Nor Azizah Yacob · Mesliza Mohamed
Megat Ahmad Kamal Megat Hanafiah
Editors

Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014)

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Editors
Nor Azizah Yacob
Universiti Teknologi MARA
Pahang
Malaysia

Megat Ahmad Kamal Megat Hanafiah
Universiti Teknologi MARA
Pahang
Malaysia

Mesliza Mohamed
Universiti Teknologi MARA
Pahang
Malaysia

ISBN 978-981-10-0532-9 ISBN 978-981-10-0534-3 (eBook)
DOI 10.1007/978-981-10-0534-3

Library of Congress Control Number: 2016931603

Printed on acid-free paper

This Springer imprint is published by SpringerNature
The registered company is Springer Science+Business Media Singapore Pte Ltd.

Preface

The Regional Conference on Science, Technology and Social Sciences 2014 (RCSTSS 2014) is a biennial conference organized by Universiti Teknologi MARA (UiTM) Pahang. Showcasing recent advancements and trends in the three major academic disciplines, namely science, technology, and social sciences, RCSTSS 2014 facilitated knowledge sharing and networking among participants concerning new challenges in their fields. But more importantly, it also served as a platform to disseminate research findings and a catalyst to promote innovations in the development of the country as well as the region. More than 200 papers were presented by participants from various local and foreign universities and institutions of higher learning. Of these, 64 science and technology manuscripts have been selected to be included in this publication, namely architecture, biology, computer and information technology, engineering, environment and management, food science, forestry, health and medicine, mathematics and statistics, plantation and agrotechnology, physics, robotics and sport science. The papers included in this book have undergone a careful selection process to ensure that they meet the objectives of the conference. Hopefully, this publication will serve as a significant reference to academicians, researchers, and students who are pursuing further research in their respective fields.

Pahang, Malaysia

Nor Azizah Yacob
Mesliza Mohamed
Megat Ahmad Kamal Megat Hanafiah

Acknowledgements

In the name of Allah, the Most Gracious, the Most Merciful. Praise be upon him for giving us the courage, strength, and patience to complete the *Proceedings of the Regional Conference on Science, Technology and Social Sciences* (*RCSTSS 2014*), UiTM Pahang.

We would like to express our sincere gratitude to all RCSTSS 2014 committee members, participants and reviewers for their help and support. Many thanks also go to the Editorial Committee, Mohd Rozaidi Ismail, Aiza Harun, Shaikh Abdul Karim Yamani Zakaria, Nazirah Ramli, Neni Kartini Che Ramli, Mohd Kamal Azman Jusoh, Fairuz Shohaimay, Zurhana Mat Hussin, Faizan Abdul Jabar, Sharifah Norhuda Syed Wahid, Siti Noorul Ain Nor Azemi, Salimah Ahmad, and Siti Suhaila Harith, for their tireless effort in the preparation of this book.

Special thanks also go to the Rector of UiTM Pahang Prof. Dr. Jamaludin Kasim and the RCSTSS Chair, Associate Prof. Dr. Azhan Hashim for their encouragement and moral support. The editors would also like to thank Universiti Teknologi MARA Pahang for the technical and financial support that ensured the materialization of RCSTSS 2014.

Alhamdulillah. Thank you.

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Part I
Engineering

Chapter 1
Strength Properties of Lightweight Foamed Concrete Incorporating Waste Paper Sludge Ash and Recycled Concrete Aggregate

Siti Shahidah Sharipudin, Ahmad Ruslan Mohd Ridzuan, Raja Nor Husna Raja Mohd Noor and Asmawati Che Hassan

Abstract A rapid growth in concrete industry is known to leave an enormous environmental footprint on planet. As the amount of cement being produced continues to rise, it results the high levels of carbon dioxide. In the meantime, a growing development in construction sector creates the sheer volumes of construction waste, mainly concrete waste. Thus, the present study aims at correlating the strength response to the contribution of using waste paper sludge ash (WPSA) and fine recycled concrete aggregate (FRCA) as an alternative of cement and natural fine aggregate substitute in the manufacturing of lightweight concrete (LWC). The different levels of WPSA and FRCA which are 0, 5, 10, 15, 20 and 30 % to cement and sand weight respectively were adopted. In this investigation, the densities of the foamed concrete used varied between 1400 and 1800 kg/m^3. The results found that the presence of proportion of WPSA had reduced the compressive strength of foamed concrete. It is revealed that the compressive strength of foamed concrete with addition of FRCA attained favourable strength at the optimum replacement of 5 and 15 % for density of 1400 and 1800 kg/m^3 respectively. It also showed that 1800 kg/m^3 concrete that contained a combined 20 % WPSA and 30 % FRCA recorded higher strength than that of control spec-

