achieve the required workability. Fly ash is one of the most popular pozzolana, whose addition to concrete mixtures results in low permeability and bleeding. In HPC, materials and admixtures are carefully selected and proportioned to form high early strength, high ultimate strength and high durability beyond conventional concrete..these aspects resulted in prescribing norms to the minimum and the maximum cement contents permissible in the different environments.

SALIENT FEAUTURES OF HIGH PERFORMANCE CONCRETE

Low permeability and resistance to chemical attack

Due to high compressive strength, the cross sectional area of structural element gets reduced, Increased durability in marine environment Higher strength at earlier ages and low heat of hydration. It has good resistance against abrasion, cavitation and erosion. Very little micro cracks, Long life in severe environments. Ease of placements and completion without segregation. Long term mechanical properties.

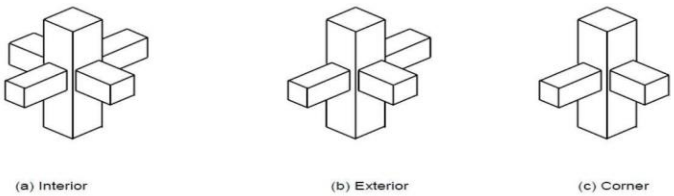
FOUNDRY SAND

Foundry sand is high-quality uniform silica sand that is used to make moulds and cores for ferrous and nonferrous metal castings. Foundry sand is a by-product of the castings industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. Foundry sand is the most essential raw material and its importance is sometimes forgotten amongst Foundry personnel. Foundry sand is as used by Foundries is desired for its thermal 3 resistance and availability. Most metal casting sand (FS) is high quality silica sand with uniform physical characteristics.

APPLICATION OF FOUNDRY SAND

As a partial replacement for fine aggregate in asphalt mixtures; It can be using in partial replacement for fine aggregate in Portland cement concrete; As source material for the manufacture of Portland cement; and Foundry sand can be used in masonry mortar mixes. FLY ASH Fly ash is finely divided residue resulting from the combination of ground or powered coal.

TYPES OF BEAM-COLUMN JOINT



II. LITERATURE REVIEW

Oral buyukozturk and denvid lau (2000), They carried out the experimental investigated that the difference between the normal concrete and high strength concrete, stress strain relationship under biaxial and triaxial loading are described. These criteria are analysed such as strength, permeability and cracking resistance.

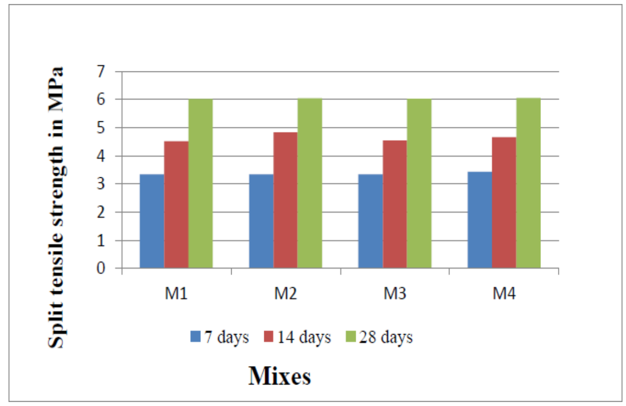
Keerthinarayana *et al* (2010), They carried out an experimental investigated on study on strength and durability of concrete by partial replacement of fine aggregate using crushed spent fire bricks.

Magudeaswaran and Dr. Eswaramoorthi (2013), They carried out the experimental investigated that the increase in the percentage of fly ash and silica fume there was steady increase in the water absorption and alkalinity which significantly indicates the mark able change in strength and durability characteristics of concrete.

