Indexed in
Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific
Journals, Poland, Directory of Research Journals

International Journal of Earth Sciences and Engineering

www.cafetinnova.org

ISSN 0974-5904, Volume 09, No. 03

June 2016, P.P.487-490

Study on Magnesium Potassium Phosphate Cement Blended With Fly Ash by Concentric Loading Test

LENIN SUNDAR M[1], TINESH THA[1] AND M VADIVEL[2]
[1]*Sri Krishna College of technology, Coimbatore, Tamil Nadu, INDIA*
[2]*Nehru Institute of Technology, INDIA*
Email: *m.leninsundar@skct.edu.in, tinesh2509@gmail.com, vadivelnitcbe@gmail.com*

Abstract: One of the main ingredients used for the production of concrete is the Ordinary Portland Cement (OPC). Carbon-dioxide (CO_2) gas which is a major contributor in greenhouse effect and the global warming, is produced in the production of cement, hence it is needed either to search for another material or partially replace cement by some other material. In recent years, fly ash when replaced with cement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits. Magnesium potassium phosphate cements (MKPCs), blended with partially weight percentage of fly ash (FA) to reduce heat evolution, water demand and cost, were assessed using compressive strength. In addition to the main binder phase, struvite-K, an amorphous orthophosphate phase was detected in FA/MKPC system. It was postulated that an aluminium-phosphate phase was formed; however, no significant Al–O–P interactions were identified. This study demonstrates the need for further research on these binders, as FA is generally regarded as inert fillers within MKPC. The effects on using MKPC concrete of various mix(20%,30%,40% and 50%) was studied by workability, compressive strength & split tensile strength. The durability study by sulphate attack test was performed. The concentric load behavior will be monitored in column by casting with optimum percentage mix of MKPC/Fly ash concrete.

Keywords: *MKPC, Struvite-k, Fly ash, Aluminium-phosphate phase*

1. Introduction

Magnesium potassium phosphate cement (MKPC) is a kind of cementitious binder in which the chemical bond is formed via a heterogeneous acid-base reaction between dead burned magnesia powder and potassium phosphate solution at room temperature. Small amount of boron compounds can be incorporated in the cement as a setting retarder. The chemical reaction resulting in the formation of MKPC's is based on the dissolution of MgO and KH_2PO_4 reacting in solution to form struvite-K ($MgKPO_4{\cdot}6H_2O$), which is iso-structural to struvite ($NH_4MgPO_4{\cdot}6H_2O$) and is naturally cementitious.

$$MgO+KH_2PO_4+H_2O \rightarrow MgKPO_4{\cdot}6H_2O$$

In practical application, MKPC binders are frequently blended with fly ash (FA) from the coal combustion process to reduce their production cost, reduce water demand of the paste, and lower the exothermic output of the acid–base reaction which avoids cracking of the hardened paste. Alumino silicate glass can react with phosphoric acid to form strong phosphate bonded cement. It is conceivable that the glassy alumino silicate fraction of the FA reacts in the initially acidic environment of the MKPC, forming a secondary phase intermixed with struvite-K. If this occurs, it could result in a matrix of higher density that would be more impermeable to water, have a higher mechanical strength.

2. Material Properties

The properties of materials used in the concrete are discussed below:

2.1 MKP Cement

The reaction product is magnesium potassium phosphate ($MgKPO_4$. $6H_2O$) that is formed by dissolution of MgO in the solution of KH_2PO_4 and its eventual reaction to form the product according to the reaction.

2.2 Fine Aggregate

The sand sieved through 4.75 mm sieve is used having specific gravity of 2.74. The fine aggregates belonged to grading zone III.

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 12.5 mm is used. The specific gravity of coarse aggregate that was taken was 2.74.

2.4 Fly ash

Fly ash is used as a replacement for cement. The specific gravity of fly ash that was taken was 2.2.

2.5 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

2.6 Magnesium oxide

Magnesium oxide is used as a replacement for cement. The specific gravity of magnesium oxide was taken as 2.96.

2.7 Retarder

Small amount of boron compounds can be incorporated in the cement as a setting retarder such as 0.25-1% of cementations material.

3. Experimental Investigation

In this investigation the hardened properties of MKPC concrete for various replacement percentages of fly ash as partial replacement of MKP cement.

3.1 Mix proportions

Recommended guidelines of concrete mix design using Indian Standard Code (IS:10262-2009) the mix proportions of concrete were prepared for M30 grade.

3.2 Hardened properties of MKP concrete

In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cube (150 X 150 X 150 mm) specimens. For each combination, two specimens were tested.

In order to find the split tensile strength of concrete 28 days of cylinder (150 X 300 mm) specimen are cast. For each combination, two specimens were tested.

3.2.1 Compressive Strength Test

The compressive test for various mix of 20%, 30%, 40% &50% replacements of MKPC concrete were calculated and described below.

