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MATHEMATICAL MODELLING FOR STRENGTH CHARACTERISTICS OF FLY ASH CONCRETE

***Suganya.S, **B.Hagnesh, A.Gandhimathi^, Dr.T.Meenambal@**

UG Student, Dept. of Civil Engineering, Government College of Technology, Coimbatore, Tamilnadu, India
*****UG Student, Dept. of Civil Engineering, Jansons College of Technology, Coimbatore, Tamilnadu.***
^Asso.Prof, Dept. of Civil Engineering, SNS Institute of Technology, Coimbatore, Tamilnadu, India
@Prof, Dept. of Civil Engineering, Government College of Technology, Coimbatore, Tamilnadu, India

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ABSTRACT

Cement is a fundamental raw material used in construction. Production of cement releases large amount of CO_2 which is a major cause for the global warming issue. Hence calculated percentage of cement can be replaced by other materials such as fly ash, rice husk ash, meta kaolin, silica fume, geo-polymer etc. without cutting down much the strengths of concrete. Fly ash is one of the most normally preferred substitutes for cement because concrete workability and durability are enhanced by fly ash by their small size and round shape. A mathematical model was constructed using SPSS software for the strength characteristics like compressive strength, flexural strength and split tensile strength when cement is replaced with fly ash at a range of 0% to 50 %. As the percentage of replacement of fly ash in the concrete increases, the strength characteristics decrease. Water content and cement/aggregate ratio are the main parameters which influence the strength characteristics. A comparative study between the results obtained from the laboratory and SPSS has been made and it is found that the differences between these two values are minimum.

Key words : Cement, Fine Aggregate, Coarse Aggregate, Fly Ash, Concrete cubes, cylinders, beams, mathematical modeling, SPSS software.

1.0 INTRODUCTION

Fly ash is the mineral residue produced during combustion of coal, and comprises the fine particles that rise with the flue gases. Fly ash comes primarily from coal-fired electricity generating power plants. These plants grind coal to powder fineness before it is burned.

Effective utilization of wastes should be carried out in a profitable manner thereby reducing the volume of waste. The disposal of fly ash has become mandatory as it poses a serious environmental issue. In India, out of the more than 110 million tons of fly ash produced annually, the unused fly ash occupies vast track of valuable land as ash ponds. It is being used in production of concrete by partial (only 20-25 %) replacement of cement. As per the recommendation of IRC: SP : 62-2004, the fly ash content as partial replacement of ordinary Portland cement can be up to 35 %.

2.0 LITERATURE REVIEW

Some important observations of the review are presented

Charles Berryman, Jingyi Zhu, Wayne Jense, Maher Tadros (2005) .concluded that Test cylinders with varying percentages of Class C (25-65%) and Class *F (25-75%)* fly ash and a water-reducing admixture (WRA) were created under field manufacturing conditions and tested for 7-

day compressive strength. Seven-day compressive strength for the concrete/fly ash/WRA was found to be highest when the concrete mix included approximately 35%'Class C or 25% Class F fly ash

Binod Kumar, Tike G.K, Nanda P.K (2007) in their laboratory test results showed that fly ash concrete mixtures containing 50-60% fly ash can be designed to fulfill the requirement of strength and workability suitable for cement concrete pavement construction. At all w-cm ratios, the concrete mixture containing 60% OPC and 40% fly ash developed maximum strength at the age of 90 days and beyond

3.0 MATERIALS AND METHODS

Fly ash is comprised of the non-combustible mineral portion of coal. When coal is consumed in a power plant, it is first ground to the fineness of powder. Blown into the power plant's boiler, the carbon is consumed – leaving molten particles rich in silica, alumina and calcium. These particles solidify as microscopic, glassy spheres that are collected from the power plant's exhaust before they can "fly" away. Thus fly ash is a residue generated in combustion that rises with the flue gases and is captured by electrostatic precipitators or other particle filtration equipment.

Using the different mixes the concrete moulds are prepared and are tested for strengths after curing in 7, 28, 56, 90 days. The split tensile and compressive strengths are determined using the Compression Testing Machine (CTM).

4.0 EXPERIMENTAL RESULTS AND DISCUSSION

4.1. Concrete mix design

Cement is partially replaced by fly ash in the range of 0% to 50%. Detailed mix proportions as per IRC: 44-2008are given below. Results of compression strength test, split tensile strength and flexural strength on these mixes test are listed (Table2,3,4.).

