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Experimental and Analytical Investigation on concrete containing Metakaolin and Fly ash

Harshal Patil[1], Dr. Umesh P. Patil[2]

[1]M.Tech (Structural Engg.) Student, Department of Civil Engineering, KLEMSSCET, Karnataka, India.
[2] Associate. Prof, Department of Civil Engineering, KLEMSSCET, Karnataka, India.

Abstract - The main objective of this research is to investigate the effect of polymer addition on mechanical properties of binary and ternary blended concrete by incorporating (10%) Metakaolin and (30%) fly ash. The workability properties of polymer modified concrete were also investigated. Adopted polymer includes the Styrene-butadiene-rubber (SBR) latex varied at the rate of 2%, 3% and 4% by weight of cementitious material. The strength properties considered for the study are Compressive strength, flexural strength and Tensile strength of concrete. The strength properties of ternary blend concrete are compared with strength properties obtained for conventional concrete and ternary blend concrete with Metakaolin and fly ash individually in the mix.

***Key Words*: Polymer, Metakaolin, Fly ash Compressive strength, Tensile strength, Regression Analysis.**

1. INTRODUCTION

Concrete is the most extensively and widely used building material for construction all over the world. Concrete can be produced by regionally accessible constituents; wide variety of structural configurations can be casted using concrete, and it requires minimum maintenance during entire service life. It is attractive in many applications because it offers considerable strength at a relatively low cost. To get the high strength for concrete by reducing the water content can achieve by adding the chemical admixture like water reducing agents to concrete. In some cases high strength requirement is not sufficient even other properties also to be enhanced like durability, low permeability and good workability. The production of every one tone of Portland cement, releases the same amount of carbon dioxide into the atmosphere. For this purpose pozzolanic materials are incorporating in to concrete like fly ash, silica, GGBS etc those are called as supplementary cementitious materials (SCMs). Incorporation of these SCMs not only enhance the properties of concrete they also reduces the cement content in concrete. The reduction of cement content means it minimize the environment impacts caused in cement production process and most of these materials are industrial by-products, problems with disposal also can be solved. SCMs are added to batch immediately or during mixing to modify one or more of the properties of concrete in fresh and hardenedstate. The use of SCMs as partial replacement to cement in concrete is common practice in modern concrete technology.

2. OBJECTIVE OF THE STUDY

Following are the objectives of this experiment:

- To investigate Strength parameters of concrete containing Fly ash and Metakaolin.
- To compare the strength parameters of concrete with different mix proportions of Fly ash and Metakaolin with the conventional control mix of concrete subjected to Polymer.
- To determine the Residual strength of concrete mix containing Fly ash and Metakaolin and comparing those with the conventional control mix.
- To determine compressive strength equation using Regression analysis.

3. MATERIALS AND METHODS

3.1 Cement

OPC 43 grade with specific gravity 3.15 was used conforming to IS: 8112: 2013.

3.2 Fine aggregates

The fine aggregate (M-sand) which was used for experimental works where locally obtained. Based on experimental results it belonged to Zone-I. The specific gravity of fine aggregates (M-sand) was found to be 2.65.

3.3 Coarse aggregates

Locally available 20mm down sized coarse aggregates where used for experimental works. The specific gravity based on experimental results was found to be 2.88.

3.4 Metakaolin and Fly ash

3.5 The metakaolin used in the experimentation was obtained from Raviraj industry, Udaipur, Rajasthan. The specific gravity of metakaolin is 2.54and Fly ash is procured from Balaji concrete Belagavi specific gravity is 2.85.

3.5 SBR Latex Polymer

SBR Latex Polymer specific gravity at 1.22.

3.6 Mix Design

The results are obtained using IS 10262–2009 code, mix design is carried out for M30 grade of concrete. The mix proportion obtained for M30 grade concrete is 1: 1.46: 2.88 for water cement ratio of 0.42.