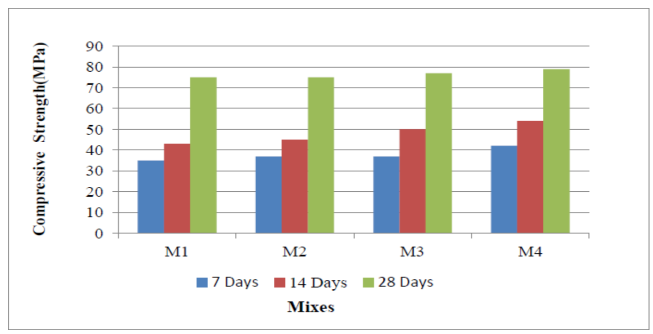
III. RESULT AND DISCUSSION

MECHANICAL PROPERITES

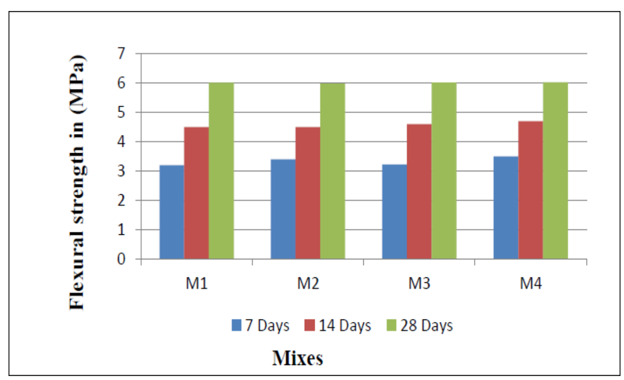
Mix proportions (%)	**Compressive Strength (MPa)**			**Split Tensile Strength (MPa)**			**Flexural Strength (MPa)**		
	7 Days	**14 Days**	**28 Days**	**7 Days**	**14 Days**	**28 Days**	**7 Days**	**14 Days**	**28 Days**
M1	35	43	75	3.345	4.512	6.015	3.2	4.5	6.012
M2	37	45	75	3.445	4.834	6.040	3.4	4.5	5.999
M3	37	50	77	3.344	4.545	6.022	3.2	4.6	6.022
M4	42	54	79	3.433	4.656	6.055	3.5	4.7	6.030



Variation of compressive strength with various mixes



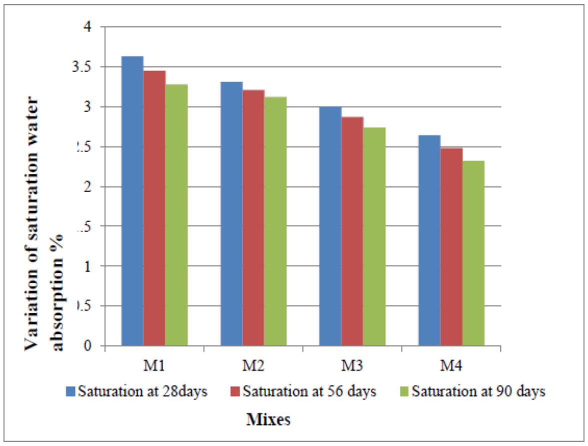
Variation of split tensile strength with various mixes



Variation of flexural strength with various mixes

DURABILITY STUDIES

Mix proportions (%)	**Average reduction in weight (%)**		
	28 days	**56 days**	**90 days**
M1	3.63	3.45	3.28
M2	3.31	3.21	3.12
M3	3.00	2.87	2.74
M4	2.64	2.48	2.32

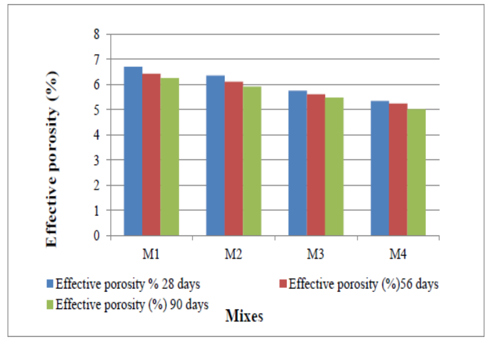


Saturated Water Absorption Test Result Graph

POROSITY

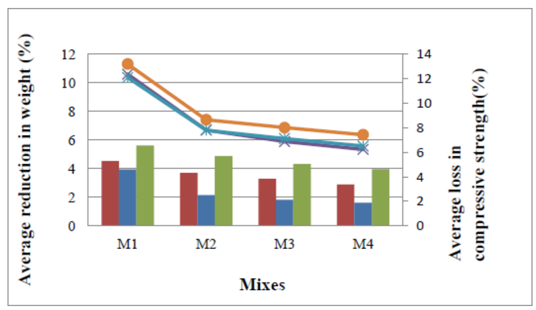
Porosity Test Result

Mix proportions (%)	**Effective porosity (%)**		
	28 days	**56 days**	**90 days**
M1	6.70	6.43	6.26
M2	6.36	6.11	5.92
M3	5.76	5.62	5.48
M4	5.35	5.24	5.02



