THE IMPACT ON THE UTILIZATION OF MICRONISED BIOMASS SILICA IN RECYCLED AGGREGATE CONCRETE

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ABSTRACT. *Recycled Aggregate Concrete (RAC) has been recognized as concrete with lower performance compared to Natural Aggregate Concrete (NAC). Thus to improving the performance of RAC, the Micronised Biomass Silica (MBS) has been used as pozzolanic material. This paper discusses the impact of Micronized Biomass Silica, which is produced from rice husk ash in recycled aggregate concrete in terms of its compressive strength and water permeability. Various percentages of Micronised Biomass Silica have been used as pozzolanic material for producing RAC. The result shows that after 365 days, 12 % of Micronised Biomass Silica has the ability to enhance the performance of fully application of Recycled Aggregate in concrete for compressive strength up to 24 % and reduce the water permeability coefficient and water penetration up to 44 % and 22% respectively.*

KEYWORDS. Recycled Aggregate Concrete, Micronised Biomass Silica, compressive strength, water permeability coefficient, water penetration

INTRODUCTION

Concrete is the most favorite choice used in construction industry. This is due to its basic ingredients (cement, coarse aggregate, fine aggregate, water) are easily to find, little maintenance service, easily to handle, most economical material, good in compression, durable and good fire resistance. Because of these factors, there is scarcity that natural sources like coarse aggregate will diminish. Thus, to preserve this source, the application of Recycled Aggregate (RA) for producing concrete is introduced.

In Malaysia the concrete which used RA or known as Recycled Aggregate Concrete (RAC) is considered new. However, it is not a new material in South Africa, Netherland, United Kingdom (UK), Germany, France, Russia, Canada and Japan (Olorunsogo and Padayachee, 2002). These countries have gained many experiences on application of RAC in their construction industry.

Although RA is becoming a good alternative material, there is still a weakness on its performance in concrete. In fresh concrete performance, it was found that RAC obtained lower in workability compared to concrete using Natural Aggregate or known as Natural Aggregate Concrete (NAC) (Topcu and Sengel, 2004: Limbachiya 2004). For hardened concrete performance, i.e. compressive strength, it was recognised that RAC obtained lower in strength compared to NAC (Topcu and Sengel 2004: Fraaij *et al*, 2002: Kenai *et al.*, 2002 and Poon *et al*., 2004).

For improving the performance of RA, the application of new method like Two-Stage Mixing Approach (TSMA) by Tam *et al.*, (2007) and utilization of pozzolanic material like fly ash by Kou, Poon and Chan (2007) has been introduced. Both studies have contributed into improvement IN performance of RAC.

This study presents the results of an experimental study on the performance of RAC with utilization of Micronised Biomass Silica as pozzolanic material. The study is focused on the influence of various percentages of MBS in RAC on the compressive strength and water permeability.

EXPERIMENTAL WORK

The experimental work for this study is including the materials used for experimental work, the concrete mixes proportion, testing that has been used for determine the fresh concrete performance and testing that has been conducted for assessing the hardened concrete performance.

Materials Used

In this study, these materials were used for experimental work. There are Ordinary Portland Cement (OPC), sand, natural gravel with maximum size 20mm, and superplasticizer. Recycled Aggregate (RA) was prepared by crushing the waste cube which has been thrown away at the outside of Material Laboratory. The waste cubes were broken into smaller pieces by hammer and crushed using a jaw crusher. Maximum size of RA that has been produced is 20mm and minimum size is 5mm. Then, the Micronised Biomass Silica (MBS) was prepared by burning the rice husk in rotary furnace. This furnace has been located at Material Laboratory UTHM and enables to synthesis any biomass silica material with different regime of temperature. In order to obtain an amorphous material, the temperature for rotary furnace is fixed at 500 ^{0}C. Off white amorphous material is obtained after one (1) hour. Before that, rice husk is fed manually into the rotary furnace. Then, Jar Mill is used to produce finer biomass silica. After been grinding by Jar Mill for one (1) hour, the particle size of MBS is reduced from 48 µm to 25 µm.

Concrete Mixes

For this experimental work, eight (8) concrete mixes as shown in Table 1.0 have been prepared. These concrete mixes were designed according to DOE Standard. The target strength for concrete at 28 days is 25 MPa. Meanwhile, the slump target was designed between 60mm and 180mm. Concrete mixes were prepared by using both fully application of RA or Natural Aggregate (NA) and various proportions of Micronised Biomass Silica (4%, 8% and 12%) as cement replacement material by weight.

