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PROPERTIES OF MORTAR BLOCKS WITH WASTE CONCRETE ASH (WCA) AS A CEMENT REPLACEMENT

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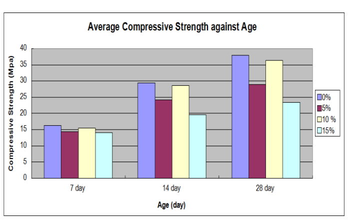
N. F. Abas*, M. A. Karim

School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, MALAYSIA

*Corresponding author
nfaisal@usm.my

Graphical abstract



Abstract

This paper presents the experimental investigation into the properties of mortar blocks containing waste concrete ash (WCA) as a cement replacement. In the experimental investigation, the properties of the mortar blocks were assessed through 3 different type of mixing. The replacement of waste concrete ash (WCA) had been divided into percentage which 0% (control), 5 %, 10 % and 15%. This different type of mixing had been tested with different duration with 7 day, 14 day and 28 day. Three cube specimens and three blocks specimens were prepared for each test. The total specimen that were prepared and tested are 36 cubes and 36 blocks. Workability test (slump test), density test, ultrasonic pulse velocity test, compressive strength test, flexural test and water absorption test were carried out. The experimental results of this study indicate that to observe the inclusion of waste concrete ash (WCA) in mortar blocks enhances the properties of mortar blocks in aspect of replacement of cement.

Keywords: Mortar blocks, cement replacement, waste concrete ash (WCA)

Abstrak

Kertas kerja ini membentangkan penyelidikan eksperimen tentang sifat-sifat blok mortar yang mengandungi abu sisa konkrit (WCA) sebagai pengganti simen. Dalam ujikaji yang dibuat, sifat-sifat blok mortar dinilai melalui 3 jenis campuran yang berbeza. Penggantian abu sisa konkrit (WCA) telah dibahagikan kepada peratusan 0% (kawalan), 5%, 10% dan 15%. Jenis campuran yang berbeza telah diuji dengan tempoh yang berbeza iaitu 7 hari, 14 hari dan 28 hari. Tiga kiub spesimen dan tiga blok spesimen telah disediakan untuk setiap ujian. Jumlah spesimen yang telah disediakan dan diuji adalah 36 kiub dan 36 blok. Ujian kebolehkerjaan (ujian kemerosotan), ujian ketumpatan, ujian ultrasonik halaju nadi, ujian kekuatan mampatan, ujian lenturan dan ujian penyerapan air telah dijalankan. Keputusan eksperimen kajian ini adalah untuk melihat kemasukan abu sisa konkrit (WCA) di blok mortar meningkatkan sifat-sifat mortar blok dalam aspek penggantian simen.

Kata kunci: Blok mortar, penggantian simen, abu sisa konkrit (WCA)

1.0 INTRODUCTION

The high performance of economic in aspects of development of land use and the rapidity of structural buildings rises which the demand of the market also increases. The high-rise buildings and futuristic architecture buildings are example of the demand. The increase of the demand moves along to the quality of the building in aspects of the performance of building materials. Construction and demolition waste defined as a mixture of surplus materials arising from any excavation, civil or building construction, site clearance, demolition activities, road works and building renovation. According to an investigation conducted in 2002 by the Ministry of Land, Infrastructure and Transport (MLIT), the amount of construction waste produced in Japan is approximately 83 million tons per year, most of which is recycled in compliance with related laws and ordinances [1].

The disposal of construction and demolition waste at landfills has caused major environmental concerns. Government sources indicate that there is an acute shortage of landfill space in Malaysia and the continuation of disposal of construction and demolition waste at landfills would risk to the strategic use of landfills for the disposal of the more demanding waste types such as domestic refuse and hazardous waste. There are greater health and safety concerns relating to unmanaged C&D Waste, such as illegal dumping and related health and safety issues. Unmanaged waste posing a strain on landfills and incinerators. Beside that, hazardous substances in demolitions wastes such as asbestos can lead to public health concerns if not managed properly. Illegally dumped wastes can lead to mosquito breeding problem which could promote the transmittal of diseases [2].

Furthermore, the increasing of demand in cement product lead to the supplier to increase the price of cement. When contacted by StarBizWeek, cement majors are mostly tight-lipped over their actual cement price hike but industry sources say the average domestic cement price is currently pegged at RM380 to RM400 per tonne, which is higher than RM370 per tonne a year earlier [3, 4].

