Investigation on Structural Properties of Concrete Modified by the Addition of Metakaolin

Feba Ray Jacob
Dept. of Civil engineering
Sree Buddha college of Engineering
Pathanamthitta India

Aswathy S Kumar
Dept. of Civil engineering
Sree Buddha college of Engineering
Pathanamthitta India

Abstract **- Nowadays, deterioration of concrete structures is one of the major problems of the construction industry. The application of geogrids in concrete constitutes a new dimension for using geosynthetics in infrastructure. Modern techniques are evolved and applied for effective strengthening and retrofitting methods .the aim of this thesis is to study the behaviour of large-scale RC walls strengthened using the wire mesh-epoxy composite. Geogrid is a new material used as reinforcement in structural members therefore it is necessary to identify the benefits and feasibility of using geogrids in concrete. A geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as subbases or subsoils below roads or structures. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Stone that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The aim of this paper is to investigate the performance of concrete walls with geogrid as reinforcement in the M40 concrete all with Metakaolin for partial replacement of cement.**

Keywords – Retrofiiting,Metakaolin,Biaxial,Geogrid, kaolinite

I.INTRODUCTION

Nowadays, deterioration of concrete structures is one of the major problems of the construction industry. Modern techniques are evolved and applied for effective strengthening and retrofitting methods .the aim of this thesis is to study the behaviour of large-scale RC walls strengthened using the wire mesh-epoxy composite. Concrete is a heterogeneous material made by the mixture of cement, fine and coarse aggregates, and water. Proportion of these constituents affects the mechanical and durable properties of concrete. Concrete is the most widely used construction material in the world. It is a heterogeneous material made by the mixture of cement, fine and coarse aggregates, and water; the proportion of these constituents affects the mechanical and durable properties of concrete. Also it is a versatile material due to the continuous demand. In recent years, lot of researches has been focused on im0proving the quality of concrete.

II.OBJECTIVES

The main objectives of this study are:-

- To design M40 grade concrete as per IS 10262:2009
- To investigates the strength development of concrete with the addition of Metakaolin

III. PRELIMINARY INVESTIGATION PROPERTIESOF CONSTITUENT MATERIALS

Table 1 :Grain Size Distribution of Fine Aggregate

IS Sieve size	Weight retained on each sieve (g)	Percentage retained on each sieve (g)	Cumulative % retained on each sieve	% finer
4.75mm	16	1.6	1.6	98.4
2.36mm	95	9.5	11.1	88.9
1.18mm	185	18.5	29.6	70.4
600µ	132	13.2	42.8	57.2
300µ	284	28.4	71.2	28.8
150µ	198	19.8	91	9
Pan	90	9	100	0

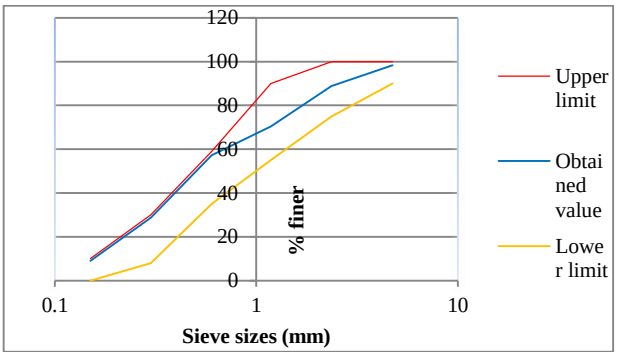

Fig 1 :Gradation curve of fine aggregate

Table 2 : Properties of fine aggregate

Properties	Obtained value	IS specification	IS code
Grain size distribution (Fineness)	Zone II	Zone I, II, III – for R C structures	IS 383:1970
Bulk density (kg/m^3)	1734	-	IS 2386:1963 part3
Specific gravity	2.60	-	IS 2386:1963, part3