4.2. Mix Proportions as per IRC: 44-2008

The mix proportions are designed as per IRC 44-2008 and cement is replaced by fly ash in increasing steps of 10% for the same quantity of fine aggregate, coarse aggregate and water(Table 1)

Mix	% of fly ash content	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lit)
M1	0	412.00	0	679	1216	159
M2	10	359.23	42.97	679	1216	159
M3	20	334.56	89.65	679	1216	159
M4	30	298.87	129.12	679	1216	159
M5	40	258.25	168.36	679	1216	159
M6	50	221.32	207.96	679	1216	159

(Table 1) The mix proportions

Mix	% of Fly Ash	Compressive strength (MPa)			
		7 days	28 days	56 days	90 days
M1	0	29.26	42.39	44.51	45.65
M2	10	28.65	40.54	43.06	45.31
M3	20	25.32	38.35	41.26	42.21
M4	30	22.45	37.28	40.31	41.62
M5	40	18.85	32.28	37.07	40.76
M6	50	14.24	28.47	34.54	39.52

(Table 2) Compressive strength result of flyash concrete.

Mix	% of Fly Ash	Flexural strength (MPa)		
		28 days	56 days	90 days
M1	0	4.85	5.01	5.23
M2	10	4.63	4.95	5.12
M3	20	4.52	4.90	5.03
M4	30	4.36	4.83	4.97
M5	40	3.94	4.58	4.72
M6	50	3.51	4.14	4.36

(Table 3) Flexural strength results of fly ash concrete

4.3 COMPARATIVE STUDY OF COMPRESSIVE STRENGTH OF FLY ASH CONCRETE

The comparative study has been made between the experimental value and the theoretical values which are derived from the SPSS software.

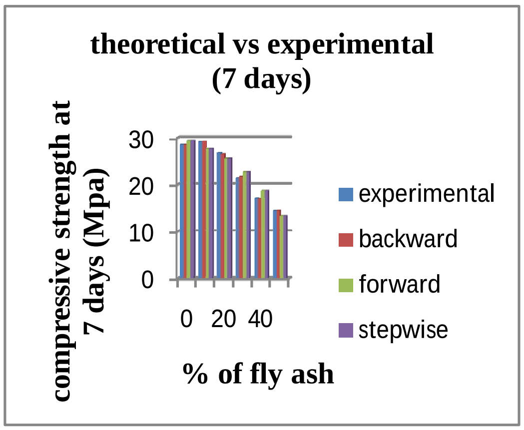

Figure 1.Comparative study of theoretical and experimental values of compressive strength at 7 days

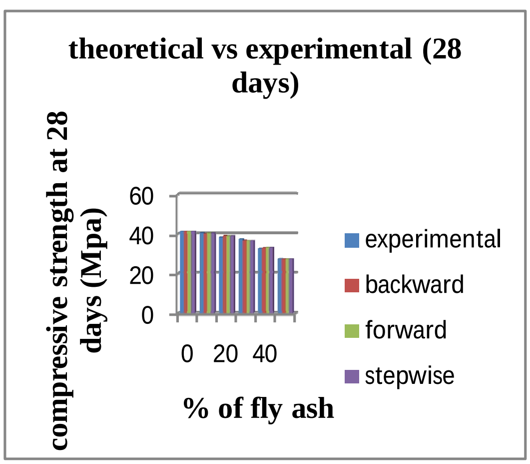

Figure 2.Comparative study of theoretical and experimental values for compressive strength at 28 days

For compressive strength at 28 days the parameters influencing the strength in forward and stepwise regression are same.

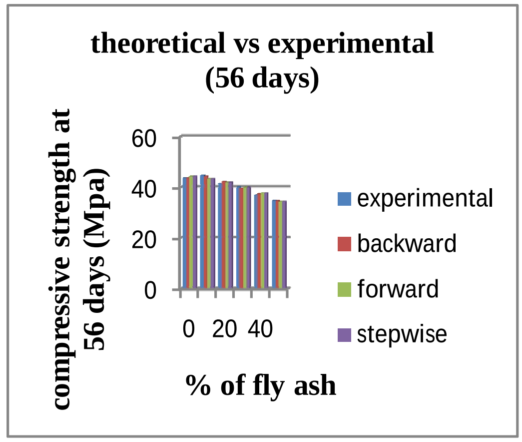

Figure 3 Comparative study of theoretical and experimental values for compressive strength at 56 days