S.S. Sharipudin (✉) · A. Che Hassan
Faculty of Civil Engineering, Universiti Teknologi MARA, Masai, Johor, Malaysia
e-mail: sitishahidah85@yahoo.com

A. Che Hassan
e-mail: asmawati_chehasan@yahoo.com

A.R. Mohd Ridzuan
Faculty of Civil Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
e-mail: ruslanridzuan@yahoo.co.uk

R.N.H. Raja Mohd Noor
Faculty of Civil Engineering, Universiti Teknologi MARA, Kepala Batas, Pulau Pinang, Malaysia
e-mail: rajanorhusna@ppinang.uitm.edu.my

N.A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014)*, DOI 10.1007/978-981-10-0534-3_1

imen. The results confirmed that the density and different replacement level of WPSA and FRCA have influenced in the strength of foamed concrete.

Keywords Compressive strength · Fine recycled concrete aggregate · Foamed concrete · Waste material · Waste paper sludge ash

1 Introduction

In recent years, the construction industry has shown significant interest in the use of lightweight concrete (LWC) particularly foamed concrete as a building material in construction application. The typical range of densities of foamed concrete is approximately 300–1850 kg/m^3 (Neville 2002). It has been successfully utilised since the ancient Roman times and it has gained its popularity due to its low density, superior thermal insulation, reduction of dead load, faster building rate and lower haulage cost (Bai et al. 2004). Nevertheless, it is stated that a lower density foamed concrete can achieve the strength similar to that of higher density foamed concrete by increasing cement content (Hamidah et al. 2005). It is known that cement is mainly used for the production of concrete that leads to the release of a significant amount of CO_2 and other greenhouse gas (GHGs). Therefore, this has challenged to look for sustainable solutions for future concrete construction. The solution of this issue is to use the supplementary cementitious material, such as silica fume, fly ash, rice husk ash, palm oil fuel ash and others to replace as much cement. However, the extensive use of industrial by-product in concrete production needs for the search a new material that comparable to those ashes.

Waste paper sludge ash (WPSA) from burning process of waste paper residue incinerator has been investigated in order to reduce the waste products resulted from an incineration process and turned this waste into useful building materials. According to Mozaffari et al. (2009), WPSA is possible reuse as a cement replacement in the production of concrete, since it can facilitate the hydration of hydraulic materials as well as undergo its own hydration. Previous attempts have also reported the use of WPSA as constituents in concrete in which this ash contained considerable amounts of alumino-siliceous material and could be used as a pozzolanic material (Bai et al. 2003; Chaipanich et al. 2005). However, utilisation of WPSA to replace part of cement is not well known in producing lightweight foamed concrete.

Concrete waste is another waste material which has been dumped by construction site until today. In Malaysia, it is estimated that concrete wastes recorded the highest amount of total recycled construction waste materials with 67.64 % (Begum et al. 2006). On another note, the reduction in available sources of natural aggregate is also affecting the production of concrete. Thus, recycling of concrete wastes as a source of aggregate is one of the few viable options to solve the increasing concrete waste that generated from the construction industry. Durmus et al. (2009) have proven that the coarse recycled concrete aggregate (CRCA) can be successfully used as a partial or full substitution of natural aggregates (NA) in the production of concrete. Although the consumption of RCA has become more popular, it is still fewer studies on the use of the smallest size fractions of the fine recycled concrete aggregate (FRCA) (i.e. <1.18 mm) in concrete product.

WPSA and FRCA have been found to be studied separately as a replacement for raw material to produce concrete. However, there is limited data available on the use of these two waste materials combined to produce lightweight foamed concrete. Thus, the strength properties of foamed concrete containing different level of WPSA and FRCA corresponding to cement and sand substitute are thoroughly studied.

