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ESTEEM

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Foreword

Welcome to ESTEEM Volume 2. In this issue, we address a gamut of topics from the engineering disciplines to language education. We hope that ESTEEM, by publishing articles from a diverse range of disciplines, will encourage debate and exchange among researchers from assorted academic backgrounds.

I would like to thank our advisor, Prof. Madya Mohd Zaki Abdullah for his distinctive imprint on this edition. His leadership of the journal in its 2nd year of growing impact and reputation has been outstanding. His vision, commitment to excellence, and attention to detail are widely recognized by the Penang academic community as determining factors in the journal's success so far. We will do our best to continue and expand on this tradition of excellence.

Since its launch in 2003, ESTEEM is indeed fortunate to have a dynamic Editorial Team. These people have provided the journal with an outstanding service of reviewing submissions for publications. The journal follows the established policy of a blind review process consisting of at least two peer reviewers per submission. We depend upon their knowledge and judgement in advancing the scope and utility of this journal. Without their support and enthusiasm none of this would have been possible. Also, my thanks to all the contributors, both the successful and not so successful.

Our vision of the ***ESTEEM*** journal is that it should be the journal that belongs to you, the academic and research community. This includes all engineers and academicians working to unravel the mysteries of research, teaching and learning, in all its facets. We wish the journal to be responsive to your needs and your interests. Please feel free to contact any of us in the editorial board to give us your ideas and suggestions for the development of the journal. We look forward to working with you all in expanding this emerging venue for communicating high quality research on the many aspects of academia.

Finally, I would like to take this opportunity to invite all authors and readers to contact me at **esteem@ppinang.uitm.edu.my** to share their comments and advice on how to further enhance the journal's value to the wider research community in knowledge and how to move ESTEEM to the next level of excellence.

The Chief Editor
May, 2005

A Study on Compressive Strength of Concrete Cointaining MK7003 with Various Water Binder Ratio

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ABSTRACT

The study was conducted to determine the effects of using MK7003 as a partial replacement material for OPC on the compressive strength of concrete. The study was further enhanced by studying the effects of varying the water binder ratio. Replacement level of 5%, 10% and 15% by weight of OPC in the control concrete were considered while maintaining water binder ratio at 0.47. Another study was conducted by varying the water binder ratios of 0.35, 0.45 and 0.55 while maintaining MK7003 content at 10% by weight. From the study it was found that increasing the level of MK7003 has a significant increase in the compressive strength of concrete but as the water binder ratio is increased the compressive strength of concrete will decrease.

Introduction

The use of alternative binders of cement replacement materials has become a necessity for the construction industry because of the economic, environmental and technological benefits derived from their usage: (Sidney, Francis and Dawid 2003). The world-wide utilization of by product cementitious materials as partial cement replacement for concrete products is supposed to reduce production energy cost and environmental concerns.

Natural pozzolans in the form of calcined earth blended with calcium hydroxide (lime) have been used to produce cementitious material since ancient times: (Metha, 1996). The interest in using Metakaolin as modified natural pozzolans in the production of concrete has revived in recent years. Metakaolin is the term used to describe kaolin which has undergone the process of calcination. Kaolin is white clay of which the particle size can be as small as 2 mm and it behaves like pozzolanic when mixed with water: (Wild and Katib 1996). The Metakaolin particles are about 10 times smaller than cement particles, which results in a denser, more impervious concrete. Metakoalin is manufactured from kaolin or white clays which are calcined at the temperature between 650°C – 850ºC under controlled conditions to give a highly reactive product: (BB Sabir, Wild and Khatib 1996).

From the previous study, it was reported that Metakaolin plays an important role in improving the durability of structures: (Saad et al, 1982). For example Metakaolin decreases the porosity of the bulk cement matrix and thus results in less permeable concrete. Metakaolin also enhances several mechanical properties, for example, the early-age of compressive strength and flexural strength: (BB Sabir, Wild and Khatib 1996).