Holding a 3 aspect of sustainability which Reduce, Recycle and Reuse this investigation to reduce the uses of cement product and recycle with reuse back the concrete waste to replacement of cement product [5]. It is absolute essential to protect our environment and stop reckless of our planet, Earth. Such damage has been taking place progressively which is now leading us towards many catastrophes and natural disasters. The increases of cement price lead to the high cost of development project.

This investigation will discover the different in properties of the normal mortar block compare to cement replacement with concrete waste ash (WCA) mortar block.

2.0 MATERIALS

2.1 Portland Cement SEM1:

Portland Cement CEM I with specific surface area of 1043.2 m^2/kg, specific gravity of 3.02 and median particle size of 3.9 μm is used for specimen preparation which is supplied by concrete laboratory of School of Housing, Building and Planning, Universiti Sains Malaysia.

2.2 Fine Aggregates

For this study, uncrushed fine aggregates are used in mortar mixes as a constituent material with a specific gravity of 2.83 and a maximum aggregate size of 5mm. The fine aggregates were graded in accordance to BS 812: Part 102 and the fitness modulus were determined to be 3.26.

2.3 Water

The water has to comply with the requirements of MS 28. It has to be clean and free from material deleterious to concrete in a plastic and hardened state, and has to be from a source. Since it helps to strengthen the cement gel, the quantity and quality of water required has to be carefully considered. The water-cement ratio used was 0.56 for M 25 concrete.

3.0 ADMIXTURES

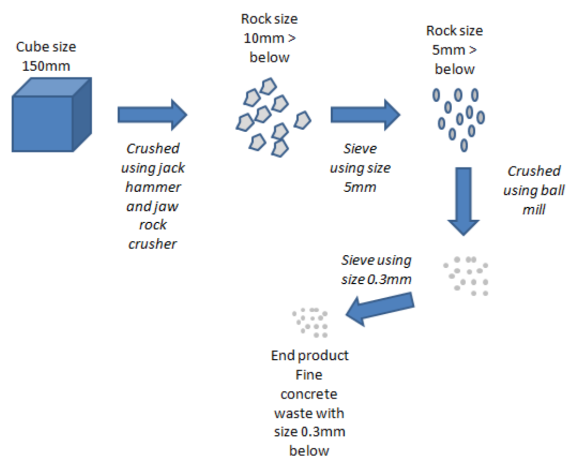


Figure 1 The process producing a waste concrete ash

3.1 Waste Concrete Ash (WCA)

Figure 2 Waste concrete ash (WCA)

Large concrete pieces are broken using jaw rock crusher and mechanical hammer. The rock size was produce from 10 mm and below. Then, sieve analysis is tests for these rocks by using 5 mm screening of the crushed material. Until there were produced 5 mm of size below. To produce end product, fine concrete waste with size 0.3 mm below are tested by using ball mill. Apart from produced this method, sieve using 0.3 mm is applied to complete this process.

4.0 EXPERIMENTAL SETUP

For this study, the mix proportion of mortar block specimens is calculated based on Kaedah Jabatan Alam Sekitar [5]. Table 1 shows the mix proportion of mortar block specimens that need to investigate. Size of 100 mm in length, 100 mm in width, and 100 mm in height for cube specimens and 500 mm in length, 100 mm in width, and 200 mm in height for block specimens were prepared to determine the properties with follow a density test, ultra pulse velocity test, compressive strength test, flexural test and water absorption test by using certain laboratory machine at the age of 7, 14, and 28 days with standard curing room temperature.

Table 1 Mix proportion of mortar block specimens

Concrete mix	Cement (kg)	Fine aggregates (kg)	Water Content (kg)	Water-Cement ratio	Waste Concrete Ash (kg)	Cement-Sand ratio
C	50.0	125.0	22.5	0.45	0.0	1:2.5
5%	47.5	125.0	22.5	0.45	2.5	1:2.5
10%	45.0	125.0	22.5	0.45	5.0	1:2.5
15%	42.5	125.0	22.5	0.45	7.5	1:2.5