Three (3) duplicates of 100 mm cubes were prepared for testing. The concrete cubes were produced by using steel mould and have been removed after 24 hours. Then, the cubes were cured in water until the day of testing.

Table 1. Mix Proportions for Concrete Mixes

Concrete Series	RA (%)	MBS (%)	Cement (kg/m^3)	Water (kg/m^3)	Coarse Aggregate (kg/m^3)		Fine Aggregate (kg/m^3)	SP (ml/kg^3)
					NA (kg/m^3)	RA (kg/m^3)		
Control Concrete	0	0	450	225	1115	0	892	4500
RA100	100	0	450	225	0	1115	892	4500
MBS4	0	4	432	225	1115	0	892	4500
MBS4-RA100	100	4	432	225	0	1115	892	4500
MBS8	0	8	414	225	1115	0	892	4500
MBS8-RA100	100	8	414	225	0	1115	892	4500
MBS12	0	12	396	225	1115	0	892	4500
MBS12-RA100	100	12	396	225	0	1115	892	4500

note RA= Recycled Aggregate, MBS= Micronised Biomass Silica, NA=Natural Aggregate, SP= Superplasticizer

Testing of Fresh Concrete

Slump test was applied to determine the workability of concrete. This test has been conducted according to BS 1881: Part 102: 1983.

Testing of Hardened Concrete

Performance of hardened concrete was assessing by using three tests which are compressive strength test, water permeability coefficient test and water penetration test. The compressive strength test was conducted according to BS 1881: Part 116. Water permeability coefficient and water penetration test were conducted according to ISO/DIS 7031 and DIN 1048 respectively.

RESULTS AND DISCUSSION

The results and discussion for slump value, compressive strength, water permeability coefficient and water penetration were revealed at next sub-section.

Slump Value

The slump value for fresh concrete with respect to percentage of RA in concrete mixes is shown in Figure 1. It can be seen that as RA content increases, its slump value decreases. These results are expected because RA obtained high capacity to absorb water (Suraya Hani *et al*., 2009). Remaining mortar in RA absorbed the water and makes the concrete mixtures harsher and less cohesive. The angular (crushed) shape of aggregate cause larger specific surface area as noted by Taylor (2000) and thus can absorb more water (for about 15- 20 percent increases). Furthermore, this figure also revealed that as MBS content increases, it slump value decreases. This is due to cellular characteristic of MBS which lead into absorption properties in concrete containing MBS. These absorption characteristic is same as other pozzolanic material like silica fume (Mazloom, Ramezanianpour, Brooks, 2004) and rice husk ash (Kartini, 2009: Nehdi, 2003).