MK7003 is a term used to describe Metakaolin which has undergone a calcination process in three hours with the temperature of 700°C. Earlier study reported that the optimum compressive strength of concrete was achieved with MK7003: (Arshad, 2003). Table 1 and Figure 1 show the effect of burning temperature and calcinations duration on the compressive strength of cubes.

Table 1: The Effect of Burning Temperature and Calcinations Duration to the Compressive Strength of Cubes: (Arshad, 2003)

Type of Cement	Duration (Days)					
	0	3	7	14	28	90
OPC	0	14.33 MPa	27.22 MPa	34.33 MPa	36.37 MPa	38.58 MPa
MK 6002	0	33.00 MPa	40.83 MPa	42.67 MPa	45.38 MPa	47.36 MPa
MK 7002	0	21.33 MPa	29.67 MPa	38.33 MPa	41.29 MPa	46.65 MPa
MK 8002	0	12.00 MPa	31.33 MPa	36.37 MPa	37.15 MPa	40.81 MPa
MK 6003	0	29.30 MPa	34.00 MPa	32.33 MPa	41.70 MPa	44.42 MPa
MK 7003	0	21.67 MPa	34.47 MPa	46.67 MPa	48.74 MPa	51.06 MPa
MK 8003	0	27.67 MPa	41.00 MPa	43.33 MPa	44.91 MPa	48.23 MPa
MK 6004	0	23.22 MPa	37.33 MPa	41.67 MPa	43.51 MPa	47.32 MPa
MK 7004	0	26.73 MPa	37.00 MPa	38.33 MPa	42.15 MPa	43.70 MPa
MK 8004	0	21.67 MPa	37.07 MPa	39.67 MPa	41.67 MPa	49.19 MPa

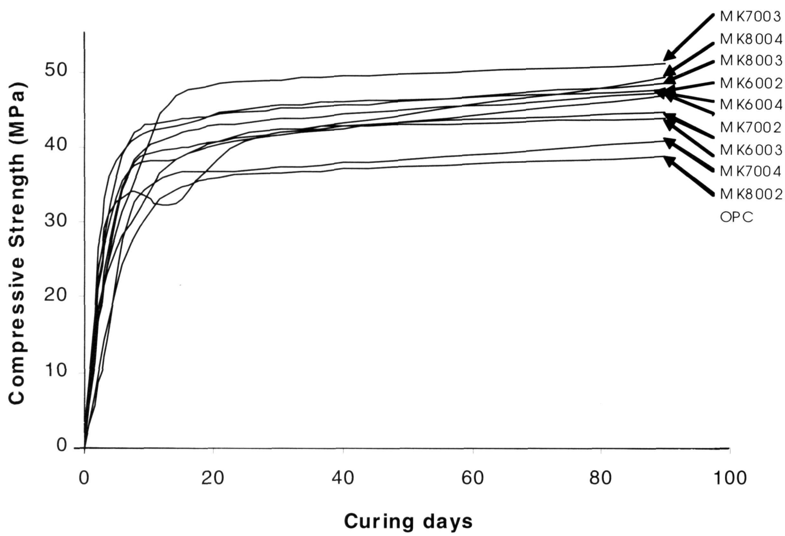

Figure 1: The Effect of Burning Temperature and Duration to the Compressive Strength of Cubes: (Arshad, 2003)

Experimental Investigation

The MK used in this study is MK7003 which is produced by burning it at the temperature of 700°C for 3 hours. The mix design was carried out according to BS 5328: 1981. The design was made for a concrete characteristic strength of grade 40, since concrete containing Metakaolin is known to produce a high strength concrete. Several mixtures with 10% MK7003 were prepared in various water binder ratios to study its effect on the compressive strength of concrete. Table 2 shows the mixture proportions by weight for 72 cubes. The cubes were prepared by using 100 mm x 100 mm x 100 mm cube mould with maximum size of 10 mm course aggregates. In order to prevent bleeding, the water binder ratios were restricted to the range 0.35 – 0.45.