5.0 RESULT AND DATA ANALYSIS

5.1 Density Test

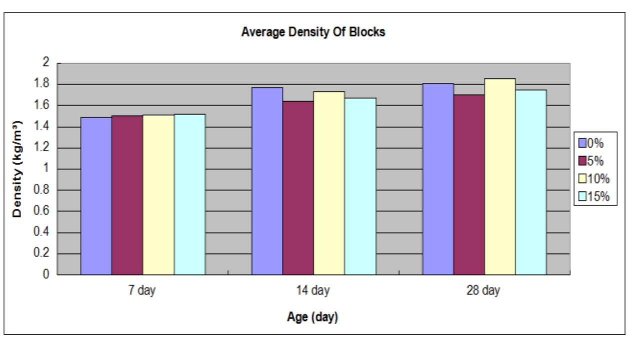


Figure 3 Density of blocks against age

From Figure 3, density test for mortar block specimens resulted an increasing for all percentage of waste concrete ash (WCA) against age (day). The highest density gained by 10% of waste concrete ash (WCA) mortar block specimens compare to others percentage with result 1.85 kg/m³ at age 28 day. 10% of waste concrete ash (WCA) mortar block specimens increased from 1.51 kg/m³ at the age 7 day until 1.73 kg/m³ at the age 14 day. Then, it continues increased until 28 day. The second highest gained by 0% mortar block specimens with reading 1.81 kg/m³ at the age 28 day which was a slightly different 10%. We could see 0% mortar block specimens increased from 1.49 kg/m³ at the age 7 day until 1.77 kg/m³ which was higher compare to others at the age 14 day.

For 15% of waste concrete ash (WCA) mortar block specimens, we could see the increased from 7 day with result 1.52 kg/m³ until 28 day with result 1.75 kg/m³.

Lastly, 5% of waste concrete ash (WCA) mortar block specimens gain the highest result at the age 7 day with result 1.50 kg/m³ compare to others percentage and then it increased until 28 day with result 1.70 kg/m³ which had a slightly different with 15%. We can conclude the optimum percentage for waste concrete ash (WCA) mortar block specimens was 10%.

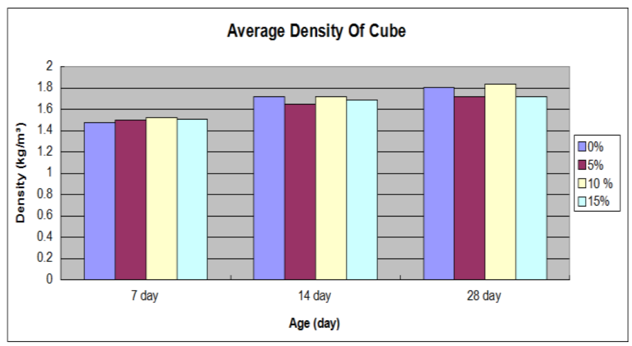


Figure 4 Density of cubes against age

From Figure 4, density test for mortar cube specimens resulted an increasing for all percentage of waste concrete ash (WCA) against age (day). The highest density gained by 10% of waste concrete ash (WCA) mortar cube specimens compare to others percentage with result 1.84 kg/m³ at age 28 day. 10% of waste concrete ash (WCA) mortar cube specimens increased from 1.52 kg/m³ at the age 7 day until 1.72 kg/m³ at the age 14 day. Then, it continues increased until 28 day. The second highest gained by 0% mortar cube specimens with reading 1.81 kg/m³ at the age 28 day which was a slightly different 10%. It increased from 1.48 kg/m³ at the age 7 day until 1.72 kg/m³.

For 15% of waste concrete ash (WCA) mortar cube specimens, we could see the increased from 7 day with result 1.51 kg/m³ until 28 day with result 1.72 kg/m³. Lastly, 5% of waste concrete ash (WCA) mortar cube specimens increased from 1.50 kg/m³ at the age 7 day until 28 day with result 1.72 kg/m³ which was same result with 15% at the age 28 day. So, the optimum percentage for waste concrete ash (WCA) mortar cube specimens was 10%.

5.2 Ultrasonic Pulse Velocity Test

This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1)–1992. The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity.