Table 3 : Grain size distribution of coarse aggregate

IS Sieve size	Weight retained on each sieve (g)	Percentage retained on each sieve (g)	Cumulative % retained on each sieve	% finer
25mm	26	2.6	2.6	91.4
20mm	244	24.4	27	73
16mm	418	41.8	68.8	31.2
12.5mm	280	2.8	96.8	3.2
10mm	26	2.6	99.4	0.6
6.3mm	6	0.6	100	0
4.75mm	0	0	0	0

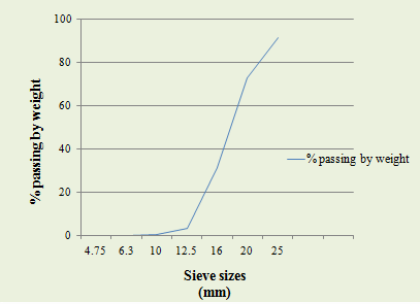

Fig 2.Gradation curve of coarse aggregate

Table 4 : Properties of coarse aggregate

Properties	Obtained value	IS specification	IS code
Grain size distribution (Fineness)	Maximum size 12.5mm, 91.05% passing through 12.5mm sieve size	Table 2, IS 383:1970	IS 383:1970
Bulk density (kg/m^3)	1541.92	-	IS 2386:1963 part3
Specific gravity	2.62	-	IS 2386:1963 part3

A. Chemical Admixtures

Admixtures are natural or man manufactured chemicals which are added to the concrete before or during mixing. They increase the efficiency of cement paste by improving workability of the mix and there by resulting in considerable decrease of water requirement.

Different types of chemical admixtures are:
- ✓ Air entraining agents
- ✓ Retarders
- ✓ Accelerators
- ✓ High Range water reducers (HRWR) or Super plasticizers

The advantages of Master Glenium Sky 8233 are:
- Elimination of vibration and reduced labour cost in placing
- Imparts higher modulus of elasticity
- Improved adhesion to reinforcing and stressing steel
- Better resistance to carbonation and other aggressive atmospheric conditions
- Lower permeability
- Increased durability
- Reduced shrinkage and creep

The performance test data of Master Glenium sky 8233 are shown in Table

Table 5: Performance test data

Aspect	Light brown liquid
Relative density	1.08± 0.01 at 25°C
pH	≥6
Chloride ion content	< 0.2%

Fig 3: Super plasticizer

B.Mineral Admixture

The mineral admixture used for replacing cement by different percentages in this study is metakaolin. It is typically a highly effective pozzolanic material.The properties of metakaolin is shown in Table below.

Table 6: Properties of Metakaolin

Property	Specifications		UOM
	LSL	USL	
Appearance	Off white powder		visual
pH value	4	6	Numbers
SiO_2 content (%)	52	54	%
Bulk Density	0.4	0.5	Kg/lit
Al_2O_3	44	46	%
TiO_2	0.8	1	%
Fe_2O_3	0.6	0.8	%
Specific gravity (g/cc)	2.5	2.6	Gm/cc
Moisture	0.5	1	%
Lime Reactivity	750	1000	Mg/gm

IV.MIX DESIGN

The mix proportion for M40 grade concrete is arrived through different trial mixes. Trial mixes are prepared done by using the properties obtained from various material tests and as per recommendations of IS 10262:2009. The mix is selected for hand place concrete and slump of 90mm. The detailed mix design is provided in Appendix A.

The mix proportion for M40 grade concrete is shown in Table below.

Table 7: Details of M40 mix design

	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (ml)	Super plasticizer (%)
Quantity	350	695.44	145.8	140	0.5
	350	695.44	145.8	140	0.6
	350	695.44	145.8	140	0.75
Ratio	1	1.98	3.56	0.4	

Table 8:Different slump obtained for different SP %

Mix id	W/c ratio	Super plasticizer (%)	Slump obtained
M1	0.4	0.5	70mm
	0.4	0.6	75mm
	0.4	0.75	90mm

A.Tests On Hardened Concrete

Based on the proportion obtained from the mix design, concrete mix was prepared for determining the compressive strength, split tensile strength and flexural strength of hardened concrete. The main purpose of testing hardened concrete is to check the concrete used has developed the required strength.