ACID ATTACK

Mix proportions (%)	**Average reduction in weight (%)**			**Average loss of compressive Strength (%)**		
	28 days	**56 days**	**90 days**	**28 days**	**56 days**	**90 days**
M1	3.94	4.54	5.62	10.6	12.10	13.20
M2	2.16	3.71	4.88	6.70	7.80	8.66
M3	1.83	3.28	4.32	5.90	7.21	8.02
M3	1.61	2.89	3.96	5.35	6.51	7.43



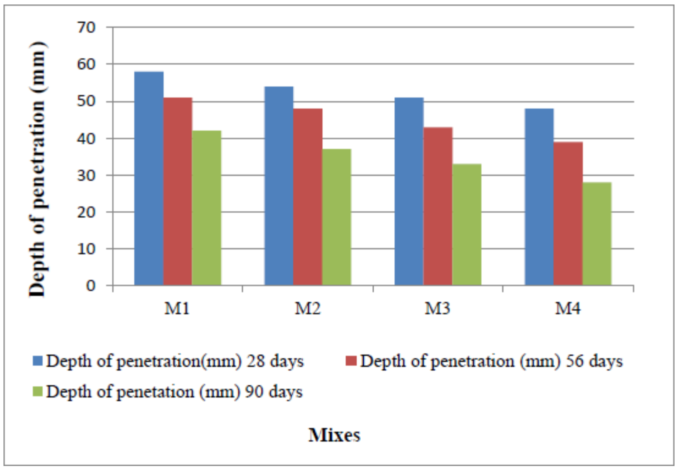
Acid Resistance Test Result

CARBONATION DEPTH

The depths of carbonation were determined by spraying on a freshly broken surface with 1% of phenolphthalein in the solution of 70% ethyl alcohol. The phenolphthalein solution is colorless. It was used as an acid–base indicator. The color of the solution was changed to purple when pH was higher than the range of approximately nine. When the solution was sprayed on a broken specimen surface, the carbonated portion was colorless and non-carbonated portion was purple.

Table 4.6 Carbonation Depth Result

Mix proportions (%)	Depth of penetration (mm)		
	28 days	56 days	90 days
M1	58	51	42
M2	54	48	37
M3	51	43	33
M4	48	39	28

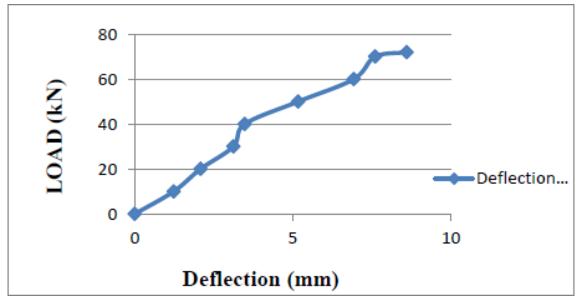


Carbonation Depth Graph

EXPERIMENTAL INVESTIGATION ON BEAM COLUMN JOINT

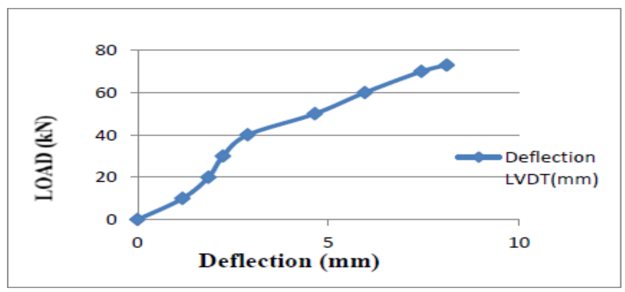
M1-control specimen		**M2-10% Replacement**		**M2-20% Replacement**		**M2-30% Replacement**	
Beam load kN	**Deflection (LVDT) mm**	**Beam load kN**	**Deflection (LVDT) mm**	**Beam load kN**	**Deflection (LVDT) mm**	**Beam load kN**	**Deflection (LVDT) mm**
0	0	0	0	0	0	0	0
10	1.23	10	1.18	10	0.45	10	1.05
20	2.08	20	1.86	20	1.17	20	1.70
30	**3.12**	30	2.24	30	1.75	30	2.50
40	3.48	**40**	**2.89**	**38**	**2.30**	40	3.75
50	5.17	50	4.65	40	2.70	**50**	**4.96**
60	6.93	60	5.96	50	4.05	60	6.30
70	7.61	70	7.45	60	5.43	70	7.58
72	**8.61**	**73**	**8.11**	70	6.75	**80**	**8.90**
				78	**7.82**		

