Journal of Science and Technology
ISSN: 2456-5660 Volume 6, Issue 3, May-June 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2021.v6.i3.pp67-74*

Selection of Optimised Replacement For Fly Ash Based CementComposition By Topsis Method

G.Shiva kumar[1], Dr. R. Bharathi Murugan[2]
[1]*(M.Tech Student, Dept. of civil engineering, Vaagdevi College of Engineering (Autonomous), Warangal, India)*
[2]*(Assistant professor, Dept. of civil engineering, Vaagdevi College of Engineering (Autonomous), Warangal, India)*
[1]*Corresponding Author: ganacharishiva7@gmail.com*

To Cite this Article
G.Shiva kumar, Dr. R. Bharathi Murugan, "Selection of optimized replacement for Flyash based cement composition by Topsis", Journal of Science and Technology, Vol. 06, Issue 03, May-June 2021, pp 67-74.

Article Info
Received:02-02-2021 Revised:25-04-2021 Accepted:10-05-2021 Published:25-05-2021

Abstract: *Concrete flexibility, durability, sustainability and economy makes mostly used construction material in civil engineering because concrete has high structural strength and stability. The main ingredients in concrete are ordinary Portland cement. So, its production is severe threat to the environment. Why because, in the production of cement with equal amount of CO_2 is released into the atmosphere which is 5% of the globally production of the pollution. The most effective way to reduce CO_2 emission from cement industry is to substitute a proportion of cement with other materials. These materials are called supplementary cementitious materials for replacement of cement. In this project I have adopted M_{40} grade of concrete with fly ash as supplementary cementitious materials for replacement of cement. I replaced cement with both fly ash and GGBS for 10%, 20%,30%,40%,50% by weight of cement. Various tests like compressive, split tensile tests and Acid attack, RCPT tests were conducted. The curing periods chosen were 7,28,56,90 days respectively. The best and sustainable mix cannot be decided from the results obtained by the strength and durability parameters alone, it is also necessary to consider the beneficial criterions. So, to get the best mix, I adopted TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)method of MCDM (Multi Criteria Decision Making) techniques in the project. By using this method, I concluded that the sustainable mix obtained was M_3 i.e., 30% replacement of cement with fly ash by considering various alternatives and criterion.*
Keywords*: TOPSIS, Flyash.*

I. Introduction

General

Cement is the important substance in concrete. The manufacturing of cement in industries results in large emission of carbondioxide. Thus, the person doing research have started finding other choices for the partial replacements for cement. Among many alternatives, FLY ASH is the industrial by product having very good binding properties to concrete and became as a substituent of cement. These changes are generally called as supplementary cementitious materials (SCMs). Concrete is a collective material formed by bonding together aggregates and liquid cement which hardens over time.Approimately production of 1ton of cement there will be release of 900kgs of carbondioxide into the environment.

Supplementary cementitious materials (SCMs) in concretes are in practice for a sensible lengthy period due to the total economy in their production and improved performance aspects in violent environments. Due to low hydration rate during starting stage Fly ash concrete mix, curing time should be extended then conventional concrete. Fly ash concretes are major step forwatd to the conventional concrete due to its cement savings; cost reduction, environmental welfare and social security. Usage of Fly ash significantly reduces high threat of damages caused by Alkali-silica reaction (ASR) provides high resistance to chloride entrance by reducing the threat of reinforcement corrosion and also gives higher resistance to attack by sulphates and other chemicals.

In this project, best selection of cementitious materials FLY ASH were evaluated partially with ordinary Portland cement. The aim of this project is to examine the mechanical as well as durability studies of M_{40} grade of concrete is studied

Technique for Order Preference by Similarity to Ideal Solution

(TOPSIS) Technique for Order Preference by Similarity to Ideal Solution method was developed by "HWANG" and "YOON" in 1981. It is based on the concept that an ideal solution is shortest distance from positive solution and it should be the longest distance from negative solution. It is a method of compensatory hostility that compares a set of substitutes by identifying weights for same criteria. Normalization is the best way to find the acquired outcomes which are how far from the ideal solution.

Why TOPSIS: it is the best method to identify the ideal solutions from a collection of possible alternatives. Topsis normalizes the outcomes and compare these to the ideal solutions. Based on the alternative outcomes it should give a rank for easy understanding of different alternatives. Topsis method used in large engineering problems often found in aeronautics and automotive industries.

Feasibility of TOPSIS

The following are the feasibilities of TOPSIS.

1. Simplicity.
2. Rationality.
3. Comprehensibility.
4. Efficiency of good computation outcomes.
5. Accurate measurement of different alternative solutions.

Aim

To obtain best mix of concrete when cement is minimally replaced by Fly ash using TOPSIS method of MCDM technique.