4. EXPERIMENTAL TEST PROCEDURE

Table-1 Mix id description

MIX ID	DESCRIPTION
M0	Control mix contains only basic ingredients used M-sand as F.A.
MB1	(50% CEMENT +50% GGBS) +1% SP
MB2	(50% CEMENT +50% GGBS) +1% SP+2% POLYMER
MB3	(50% CEMENT +50% GGBS +1% SP+3% POLYMER
MB4	(50% CEMENT +50% GGBS) +1% SP+4% POLYMER
MB5	(70% CEMENT +30% FLYASH) +1% SP
MT1	(20% CEMENT +50% GGBS +30% FA) +1% SP
MT2	(20% CEMENT +50% GGBS +30% FA) +1% SP+2% POLYMER
MT3	(20% CEMENT +50% GGBS +30% FA) +1% SP+3% POLYMER
MT4	(20% CEMENT +50% GGBS +30% FA) +1% SP+4% POLYMER

5. EXPERIMENTAL TEST RESULTS AND DISCUSSION

5.1 Workability Results

Slump test was carried out on all these mixes. Control mix has shown more slump. But all proposed mixes have satisfactory slump values.

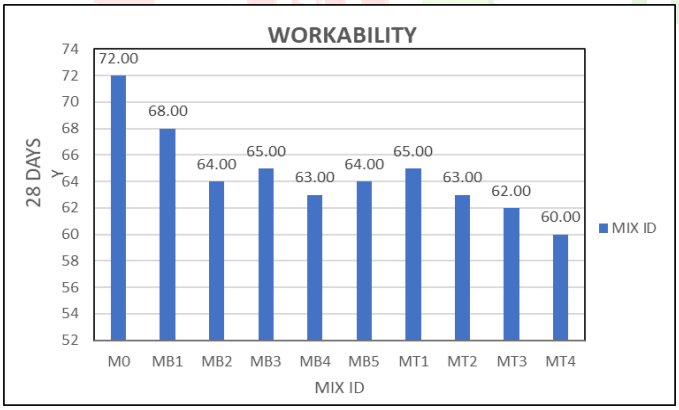

Chart-1: Variation in Slump

5.2 Compressive Strength Test Results

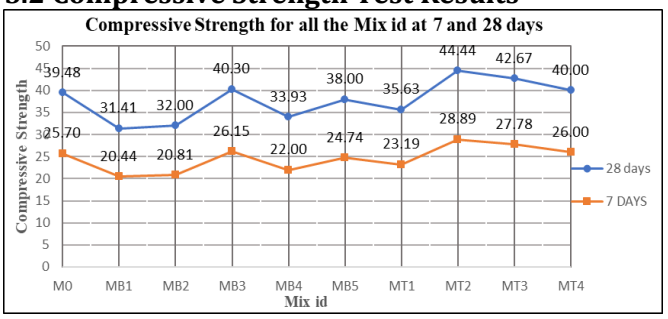

Chart-2: Variation of Compressive strength at 7 days and 28 days for all the Mixes.

Compressive strength of after 7days of curing and in range of 20.44 N/mm² to 28.89 N/mm² with mix (MT2) shows max value of 28.89 N/mm² and binary blend (MB1) shows least value of 20.44 N/mm² these values are in the accepted range of 66% of 28 days compressive strength. 28 Days compressive strength was in the range of 31.41 MPa to 44.44 MPa including binary and ternary blend concrete mixes. Mix MT2 has shown a peak value of 44.44 N/mm² and mix MB1 has shown a lower strength of 31.41 N/mm² while all mixes are in the acceptable range (for M30 concrete). In case of ternary blend mixes, there is further rise in compressive strength in all mixes, All the mixes have shown a strength above 30 N/mm² Mix MT2 has shown a peak strength of 44.44 N/mm² mix MT1 performed little low compared to other Mix in ternary producing a strength of 35.68 N/mm². Thus All Mixes have performed better in binary blend concrete. And mix MT2 performed better compared to other ternary blend concrete has shown strength of M40 concrete as the objectives to develop a concrete containing admixtures which can produce M40 concrete more economically compared with control mix, mixes MT3, MT2 and MT4 are recommended. Ternary and Binary blend with both admixtures MK and FA have shown encouragement results.