Other mixtures were prepared by taking the water binder ratio as constant while varying the quantity of MK7003. From the first test series, it was shown that, the compressive strength of concrete decreased with increasing water binder ratio. Therefore water binder ratio of 0.47 was taken as constant, even though it was shown that the water binder ratio 0.35 showed the best compressive strength. This decision was made based on the condition and understanding that, a concrete mixed with

Table 2: Mixture Proportions by Weight for 72 Cubes

W/B Ratio	Cement (kg)	MK7003 (kg)	Water (kg)	Fine Aggregate (kg)	Course Aggregate (kg)
			For Control Samples		
0.35	5.71	0	2	4.10	6.98
0.45	4.44	0	2	4.69	7.66
0.55	3.64	0	2	5.39	7.76
			With 10% MK7003		
0.35	5.14	0.57	2	4.10	6.98
0.45	3.99	0.44	2	4.69	7.66
0.55	3.28	0.36	2	5.39	7.76

water binder ratio 0.35 possess a very low workability. Figure 3 shows the relationship between water binder ratio and the compressive strength of concrete at 28 days. Tests were then conducted on concrete containing MK7003 replacements of 5, 10 and 15% by weight of OPC in the control sample (0% MK7003). Table 3 shows the mixture proportions by weight for 48 cubes. The cubes were prepared (100 mm x 100 mm x 100 mm) for compressive strength tests at 3, 7, 14 and 28 days. All specimens were cured in water at room temperature.

Table 3: Mixture Proportions by Weight for 48 Cubes

MK7003 (%)	OPC (kg)	MK7003 (kg)	Water	Fine Aggregate (kg)	Course Aggregate (kg)
0	6.4	0	3.0	10.2	8.7
5	6.1	0.3	3.0	10.2	8.7
10	5.7	0.6	3.0	10.2	8.7
15	5.4	1.0	3.0	10.2	8.7

Compressive Strength

The compressive strength of cubes for test series 1 is shown in Figure 2 and Figure 3. From Figure 2 it is clear that concrete containing MK7003 in general results in a significant improvement to the compressive strength. The increment of the compressive strength of concrete containing MK7003 is in the range of 2 – 5% from the concrete with OPC at the

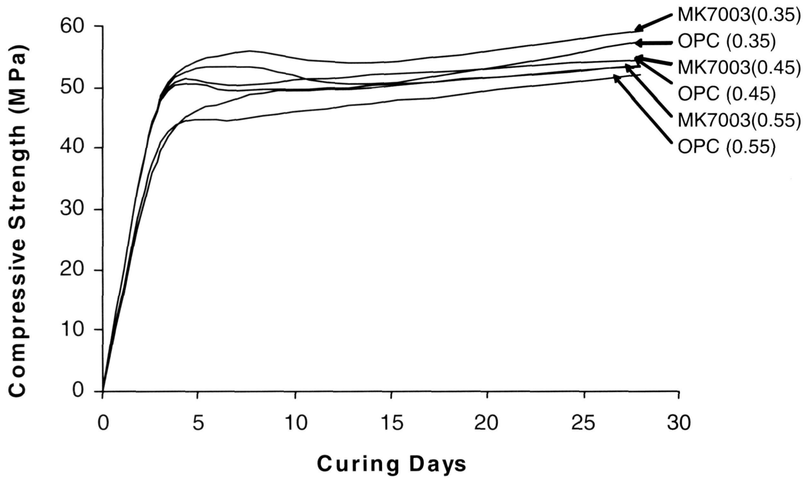

Figure 2: Relationship Between Compressive Strength of Concrete Containing MK7003 with Various W/B Ratios

age of 28 days. It is also shown that, there is a rapid development of compressive strength at the early age of concrete that is about 20% more than the concrete with OPC.

Figure 3 shows the relationships between the compressive strength of concrete with MK7003 and the water binder ratio. The compressive strength is decreasing as the water binder ratio increases. It seems that mixes with a high water binder ratio and a high cements contents will cause a reduction of the compressive strength.