Objectives

The following are the objectives set after viewing literature reviews.

1. Determine the behavior and mechanical properties of two concrete mixes when cement is partially replaced with fly ash from 0%,10%,20%,30%,40%,50%.
2. To determine the durability properties of two concrete mixes with fly ash for different curing periods as 7,28,56,90.
3. To obtain the best optimized mix of fly ash by TOPSIS method of MCDM technique.

II. Study Methodology

Material Collection

The materials used in this project were collected from nearby source. The following materials are required,

- Cement 53 grade
- Fly ash (Class-F)
- Fine aggregate
- Coarse aggregate (10mm and 20mm)

Mix Proportion

IS (10262-2019) code is used for mix design. The final mix proportion obtained for M_{40} Grade of concrete is 1:1.46:3.02:0.46.

The following quantities (kg/m^3) are obtained for the above mix proportion which is designated as "M".

Table no 1: Mix proportion for 1 m^3 of concrete

Mix	Cement	Fine aggregate	Coarse aggregate		Water
			10 mm	20 mm	
M	415	606	501	751	193

Similarly mix proportion for fly ash which are replaced by cement with 10%, 20%, 30%, 40%, 50% which is designated as M_1, M_2, M_3, M_4, M_5 respectively.

Table no 2: Mix proportions

Mix	Cement	Fly ash	Fine aggregate	Coarse aggregate		Water
				10 mm	20 mm	
M_1 (10%)	373.5	41.5	606	501	752	193
M_2 (20%)	368	83	606	501	752	193
M_3 (30%)	326.5	124.5	606	501	752	193
M_4 (40%)	285	166	606	501	752	193
M_5 (50%)	207.5	207.5	606	501	752	193

Casting

First of all, ingredients of mix are weighed accurately according to mix proportion and mix it properly to get the uniform mix. Specimens (cubes, cylinders etc.) were casted for different percentages (0%, 10%, 20%, 30%, 40%, 50%) of fly ash

Curing

After 24 hours the specimens are demoulded and kept for normal curing in 7,28,56,90 days. For different percentages of fly ash.

Testing

The following properties of concrete mix is to be evaluated.

a) Basic properties
   i) Specific gravity
   ii) Fineness
   iii) Workability
b) Mechanical properties
   i) Compressive test
   ii) Split tensile test
c) Durability studies

i) Acid attack test

ii) Carbonation test

iii) Permeability test

iv) Sorptivity test

v) Rapid chlorine penetration test

III. Results and Discussion

Si Minus The strengths (compressive and split tensile) tests and durability studies (RCPT and acid attack) tests are conducted for specimens, and the basic tests (specific gravity, fineness, workability) are found and the results are tabulated as below.

Specific Gravity Test

1. Cement = 3.15
2. Fine aggregate = 2.3
3. Coarse aggregate = 2.8
4. Fly ash = 2.25

Fineness

1. Cement = 8% (remained after sieving)
2. Fly ash = 0% (remained after sieving)

Workability

The following slump values are obtained after replacing cement with fly ash and GGBS as follows**.**

Table no 3: Slump values of concrete

% Replacement of Cement with Fly Ash	Fly Ash Slump Value (mm)
0	0
10	14
20	22
30	30
40	35
50	50

The slump values are increases with increasing in the % replacement of cement with both fly ash contents.

Compressive Test (Fly ash replacement)

The trial mix cubes are tested for compressive strength to check if it reached the target strength after accelerated curing.

Table no 4: Compressive strength results (Fly ash replacement)

Replacement of cement with Fly ash	7 days strength (N/mm^2)	28 days strength			56 days strength			90 days strength		
		T-1 (N/mm^2)	T-2 (N/mm^2)	Average (N/mm^2)	T-1 (N/mm^2)	T-2 (N/mm^2)	Average (N/mm^2)	T-1 (N/mm^2)	T-2 (N/mm^2)	Average (N/mm^2)
0	28.34	42.73	45.78	44.25	44.96	48.8	47.42	50.14	53.6	51.87
10	22.67	47.96	41.42	44.7	45.34	50.36	47.85	52.86	54.41	53.64
20	24.85	44.91	47.08	46	48	54.55	51.3	53.5	56.9	55.2
30	21.8	41.42	39.24	40.33	42.3	42.3	42.3	51.79	49.62	50.7
40	19.62	35.75	37.5	36.62	39.24	37.86	38.55	45.23	43.72	44.48

50	21	35.32	34	34.66	38.6	35.93	37.26	40.26	38.64	39.45

Split Tensile Test (Fly ash replacement)

Table no 6: Split tensile strength results (Fly ash replacement)