Load-Deflection Behaviour of Control Specimen

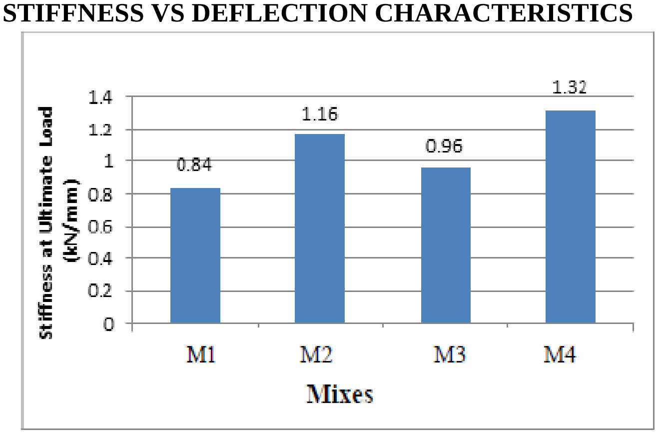


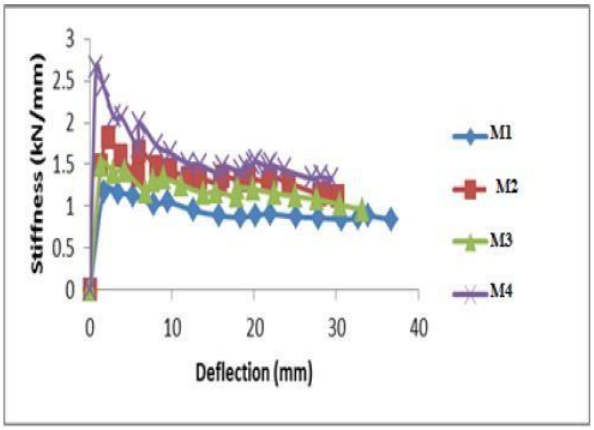
Initial crack-30kN and the corresponding deflection is 3.12 mm

Final crack-72kN and the corresponding deflection is 8.61mm



STIFFNESS VS DEFLECTION CHARACTERISTICS



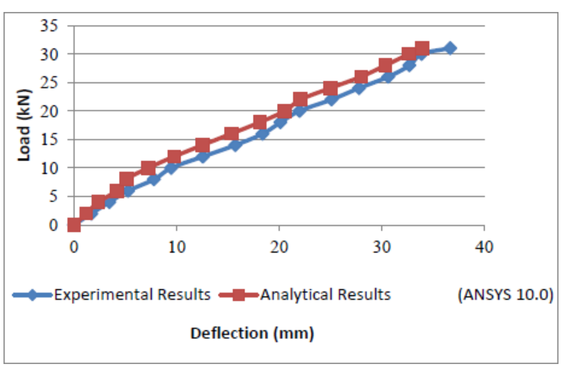


ANALYTICAL INVESTIGATION RESULT

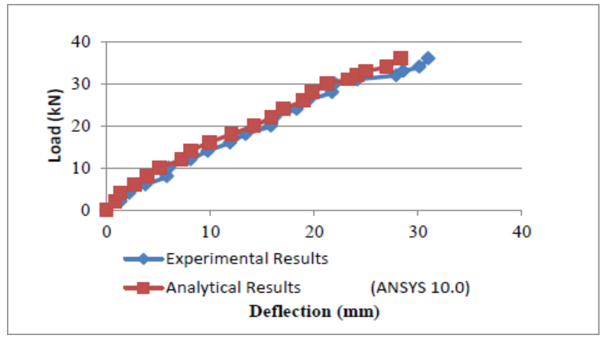
The modelled beams were analyzed up to the ultimate load. For that corresponding ultimate load the different plots such as deflection plot, strain plot and stress plot had taken and the results were discussed.