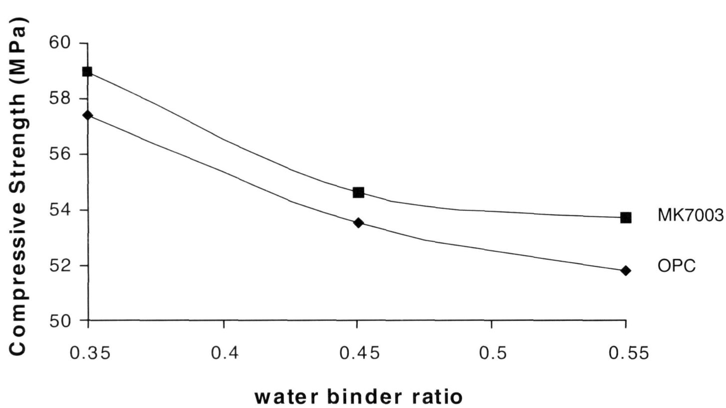

Figure 3: Relationship Between Water Binder Ratio and the Compressive Strength of Concrete at 28 Days

Figure 4 shows the compressive strength relationship with the percentage of MK7003 in the concrete mix. It is shown that the optimum compressive strength of concrete cubes is achieved at 10% MK7003.

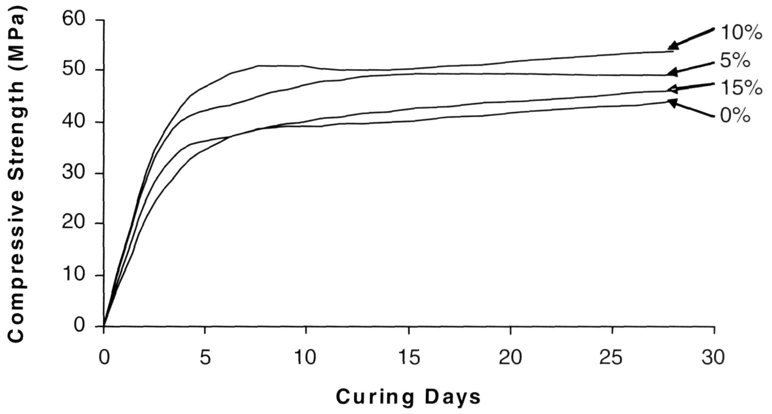

Figure 4: Compressive Strength of Concrete Cubes with Different Percentage of MK7003

The compressive strength development of the concrete cubes is quite rapid and increasing steadily after the age of 7 days. The increment of the compressive strength of concrete with 10% MK7003 after 28 days is about 22.7% compared to the control sample.

The result recorded in this study confirms the earlier findings as discussed by BB Sabir et al (1996), that Metakaolin as 10% cement replacement will increase the compressive strength even at the age of 1 day. The particle size of Metakaolin that is very small will enable it to be a good filler and providing a large surface area that will promote high reactivity during the process of hydration and pozzolanic reaction: (Wild et al., 1996). These properties are believed to be a contributing reason for concrete with Metakaolin to possess a better strength compared to concrete with OPC.

Conclusion and Future Development

It is proven that concrete containing MK7003 leads to a rapid initial increase in the compressive strength of concrete as early as the age of 3 days and reaches its maximum at about 7 days. The optimum compressive strength of concrete is achieved with 10% MK7003 as a partial cement replacement in concrete. There are 3 properties of MK7003 which govern this finding, namely being a good filler, accelerating the hydration process and its pozzolanic behaviour.

However, result of the test with various water binder ratios, clearly showed that the compressive strength of concrete with 10% MK7003 decreases as the water binder ratio increases. Nevertheless as the water binder ratio decreases the workability becomes less. Therefore the influence of MK7003 at the lower water binder ratio could not be identified in this study. The reason for this is the presence of MK7003 in the concrete mix will increase the water demand. In order to overcome the workability level the usage of superplasticizer may be considered.

In the future, further studies should be conducted to obtain a better understanding on the behaviour of concrete containing MK7003 especially on the workability measurement for lower water binder ratio. A study on the potential of adopting MK7003 in the construction of structural members like flexural member should be carried out.

Acknowledgement

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