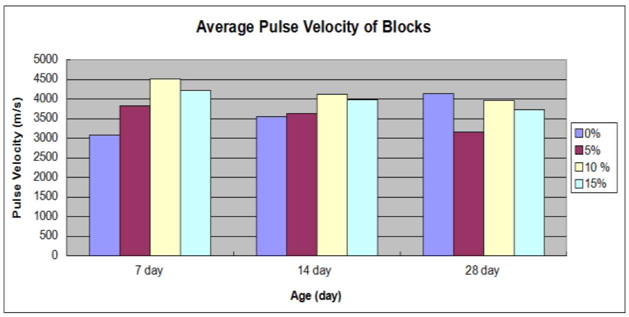


Figure 5 Pulse velocity of blocks against age

From the Figure 5, it can be seen that 10% of waste concrete ash (WCA) mortar block specimens gained the highest result at the age 7 day with 4521 m/s. Then, it decreased until 28 day with result 3962 m/s. For 0% mortar block specimens, we could see it increased from 7 day with 3089 m/s to 28 day constantly with result 4137 m/s which the highest result at the age 28 day compare to others. The 5% of waste concrete ash (WCA) mortar block specimens decreased from 7 day to 28 day with result 3156 m/s which the lowest result at the age 28 day. Beside that, 15% of waste concrete ash (WCA) mortar block specimens also resulted decreasing from age of 7 day to 28 day with result 3721 m/s. This can be conclude that, the pulse velocity for all mortar block specimens are decreased over the day except 0% mortar block specimens.

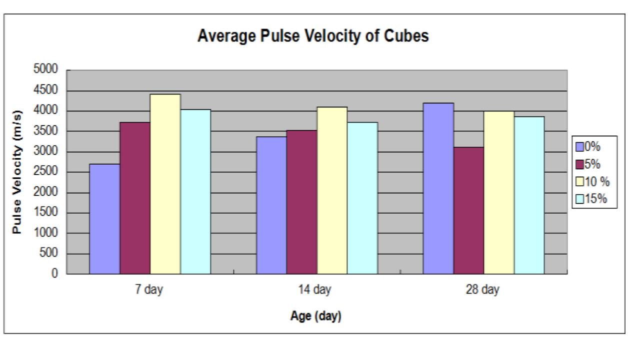


Figure 6 Pulse velocity of cubes against age

The Figure 6 showed the 0% mortar cube specimens increased from 7 day to 28 day compare to waste concrete ash (WCA) mortar cube specimens which was decreased over the day. However, the highest result gained by 10% waste concrete ash (WCA) mortar cube specimens at the age 7 day with result 4419 m/s. Then, it decreased until 3835 m/s at the age 28 day. The 5% waste concrete ash (WCA) mortar cube specimens decreased from 3714 m/s to 3115 m/s at the age 28 day which was the lowest result at the age 28 day. The same condition with 15% waste concrete ash (WCA) mortar cube specimens which was decreased from 4039 m/s to 3862 m/s at the age 28 day.

5.3 Compressive Strength Test

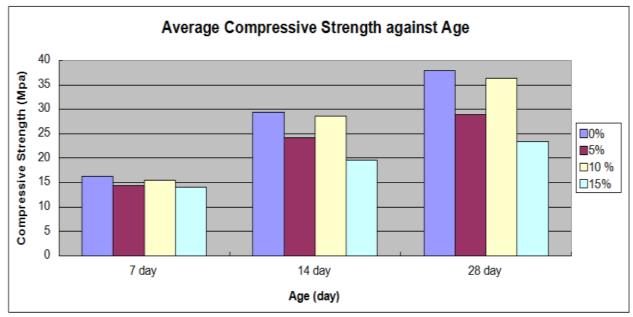


Figure 7 Compressive strength against age

The most common test preformed on concrete was for compressive strength which to assumed that the most important properties of concrete as directly related to compressive strength and the structural design codes are based on compressive strength. The test also was relatively simple and inexpensive to perform.

From the Figure 7, it can be seen the 0% mortar specimens resulted the highest compressive strength compared to waste concrete ash (WCA) mortar specimens in every age of the day. The 0% mortar specimen had a result 37.89 Mpa which compared to 10% waste concrete ash (WCA) mortar specimens with result 36.31 Mpa at the age of 28 day which had a slightly different. The 5% and 15% waste concrete ash (WCA) mortar specimens each gained a result 28.93 Mpa and 23.56 Mpa at the age 28 day. However, 10% waste concrete ash (WCA) mortar specimens gained a good result compare to others percentage and had slightly different with 0%.

5.4 Flexural Strength Test

Waste concrete ash (WCA) mortar specimens specimens were tested for flexural strength by applying increasing load until failure occurred. Thus, reading of the maximum load for failure can be obtained. In this study, center-point load method is used. The results of flexural strength test of waste concrete ash (WCA) mortar specimens are shown in Figure 8 which shows the flexural strength against age (day).