5.3 Split Tensile Strength Test Results

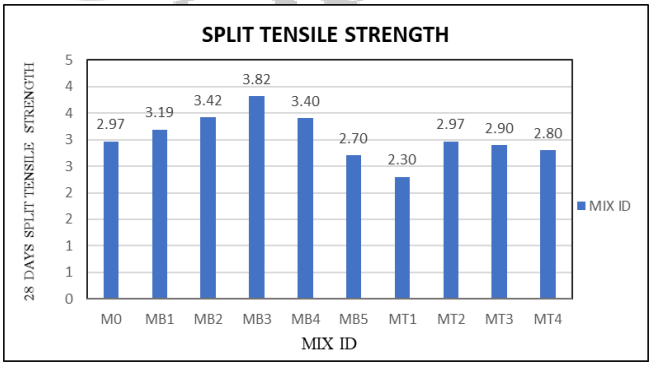

Chart-3 Variation of Split tensile strength at 28 days for all the Mixes.

28 Days Tensile strength was the range of 2.30 MPa to 3.82 MPa including binary and ternary blend concrete mixes. Mix MB3 has shown a peak value of 3.82 N/mm² and mix MT1 has shown a lower strength of 2.30 N/mm² while MT4 the acceptable range (for M30 concrete) MT1 not accepted for M30 concrete. case of ternary blend mixes, there is further drop Tensile strength in all mixes, Mix MB3 has shown a peak strength of 382 N/mm² mix MT1 performed poorly producing a strength of 2.30N/mm². Thus Mix have performed better in binary blend concrete. And mix MT2 performed better compared to other ternary blend concrete. But still it has not shown strength of M30 concrete as the objectives to develop a concrete containing admixtures which can produce M30 concrete more economically compared with control mix, Except mix MT1, and MB5 all are recommended. Ternary blend with both admixtures MK and FA have not shown encouragement results.

5.4 Shear Strength Test Results

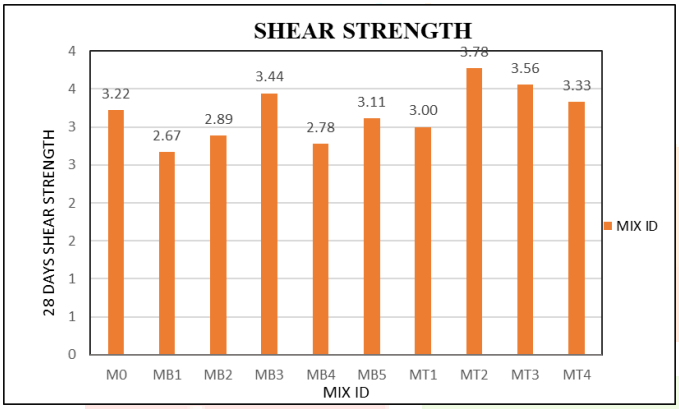

Chart -4 Variation of Shear strength at 28 days for all the Mixes.

28 Days Shear strength shows encouragement result for both binary and ternary blend concrete. MT2 shows peak value 3.78 N/mm² compared to all Mixes both binary and ternary blend concrete. This binary blend shows good result compared to ternary blend concrete where as ternary blend MT2 shows high strength 3.78 N/mm² as compared to other ternary Mixes. And MB1 shows least value 2.67 N/mm² and not reaches the M30 strength.