Table 9 : Compressive strength of M40 concrete mix

% of SP	7^{th} day ((N/mm^2))	14^{th} day compressive strength (N/mm^2)	28^{th} day compressive strength (N/mm^2)
0.5%	19.77	29.02	32.85
0.6%	23.59	33.75	39.1
0.75%	27.72	38.71	46.2

Table 10: Split tensile strength of M40 concrete mix

Mix id	Age in days	Split tensile strength
0.5%	28 days	2.328
0.6%		2.886
0.75%		3.31

Table 11 :Flexural strength of M40 concrete mix

Mix id	Age in days	Flexural strength
0.5%	28 days	3.92
0.6%		4.29
0.75%		4.775

B.Results And Discussions

From the workability test on fresh concrete and strength tests on hardened, it is obtained that the required target strength is achieved for M3 mix. So mix M3 is the selected mix. Mix proportion and mix ratio of selected mix is shown below in Table below.

Table 12:Mix proportion of selected mix

Material	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (ml)	Super plasticizer (%)
Weight (kg/m^3)	350	695.44	145.8	140	0.75
Ratio	1	1.98	3.56	0.4	0.00214

V. EXPERIMENTAL INVSTIGATION ON CONCRETE MIXES WITH METAKAOLIN

From the previous chapter, the mix which give required target strength of M40 grade concrete is selected. In order to determine the optimum quantity of Metakaolin which give maximum compressive strength, tensile strength, flexural strength mixes were prepared by partially replacing cement by different percentages of Metakaolin. Three mixes were prepared by partially replacing cement by 15%,20% and 25 % of Metakaolin.

Table 13 :Compressive strength of cubes with partial replacement of Metakaolin

% of MK	7^{th} day compressive strength (N/mm^2)	14^{th} day compressive strength (N/mm^2)	28^{th} day compressive strength (N/mm^2)
20%	28.56	38.13	49.74

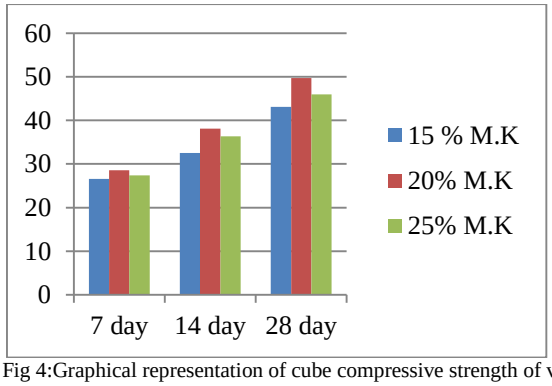

Fig 4:Graphical representation of cube compressive strength of various mixes with age

Table 14: Flexural strength of beam with partial replacement of Metakaolin

% of MK	sample	Age in days	Flexural strength	Average
20%	1	28 days	4.36	4.63
	2		5.10	
	3		4.44	

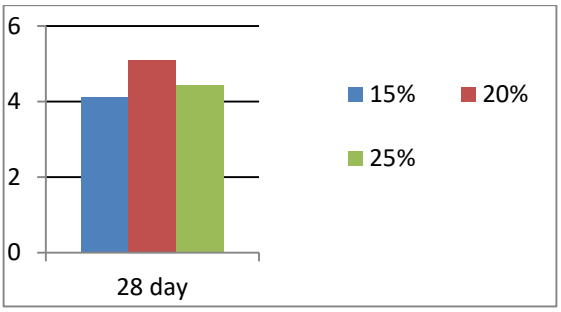

Fig 5: Graphical representation of beam flexural strength of various mixes with age