Percentage of cement with Fly ash	7 days strength (N/mm²)	28 days strength			56 days strength			90 days strength		
		T-1 (N/mm)	T-2 (N/mm²)	Average (N/mm²)	T-1 (N/mm²)	T-2 (N/mm²)	Average (N/mm²)	T-1 (N/mm²)	T-2 (N/mm²)	Average (N/mm²)
0	3.33	5	4.44	4.72	4.86	4.86	4.86	5.4	5.13	5.26
10	2.8	4.16	4.86	4.51	4.6	5	4.8	4.86	5.27	5.06
20	3.2	4.6	4.16	4.38	5	4.86	4.93	5.13	5.8	5.46
30	3	4.02	4.72	4.37	4.02	5.13	4.575	4.86	6.1	5.48
40	2.8	3.47	3.88	3.67	4.02	3.33	3.67	4.44	4.16	4.3
50	2.5	4.02	3.33	3.67	4.3	3.75	4	4.02	4.3	4.16

Acid Attack (Fly ash replacement)

- 28 days water curing and 7 days acid curing

Table no 8: Acid attack 7 days results (Fly ash replacement)

% Replacement of cement with fly ash	Acid attack factors			
	AMLF	AAF	ASLF	ADLF
0	6.54	9.375	33.33	0.00204
10	5.01	6.714	27.03	0.000909
20	3.87	4.623	21.5	0.000384
30	2.35	2.143	20	0.0001007
40	1.86	1.986	16.32	0.000059
50	1.06	1.469	7	0.0000108

Acid Attack (Fly ash replacement)

- 28 days water curing and 28 days acid curing

Table no 10: Acid attack 28 days results (Fly ash replacement)

% Replacement of cement with fly ash	Acid attack factors			
	AMLF	AAF	ASLF	ADLF
0	9.425	11.62	17.81	0.00195
10	8.169	12.582	14.23	0.0014626
20	5.750	9.673	8.98	0.0005
30	4.86	5.232	5.772	0.000146
40	3.227	3.49	3.623	0.0000408
50	2.362	2.98	1.756	0.0000126

Step wise procedure for selecting best alternative using TOPSIS Method

Table no 12: Decision matrix for Fly ash replacement

Alternatives	Criteria					
	C_1	C_2	C_3	C_4	C_5	C_6
	W	CS	SS	RCPT	AA	LCC
		28	28	28	28	

M	0	44.25	4.72	2938.95	0.00195	6475
M_1	14	44.7	4.51	923.4	0.0014626	6293
M_2	22	46	4.38	712.53	0.0005	6081
M_3	30	40.33	4.37	699.03	0.000146	5954
M_4	35	36.62	3.67	962.46	0.0000408	5623
M_5	50	34.66	3.67	988.29	0.0000126	5476

Table 13: Normalization matrix

M	0	0.44	0.45	0.83	0.78	0.44
M_1	0.19	0.44	0.43	0.26	0.59	0.43
M_2	0.30	0.45	0.42	0.20	0.2	0.41
M_3	0.41	0.40	0.42	0.20	0.058	0.40
M_4	0.48	0.36	0.35	0.27	0.016	0.38
M_5	0.69	0.34	0.35	0.28	0.005	0.37

Eg: $\frac{14}{\sqrt{14^2+22^2+30^2+35^2+50^2}} = 0.19$

Table no 14: Relative weight matrix

M	0	0.44	0.45	0.83	0.78	0.44
M_1	0.19	0.44	0.43	0.26	0.59	0.43
M_2	0.30	0.45	0.42	0.20	0.20	0.41
M_3	0.41	0.40	0.42	0.20	0.058	0.40
M_4	0.48	0.36	0.35	0.27	0.016	0.38
M_5	0.69	0.34	0.35	0.28	0.005	0.37

Table no 15: Positive matrix

							Si Plus
M	0.69	0.45	0.45	0.20	0.005	0.37	1.215
M_1	0.69	0.45	0.45	0.20	0.005	0.37	0.77
M_2	0.69	0.45	0.45	0.20	0.005	0.37	0.44
M_3	0.69	0.45	0.45	0.20	0.005	0.37	0.29
M_4	0.69	0.45	0.45	0.20	0.005	0.37	0.26
M_5	0.69	0.45	0.45	0.20	0.005	0.37	0.17

Si Plus = $\sqrt{(0.19-0.69)^2+(0.44-0.45)^2+\cdots\cdots\cdots+(0.43-0.37)^2} = 0.77$

Table no 16: Negative matrix

M	0	0.34	0.35	0.83	0.78	0.44	0.14
M_1	0	0.34	0.35	0.83	0.78	0.44	0.64
M_2	0	0.34	0.35	0.83	0.78	0.44	0.92
M_3	0	0.34	0.35	0.83	0.78	0.44	1.04