Figure 1.*Compressive strength test*

The following tables show the Compressive strength of Concrete with fly ash:

Table 1: *Compressive strength of MKPC concrete with fly ash*

S. No	Percentage replacement of fly ash	Compressive Strength 7 days (N/mm^2)	Compressive Strength 28 days (N/mm^2)
1	20	21.82	28.35
2	30	26.36	32.87
3	40	30.63	38.64
4	50	28.94	36.26

The following graph shows the variation in the Compressive strength of concrete with fly ash:

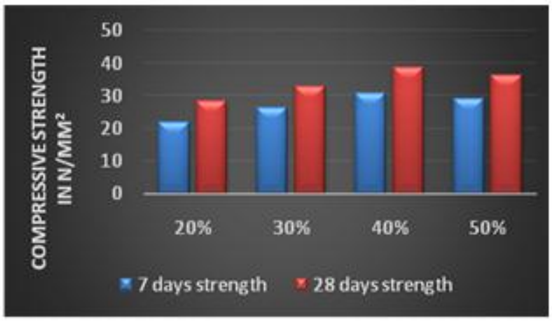

Figure 2.*Chart for compressive strength of MKPC concrete with fly ash*

3.1.1 Split Tensile Test

The Split Tensile test for various mix of 20%, 30%, 40% &50% replacements of MKPC concrete were calculated and described below.

Figure 3.*Split tensile strength*

The following table shows the split tensile strength of MKP concrete with fly ash:

Table 2: *Split tensile strength of MKPC concrete with fly ash*

S. No	Percentage replacement of fly ash	Split Tensile Strength 7 days (N/mm^2)	Split Tensile Strength 28 days (N/mm^2)
1	20	2.34	3.07
2	30	2.64	3.23
3	40	2.88	3.52
4	50	2.73	3.39

The following graph shows the variation in the split tensile strength of MKP concrete with Fly ash:

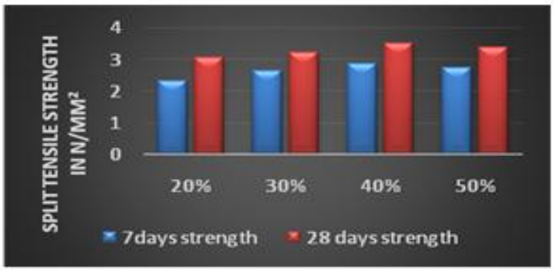

Figure 4.*Chart for split tensile strength of MKPC concrete with fly ash*

3.2 Sulphate Attack Test

Concrete cube specimens 150mm x 150mm x150mm are casted for sulphate attack. The casted specimens are kept at self-curing condition up to 28 days. The specimens were immersed in a solution of 3% of sodium sulphate in distilled water. The solutions were renewed at regular interval for accurate results. At the days of age, at 7& 28 days of exposure, the specimens were weighed and strength loss is calculated and described below.

Table 3*: Sulphate attack test with MKPC*

Percentage replacements	Weight loss %		Strength loss %	
	7 Days	28 Days	7 Days	28 Days
20	0.76	1.48	3.81	5.02
30	0.82	1.52	3.86	5.18
40	0.86	1.55	3.89	5.22
50	0.90	1.57	3.93	5.28

Figure 5.*Chart for weight loss percentage of MKPC concrete with fly ash*

Figure 6.*Chart for strength loss percentage of MKPC concrete with fly ash*

3.3 Axial load behavior test

The axial load test was performed for optimum percentages of 40% are described below with comparison of nominal mix.

The following table shows the axial load test of MKPC concrete with 40% fly ash and nominal mix.

S.no.	Nominal mix		Optimum mix	
	Load (kn)	Deflection (mm)	Load (kn)	Deflection (mm)
1.	0	0	0	0
2.	50	0.24	50	0.18
3.	100	0.69	100	0.39
4.	150	1.23	150	0.55
5.	200	1.68	200	0.71
6.	250	2.21	250	0.89
7.	300	2.75	300	1.02
8.	350	2.99	350	1.11
9.	400	3.25	400	1.28
10.	450	3.58	450	1.39
11.	500	3.71	500	1.55
12.	550	3.82	550	1.82
13.			600	2.01
14.			650	2.28
15			700	2.50
16			750	2.63

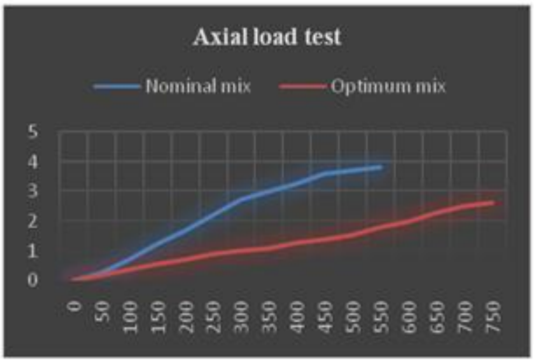

Figure 6.*Chart for comparison of axial load test for MKPC concrete with fly ash and nominal mix*

4. Conclusion

- When fly ash is added to the concrete, it increases the hardened properties of MKPC concrete.
- Fly ash could make the microstructure of magnesium potassium phosphate cement paste compact, which obviously improved the compressive strength and reduced the shrinkage of hardened magnesium potassium phosphate cement paste.
- From results of test conducted on Compressive strength and Split tensile strength, we can conclude that the addition of fly ash by 40% increases strength with increases in age of concrete and obtain high early strength.