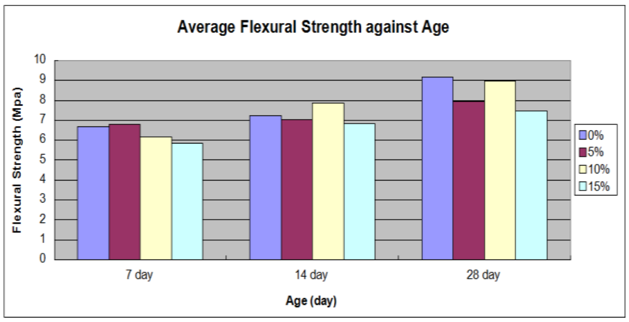


Figure 8 Flexural strength against age

From Figure 8, we can see all mortar specimens increased from 7 day to 28 day. The 0% mortar specimens resulted the highest strength compare to others percentage with result 9.15 Mpa at the age 28 day. For 10% waste concrete ash (WCA) mortar specimens gained the highest result compare to others percentage of waste concrete ash (WCA) mortar specimens with result 8.95 Mpa at the age 28 day. The 5% and 15% waste concrete ash (WCA) mortar specimens each resulted 7.93 Mpa and 7.45 Mpa at the age 28 day. We an conclude that, the 10% waste concrete ash (WCA) mortar specimens had a positive result in aspect of cement replacement material and resulted a slightly different to 0% mortar specimens [6,7].

5.5 Water Absorption Test

In this study, water absorption test according BS 1881: 122 is used to determine the durability properties of concrete specimens. This parameter is important as it relates with gas absorption, chloride penetration, porosity which contributes to durability properties of mortar. The results for 7, 14 and 28 days were shown in Figure 9.

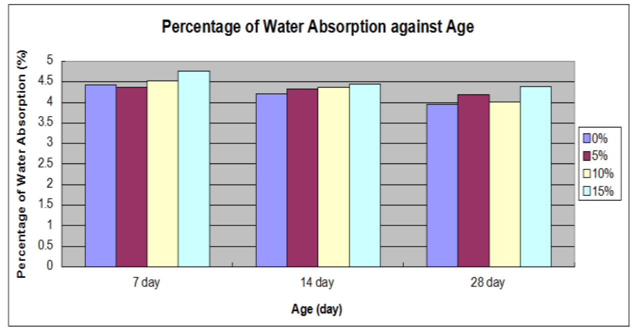


Figure 9 Percentage of water absorption against age

The Figure 9 showed all mortar specimens result a decreased from 7 day to 28 day. The 0% mortar specimens resulted the lowest percentage of water absorption compare to others mortar specimens with result 3.95% at the age 28 day. The second lowest percentage of water absorption gained by 10% waste concrete ash (WCA) mortar specimens with result 4.01% at the age 28 day which had a slightly different with 0% mortar specimens. Then, it continue by 5% and 15% specimens with result each 4.19% and 4.38% at the age 28 day. This can conclude 10% waste concrete ash (WCA) mortar specimens had lowest percentage of water absorption in aspect of cement replacement and had a slightly different with 0% mortar specimens.

6.0 CONCLUSION

This study had described various processes from primary stages of waste concrete ash (WCA) mortar specimens design up to the analysis of data obtained. Experimental laboratory works were carried out to obtain the data for strength and durability analysis containing of density test, ultra pulse velocity test, compressive strength test, flexural test and water absorption test [8]. From all experimental result and data, 10% waste concrete ash (WCA) mortar specimens had gain positive result compare to 5% and 15% WCA specimen. The compressive strength and flexural strength for 10% waste concrete ash (WCA) mortar specimens had slightly different to 0% specimen which about 1 Mpa. Altough 0% mortar specimen's a little bit higher compare to 10% waste concrete ash (WCA) mortar specimens, but it can be possible to use waste concrete ash (WCA) mortar specimens as cement materials [9]. For a long term, 10% waste concrete ash (WCA) mortar specimens could be higher than 0% mortar specimen. We can conclude that, waste concrete ash (WCA) can be use as a cement replacement in partial percentage. The good percentage for waste concrete ash (WCA) was about 10% below to gain good properties.

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