ULTIMATE LOAD AND DEFLECTION

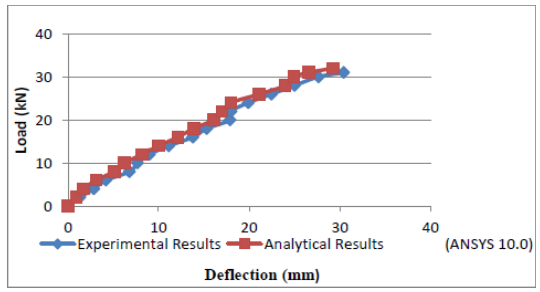
Mix	Ultimate Load (kN)		Deflection for Ultimate Load(mm)	
	Experimental	Analytical	Experimental	Analytical
M1	72	71	7.6	5.07
M2	73	76	8.06	5.36
M3	78	79	8.42	5.64
M4	75	77	7.68	5.21



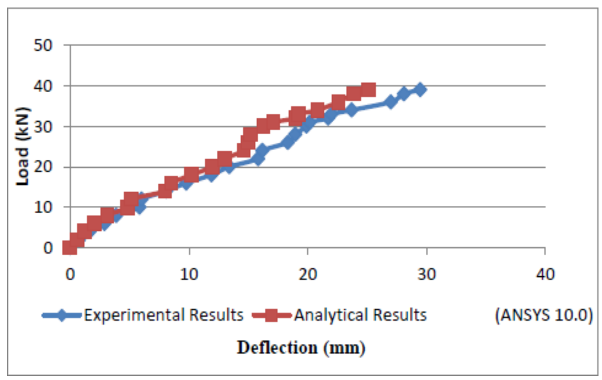
Load vs Deflection Graph for M1 Specimen



Load vs Deflection Graph for M2 Specimen



Load vs Deflection Graph for M3 Specimen



Load vs Deflection Graph for M4 Specimen

IV. CONCLUSION

In this project, the Concrete Mix M75 has been designed as 1:1.03:1.973:0.26. The concrete with optimum replacement percentage of 30% replacement of cement by fly ash and 30% replacement of fine aggregate by foundry in concrete mix quantities also arrived and the performances of exterior beam-column joint with Indian standard codes are examined experimentally.

The following conclusions are arrived from this study,

DURABILITY PROPERTIES

The water absorption percentage and the porosity percentage were found to be slightly higher for high performance concrete than those for continuously moist cured conventional concrete.

Acid resistance capacity increases when 30% replacement of cement by fly ash and fine aggregate by foundry sand compare to other specimens in high performance concrete

The carbonation depth for high performance concrete at the age of 28, 56 and 90 days was found. It can be observed that the carbonation depth is decreased when fly ash is increased.

The alkalinity measurement for high performance concrete with replacement of cement with Fly ash and fine aggregate by foundry sand of 10%, 20%, 30%, at the age of 28, 56 and 90 days was found.

BEAM COLUMN JOINT

The behaviour of exterior beam-column joint specimens in which the reinforcement designed as per IS 456-2000 under monotonic loading were studied.The test specimens with fly ash and foundary sand in High Performance Concrete mix showed better performance in both the reinforcement detailing as per IS 456- 2000 with cross diagonal bars at the joint exhibiting higher strength with minimum cracks in the joint.The test specimens with fly ash and foundary sand in High Performance Concrete mix showed increased ultimate load carrying capacity and lesser deflection than the control specimens with High Performance Concrete mix.The ultimate load carrying capacity of specimens with fly ash and foundary sand for reinforcement detailing were increased compared to the control specimens with similar reinforcement detailing.Specimens with fly ash and foundary sand in the HPC mix have higher stiffness values compared to the specimens with HPC mix by 30%.The finite element model of exterior beam-column joint was developed by using ANSYS 10.0 software.Compared the experimental and analytical beam/column results.

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