- The most important aspect followed in the project is to reduce the environmental hazards.
- From load deflection curve we have predicted that after yielding point load fails but curvature starts increasing and that will lead to failure.

5. Acknowledgement

I thank the almighty **God** for giving me the strength and determination to motive myself to complete the project.

I thank **My beloved Parents** for their encouragement, comfort, prayers and all the who have extended their help for successful completion of my project.

I thank **Sri Krishna College of Technology** for providing a very good support in terms of materials and equipments to complete my project in great success.

I thank **Dr.A. RAMESH, Ph.D., Principal, Sri Krishna College of Technology** for having providing necessary facilities to carry out this project.

I manifest deep sense of my gratitude to **Dr.I.PADMANABAN, Ph.D., Professor and Head of Department of Civil Engineering** for his continuous encouragement and helped me a lot to complete the thesis on time.

I express my whole-hearted indebtedness to my project guide **Dr.M.LENIN SUNDAR, Ph.D, Professor, Department of Civil Engineering** for his warm blessings, moral support, constant encouragement at various stages of course study and for providing all necessary facilities for completing this project work.

I also wish to thank our project co-ordinator **Dr. V. SREEVIDYA, Ph.D., Associate Professor, Department of Civil Engineering** for showing on us her valuable support.

I express my sincere and deep gratitude to **teaching** and **non-teaching staff** who have helped us directly or indirectly in the successful completion of this project work.

References

[1] Abhishek Jain, Nazrul Islam (2013), "Use of fly ash as partial replacement of sand in cement mortar", ISSN: 2319-8753, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 5.

[2] AmanJatale, Kartikey Tiwari, SahilKhandelwal (2013), "Effects on compressive strength when cement is partially replaced by fly ash".ISSN:2278-1684 Volume 5, Issue 4, pp 34-43.

[3] Alvin Harison, Vikas Srivastava and Arpan Herbent (2014) "Effect of fly ash on compressive strength of portlandpozzolona cement concrete", Journal of Academia and Industrial Research, Vol.2, ISSN: 2278-5213.

[4] Chau C.K, FeiQiao, Zongjin Li (2011) "Microstructure of magnesium potassium phosphate cement", International Journal of Engineering and Advanced Technology (IJEAT) Vol. 25(6):2911 – 2917.

[5] Freeda Christy C and Tensing D (2014), "Fly ash as a partial replacement with cement and fine aggregate in mortar", Indian journal of engineering & material science, Vol 17.

[6] Gemma Mestres, Maria-Pau Ginebra (2011) "Novel magnesium phosphate cements with high early strength and antibacterial properties",ActaBiomaterialia, ISSN: 1853-61.

[7] Hongyan Ma, Biwan Xu, Zongjin Li (2014), "Magnesium potassium phosphate cement paste: Degree of reaction, porosity and pore structure". Cement and Concrete Research, PP 96–104.

[8] IS (Indian Standard) (1959) IS 1199-1959: Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi.

[9] IS (Indian Standard) (1959) IS 516-1959: Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi.

[10] IS (Indian Standard) (1982) IS 10262-1982: Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi.

[11] IS (Indian Standard) (1982) IS 456-2000: Plain and Reinforced Concrete-Code of Practice, Bureau of Indian Standards, New Delhi.

[12] JayeshkumarPitroda, Zala L.B, Umrigar F.S (2012) "Experimental investigation on partial replacement of cement with fly ash in design mix concrete", International Journal of Advanced Engineering Technology, Vol. III/ Issue IV.

[13] Kiran T.G.S, Ratnam M.K.M.V (2014), "Fly ash as a partial replacement of cement in concrete and durability study of fly ash in acidic (H_2SO_4) environment". International Journal of Engineering Research and Development, Volume 10, Issue 12.

[14] Swaroop A.H.L, Venkateswara Rao K, Kodandaramarao P (2013) "Durability studies on concrete with fly ash & GGBFS", International Journal of Engineering Research and Applications, Vol.3, PP. 258-289, ISSN: 2248 – 9622.

[15] Zhu Ding, Biqin Dong, Feng Xing, Ningxu Han, Zongjin Li (2012), "Cementing mechanism of potassium phosphate based magnesium phosphate cement", Vol. 38(8):6281-6288.