Table 15:Split tensile strength of cylinder with partial replacement of Metakaolin

% of MK	sample	Age in days	Split tensile sength	Average
20%	1	28 days	4.62	4.5
	2		4.52	
	3		4.36	

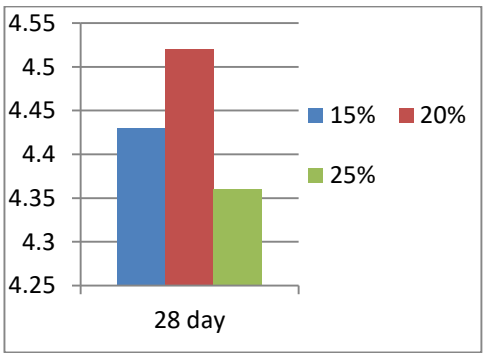

Fig 6: Graphical representation of cylinder split tensile strength of various mixes with age

VI.CONCLUSIONS

Preliminary investigation of fine aggregate, coarse aggregate, cement and Metakaolin were carried out as per IS specification .Mix design of M40 grade was carried out.Optimum of super plasticizer - 0.75% of cement.Optimum of Mk - 20 % of cement .

ACKNOWLEDGMENT

I am thankful to my guide, Asst. Professor, Aswathy S Kumar in Civil Engineering Department for her constant encouragement and able guidance. Also I thank my parents, friends etc. for their continuous support in making this work complete.

REFERENCES

[1] Anju Mary Ealias1, Binu P,"Strengthening of RC Beam Using Wire Mesh– Epoxy Composite*" International Journal of Science and Research (IJSR)* ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

[2] Annadanam Sudhakar, Prof.K.Rajasekhar "Experimental Studies on High Performance Concrete Using Metakaolin"International *journal and magazine of engineering,technology,management and research*, Volume No.4,(2017)

[3] Byong Y. Bahn1 and Ronald S. Harichandran, F.ASCE (2013)," Flexural Behaviour of Reinforced Concrete Beams Strengthened with CFRP Sheets and Epoxy Mortar" *Journal of Composites for Construction*, Vol. 12, No. 4, August 1, 2008. ©ASCE, ISSN (2013)

[4] Ismail M.I. Qeshta, Payam Shafigh, Mohd," Flexural behaviour of RC beams strengthened with wire mesh-epoxy composite", Zamin Jumaat, *Construction and Building Materials* 79 (2015) 104–114.

[5] Murali G. and Pannirselvam N," flexural strengthening of reinforced concrete beams using fibre reinforced polymer laminate", *ARPN Journal of Engineering and Applied Sciences* vol. 6, no. 11, Nov 2011

[6] Nova John,"Strength Properties of Metakaolin Admixed Concrete", *International Journal of Scientific and Research Publications*, Volume 3, Issue 6, June 2013 1 ISSN 2250-3153

[7] P. Dinakar, Pradosh K. Sahoo, and G. *Sriram,"International Journal of Concrete Structures and Materials"* Vol.7, No.3, pp.215–223, September 2013 DOI 10.1007/s40069-013-0045- ISSN 1976-0485 / ISSN 2234-1315

[8] P. Sarangia,K.C.Pandab,S.Jena "Effect of Metakaolin on the Enhancement of Concrete Strength" *Indian J.Sci*.Vol. 14 ,No.2:121-127, (2017)

[9] Rakendu K "Flexural Behaviour of Concrete Beams Reinforced with Biaxial Geogrid", *International Journal of Engineering Research and General Science* Volume 5, Issue 4, July-August, 2017 ISSN 2091-2730

[10] S.Shobana, G.Yalamesh," Experimental Study of Concrete Beams Reinforced with Uniaxial and Biaxial Geogrids." *International Journal of ChemTech Resear ch CODEN* (USA): IJCRGG ISSN: 0974-4290 Vol.8, No.3, pp 1290-1295, (2015)