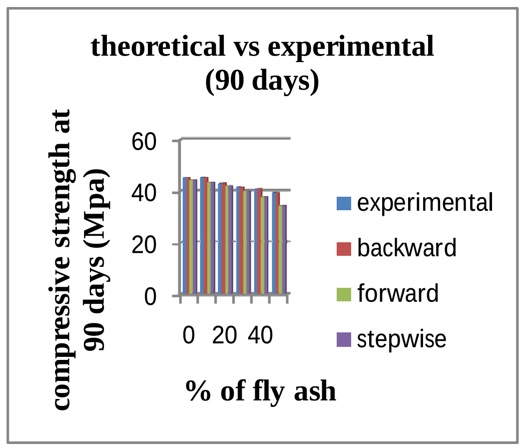

Figure 4 Comparative study of theoretical and experimental values for compressive strength at 90 days

The replacement of cement with fly ash ranges from 0 % to 50 % and the compressive strength at 7, 28, 56 and 90 days are considered in this comparison(figure 1,2,3,4). The experimental values and the results from three different regression methods are compared and it is clear that the differences in values between experimental results and the theoretical results from the software is minimum.

From the result it has been noted that the forward regression and the stepwise regression is giving the same values and parameters affecting the strength are same. The backward regression is the method which gives more number variable which is affecting the strength properties hence the backward method can be adopted.

4.4. COMPARATIVE STUDY OF FLEXURAL STRENGTH OF FLY ASH CONCRETE

Experimental values for flexural strength for 28, 56, 90 days are compared with the theoretical results obtained from the software.

In flexural strength, the forward regression and stepwise regression is giving the same parameters which affects the split tensile strength. In the case of backward regression model more number of parameters are involved in strength characteristics and hence it is the best method.

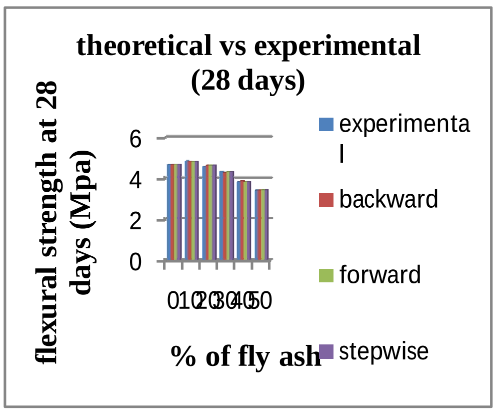

Figure 5 Comparative study of theoretical and experimental values of flexural strength at 28 days

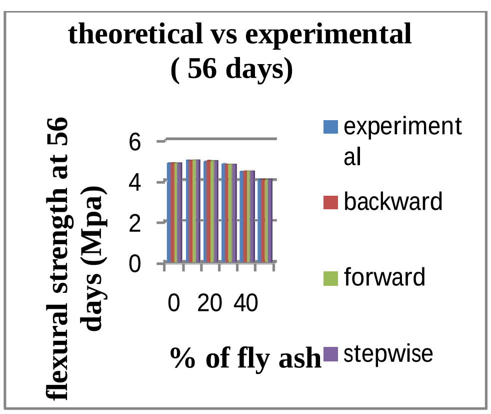

Figure 6 Comparative study of theoretical and experimental values of flexural strength at 56 days

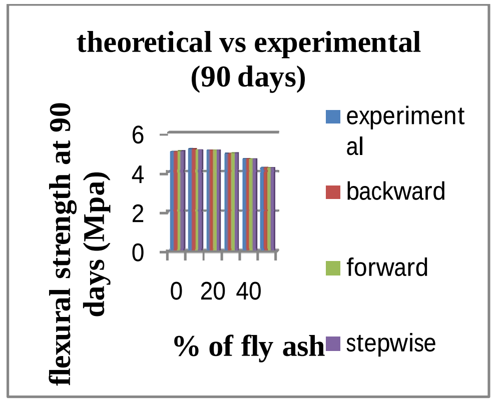

Figure 7 Comparative study of theoretical and experimental values of flexural strength at 90 days

From the figures(5,6,7) it is clear that the difference in values between the experimental value and the theoretical values obtained from the SPSS are minimum and the backward regression can be adopted.

5. CONCLUSIONS

The following conclusions are arrived based on the results obtained from the regression model using SPSS software.

1. Water content and cement/ TA are the main parameters which are influencing the strength characteristics.
2. The difference in values of strength characteristics such as compression, flexural, which were obtained from the laboratory and the predicted value from SPSS software is minimum.
3. As the percentage of fly ash increases, the strength characteristics of concrete containing fly ash slightly reduce.
4. Even though, strength characteristics decrease slightly, the nominal replacement of fly ash in cement reduces the wastage disposal problem.

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