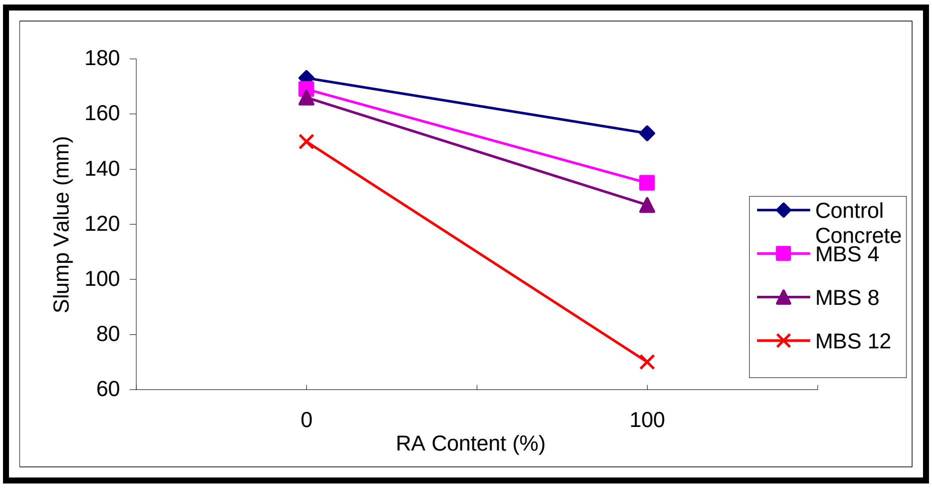

Figure 1. Slump Value for Concrete Mixes

Compressive Strength

Compressive strength results for various concrete mixes were presented in Figure 2. This figure illustrated the compressive strength at 7 days, 28 day and 365 days. From this figure, it can be seen that as RA content increases, its compressive strength decreases. Based on previous studies, it was indicated that concrete with 100% RA obtained lower in compressive strength than that of concrete with 0% RA due to few factors like higher percentage of fine particles and higher porosity of RA (Olorunsogo, 1999: Poon *et al.*, 2004). This figure also revealed that concrete (with 0% RA and 100% RA) containing MBS attained higher in compressive strength compared to control concrete. This is because silicon dioxide, SiO_2 from MBS (Suraya Hani *et al.*, 2008) has react with calcium hydroxide, $Ca(OH)_2$ from cement hydration process to form calcium silicate hydrate, C-S-H gel. This gel has an ability to fill up and reduce the micro and macropores in concrete, thus high compressive strength of concrete resulted. However, MBS inclusion to concrete with 100% RA attained lower in compressive strength compared to concrete with 0% RA. This is due to factors which have been described before.

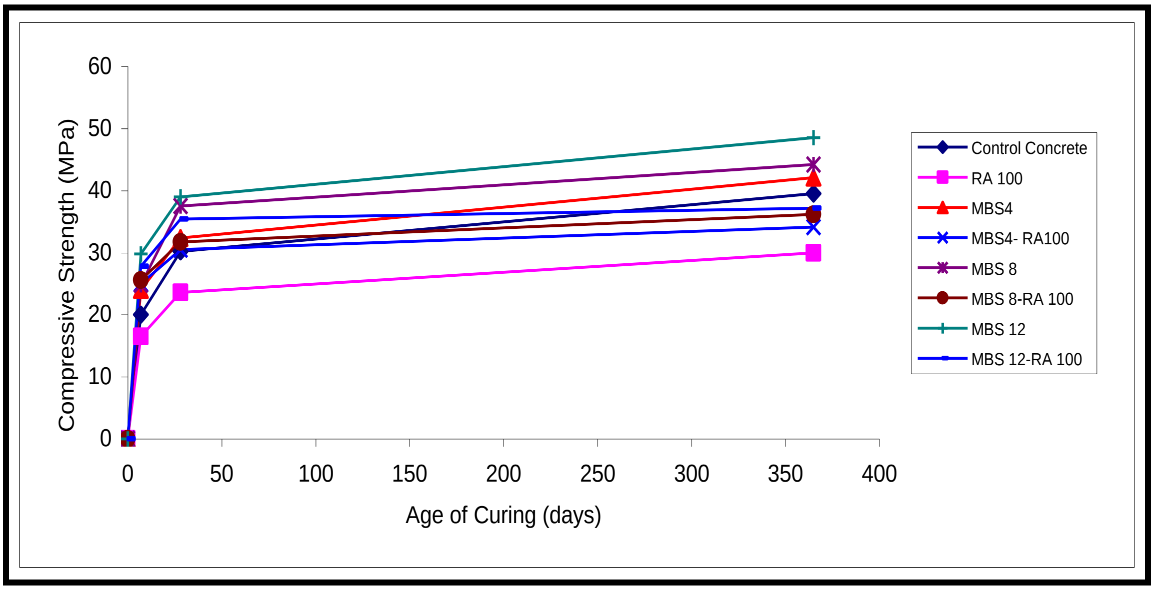

Figure 2. Compressive Strength of Concrete with Respect to Age of Curing

Water Permeability Coefficient

Water permeability coefficient was conducted for age of concrete at 7 days, 28 days and 365 days. The results were tabulated as in Table 2. Based from the table, it can seen that concrete containing RA obtained higher in water permeability coefficient compared to concrete using 0% RA. The results show that water permeability of concrete containing 0% RA is better than those of concrete with 100% RA. These results may be explained by the fact that physical property of RA is high in water absorption. According to Berndt (2009) and Topcu (1997) high water absorption of RA is due to attached mortar at RA. Mortar at RA which comprises cement, sand and water has an ability to absorb more water due to high amount of capillary pores. Thus RA indirectly has absorbed more water in concrete compared to Natural Aggregate.