5.5 Ultrasonic Pulse Velocity and Rebound Hammer Test Results

Table-2 Ultrasonic Pulse Velocity Test

1)Ultrasonic Pulse Velocity					
Mix Id	Specimen	Weight (kN)	Time of Travel (µs)	Intensity m/s	REMARKS
M0	1	8.90	30	4839	EXCELLENT
	2	9.10	31	4849	EXCELLENT
MB1	1	8.95	33.5	4478	GOOD
	2	8.88	31	4839	EXCELLENT
MB2	1	8.96	33.5	4478	GOOD
	2	9.25	30	5000	EXCELLENT
MB3	1	9.24	33	4545	EXCELLENT
	2	9.00	33.5	4478	GOOD
MB4	1	8.95	35	4286	GOOD
	2	9.25	33.5	4478	GOOD
MB5	1	9.14	30	5172	EXCELLENT
	2	8.72	31	5000	EXCELLENT
MT1	1	8.42	33.5	4348	GOOD
	2	8.44	31	4396	GOOD
MT2	1	8.70	33.5	4167	GOOD
	2	8.74	30	4169	GOOD
MT3	1	8.84	33	4528	EXCELLENT
	2	8.72	33.5	4529	EXCELLENT
MT4	1	8.46	35	4167	GOOD
	2	7.96	33.5	4478	GOOD

Table-3 Rebound Hammer Test

2) Rebound Hammer			
Mix Id	Specimen	Rebound Number	Compressive Strength
M0	1	44	45.77
	2	44	46.67
MB1	1	40	41.56
	2	40	42.67
MB2	1	38	40.00
	2	40	40.44
MB3	1	42	43.78
	2	46	46.67
MB4	1	34	35.56
	2	38	38.22
MB5	1	44	43.56
	2	42	44.44
MT1	1	32	32.67
	2	32	33.11
MT2	1	38	37.56
	2	38	38.22
MT3	1	30	32.67
	2	34	34.89
MT4	1	32	30.89
	2	30	29.33

Rebound Hammer and Ultrasonic Pulse Velocity.

Rebound Hammer was in the range of 28 Rebound No to 44 Rebound No for both binary and ternary blend concrete mixes. Mix MT2 has shown a peak value of 44 Rebound No and mix MB1 has shown a lower strength of 28 Rebound No while MB1 is the acceptable range (for M30 concrete).
Thus Mixes MB1, MB3 and MB5 have performed better in binary blend concrete .And mix MT2 performed better compared to other ternary blend concrete as the objective is to develop a concrete containing admixtures which can produce more than M30 concrete more economically compared with control mix, mixes MB3 and MB5 are recommended.

Ultrasonic Pulse Velocity was shown "Excellent" and "Good" Remark n Concrete Quality Grading Above 3.5 Pulse Velocity (Km/sec) for all mixes. Shown high intensity for MB5, MB3, MT2 (5000) and low intensity for MB4 and MT4 (4167). So all mixes were shown good and satisfactory result.

5.6 Regression Analysis

Regression Analysis for Mixes was done and shows the Equation generated was.

Comp Strength = 39.149 + 0.0033C - 0.2585F + 0.6308MK + 1.23P With Experimentally evaluated values of compressive strengths are in close agreements with Values predicted by Regression Analysis.

Regression Statistics	
Multiple R	0.786862956
R Square	0.619153311
Adjusted R Square	0.314475961
Standard Error	3.660507732
Observations	10

6. CONCLUSIONS

From the experimental statistical and SEM investigations, following are the overall conclusions.

1. It is possible to produce concrete of M30 Compressive strength as that of control mix using FA at 30% and MK at 10% replacement with cement and addition of polymer.
2. Addition of 2%, 3% 4% polymer further improves the strength characteristics of concrete.
3. Out of different % of polymer addition tried, 3% addition of polymer results n peak values of compressive strength and split tensile strength for binary blend concrete. For ternary blend concrete 2% addition of Polymer, results n peak values compressive strength and split tensile strength.
4. Binary blend Concrete containing polymer improves to be more economical than control mix hence can be recommended for all concrete applications wherever control mix s used (M30).
5. Ternary blend concrete containing polymer improves to be more economical than control mix hence can be recommended for all concrete applications wherever control mix s used (M40).
6. From regression analysis observed that the equation generated is predicting values which are in the close agreement with experimental values.
7. Results of Rebound Hammer and Ultrasonic Pulse Velocity tests are satisfactory.

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AUTHORS

Harshal Patil,
PG Student, Structural Engineering, Department of Civil Engineering, KLEMSSCET Belagavi, Karnataka, India

Dr. Umesh P. Patil,
Associate Professor, Department of Civil Engineering, KLEMSSCET Belagavi, Karnataka, India