M_4	0	0.34	0.35	0.83	0.78	0.44	1.06
M_5	0	0.34	0.35	0.83	0.78	0.44	1.17

$$\text{Si Minus} = \sqrt{(0.19-0)^2 + (0.44-0.45)^2 + \cdots\cdots\cdots + (0.43-0.44)^2} = 0.64$$

Table no 17: Relative closeness to ideal solution (C_i)

M	6	0.1
M_1	5	0.45
M_2	4	0.67
M_3	3	0.78
M_4	2	0.8
M_5	1	0.87

$$C_i = \frac{\text{Si Minus}}{\text{Si Minus} + \text{Si Plus}}$$

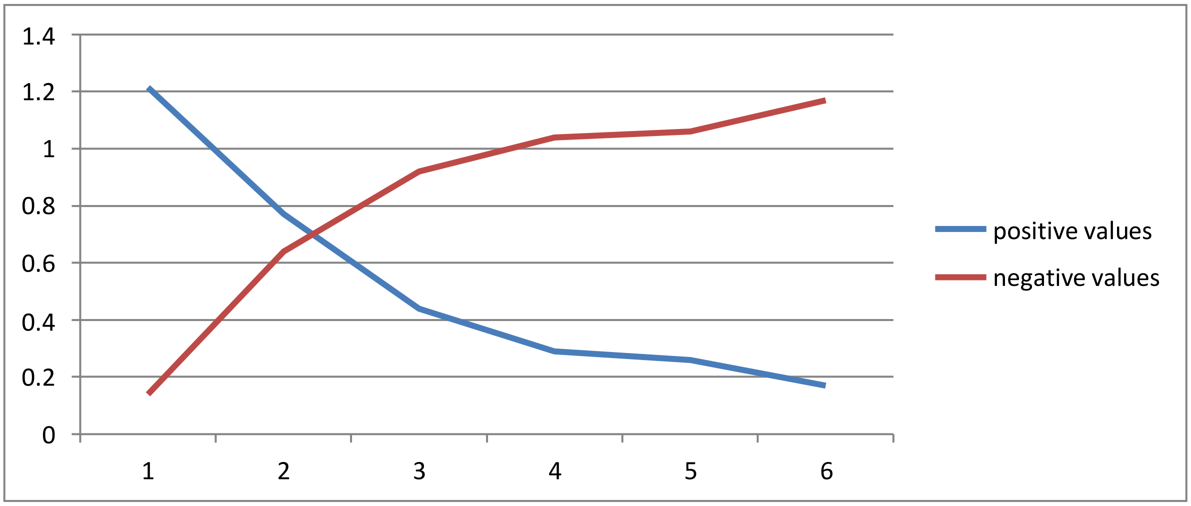

Figure 1: Relative closeness to ideal solution

The ranking for the different mixes is obtained by assuming an ideal solution. The positive solution which is nearer and the negative solution which is far from the ideal solution is adopted as the best mix. Hence from the graph we can conclude that M_3 i.e., 30% replacement of cement with Fly ash.

IV. Conclusion

Following conclusions were drawn based on experimental results.

1. The compressive, split tensile strengths of concrete is increasing with % replacement of cement with Fly ash up to 30% replacement of cement.
2. The resistance to Acid attack is increases with % replacement of cement with Fly ash increases.
3. The resistance to chlorine penetration (RCPT) increases upto 20% replacement of cement with Fly ash.
4. By using TOPSIS method I can conclude that the sustainable mix for Fly ash is M_3 i.e., 30% replacement of cement.

References

[1]. GGBS and Fly ash Effects on Compressive strength by Partial Replacement of Cement Concrete by Azmat Ali Phul, Muhammad Jaffer Memon, Syed Naveed Raza Shah, Abdul Razzaque Sandhu" volume-5, no-4, April 2019.

[2]. International Journal on Engineering and Advanced Technology (IJEAT) paper titled "Estimation of fly ash and GGBS strength efficiencies on concrete with age" by k Suvarna Latha, M V Sheshagiri Rao, V Srinivasa Reddy.

[3]. Fam F Abdel Malak, Emad A. Osman (2017) "Applying decision making techniques to civil engineering projects", Research Gate.

[4]. IOSR journal on engineering (IOSRJEN) paper titled "Partial replacement of cement with fly ash in concrete and its effect" by Vinod Goud and Niraj Soni" ISSN (e): 2250-3021, ISSN (p):2278-8719, Volume-06, Issue 10(oct.2016).

[5]. IS 10262-2019: Guidelines for concrete mix design proportioning and BIS.

[6]. ASTM C 267-01: "Acid Attack testing on concrete".

[7]. ASTM C 1202: "RCPT (Rapid Chlorine Penetration Test) testing on concrete".

[8]. IS 456-2000: Plain and reinforced concrete

[9]. M.S Shetty and S. Chand – concrete technology theory and practice.