This table also revealed that concrete with MBS inclusion attained lower in water permeability coefficient compared to concrete without MBS. This is due to calcium silicate hydrate (C-S-H) gel which has been formed from pozzolanic reaction. This gel will act to fill up the pores in concrete and Interfacial Transition Zone (ITZ) between aggregate and cement paste. These actions will lead into low permeable concrete. This table also reported that MBS capable to produce concrete containing RA with low water permeability coefficient compared to control concrete.

Table 2. Water Permeability Coefficient for Various Concrete Samples

Mixes	Water Permeability Coefficient (m/s)		
	7 days	**28 days**	**365 days**
Control Concrete	1.04E-10	1.50E-11	7.51E-12
RA100	2.08E-10	2.40E-11	9.00E-12
MBS4	1.02E-10	7.51E-12	6.20E-12
MBS4-RA100	2.85E-10	9.54E-12	7.87E-12
MBS8	9.39E-11	6.25E-12	5.59E-12
MBS8-RA100	1.99E-10	7.88E-12	6.50E-12
MBS12	3.60E-11	4.56E-12	3.91E-12
MBS12-RA100	1.06E-10	7.94E-12	5.04E-12

Water Penetration

The water penetration results for concrete are as in Figure 3. Water penetration for concrete is assessed for age of curing 28 days and 365 days. From the figure, it is found that concrete RA 100 attained highest in water penetration and the lowest was obtained by concrete MBS 12. The concrete is a good in water permeability when it performs a low water penetration. Thus, this figure indicates that concrete containing RA has high water penetration compared to concrete with 0% RA. This is due to high porosity of RA which is caused by mortar attached. Also this figure reveals that concrete containing MBS obtained low water penetration compared to concrete without MBS utilization. The C-S-H gel from pozzolanic reaction has facilitated the concrete by fill-up the pores and micro-cracks in concrete which contribute into low water penetration of concrete. MBS also can reduce the water penetration in concrete containing RA. Consequently, MBS is beneficial to improve the performance of RAC in terms of water permeability.

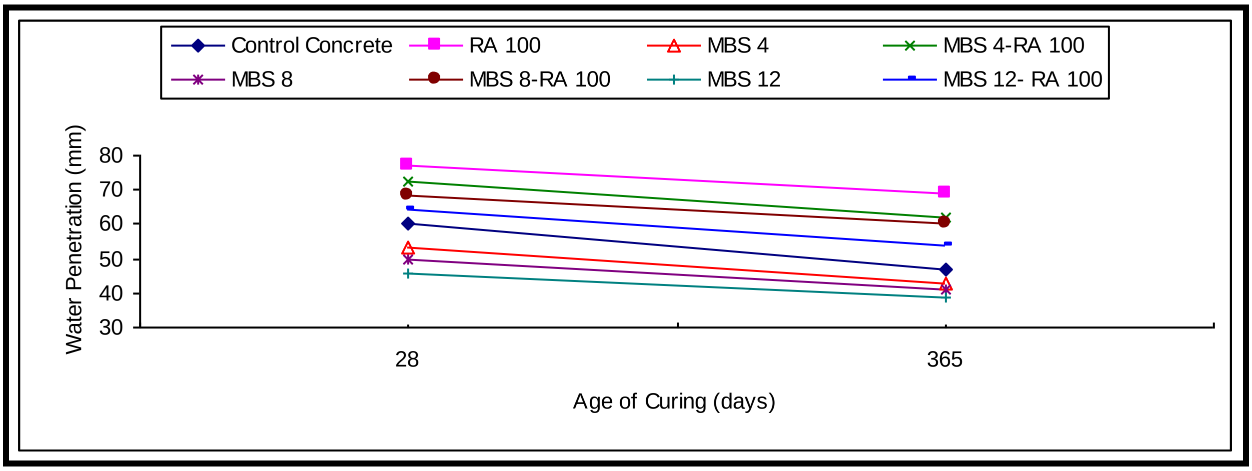

Figure 3. Water Penetration of Concrete with Respect to Age of Curing

CONCLUSIONS

Main conclusions obtained from the results are as follows:

i) RAC concrete mixes obtained lower slump value compared to NAC concrete mixes.
ii) RAC obtained lower in compressive strength than that of NAC.
iii) Water permeability of NAC is better compared to RAC.
iv) MBS can improve the performance of RAC in terms of compressive strength and water permeability.

ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Higher Education Malaysia for supporting this research under the Fundamental Research Grant Scheme (FRGS) and Public Service Department of Malaysia Scholarship for PhD programme.

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