2 Materials and Methods

Materials

Locally available ordinary Portland cement type I was used throughout this study in compliance with BS EN 197-1: 2000. The physical properties and chemical characterisation of OPC and WPSA are determined and summarised in Table 1. WPSA obtained from Malaysian Newsprint Industries Sdn Bhd (MNI), Pahang was used in the entire investigation. Silica sand with a fineness modulus and specific gravity of 2.46 and 2.67, respectively, was used in this study. FRCA was obtained from crushing waste concrete cubes in the laboratory. The crushed concrete was sieved into smallest size fraction of the FRCA (<1.18 mm). The fineness modulus and specific gravity of FRCA are 2.53 and 2.41, respectively. The particle size

Table 1 Physical properties and chemical composition of OPC and WPSA (Malaysian Newsprint Industries)

	OPC	WPSA
Physical properties		
Specific gravity	3.10	1.90
Fineness (% passing 90 μm sieve)	97.80	91.10
Chemical composition		
Silicon dioxide (SiO_2)	15.05	15.16
Aluminium oxide (Al_2O_3)	2.56	6.06
Ferric oxide (Fe_2O_3)	4.00	1.11
Titanium oxide (TiO_2)	0.12	0.45
Magnesium oxide (MgO)	1.27	2.00
Calcium oxide (CaO)	72.17	55.87
Sodium oxide (Na_2O)	0.08	0.19
Potasium oxide (K_2O)	0.41	0.34
Phosphorous oxide (P_2O_5)	0.06	0.48
Manganese oxide (MnO)	0.06	0.05
Sulphur trioxide (SO_3)	2.0	0.78
Loss of Ignition (LOI)	1.33	17.51

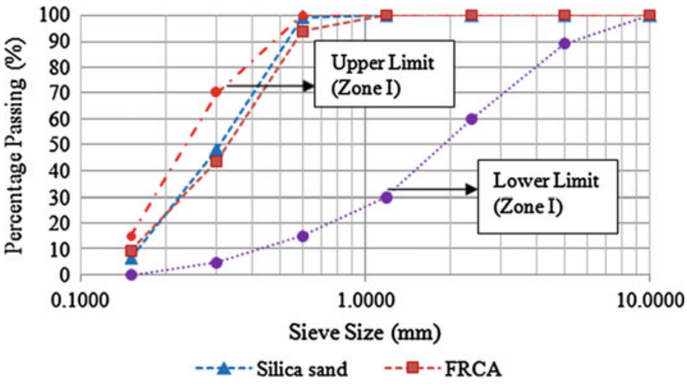


Fig. 1 Particle size distribution of silica sand and FRCA

distribution of silica sand and FRCA is illustrated in Fig. 1. The synthetic-based foaming agent was used to create air voids in the foamed concrete production.

Mix Proportions

In the present study, foamed concrete of 1400 and 1800 kg/m^3 were prepared. These densities are selected because the mix composition of paste determines the strength at the higher density in which the air voids are far apart to have an effect on the strength of foamed concrete (Ramamurthy et al. 2009). The mix proportions were prepared using a spreadsheet developed in-house to produce 1 m^3 of foamed concrete specimens. Otherwise, the sand-to-cement and water/binder ratios were set for all mixes as 1.5 and 0.6, respectively, which also can be calculated using that sheet. In this investigation, three sets of foamed concrete mixtures were prepared. For the first set, WPSA was employed as 0, 5, 10, 15, 20 and 30 % by weight replacements of the cement. In second set, FRCA was used to replace silica sand by masses 0, 5, 10, 15, 20 and 30 %. In addition, in final set of mixes, different percentages of WPSA were combined with various levels of FRCA to cement and sand content respectively. Foamed concrete mix consists of 100 % ordinary Portland cement (OPC) and 100 % sand was prepared for each density as control specimen.

Specimen Preparation

The preformed foam was prepared by mixing 900 ml of foaming agent with 17.1 l of water in a Portafoam generator. The base mix comprises of cement, WPSA, sand, FRCA, water and preformed foam was mixed in a drum mixer.

Testing of Specimens

In this study, cube specimens of 100 mm in size were prepared to determine the compressive strength of foamed concrete accordance to BS EN 12390-3: 2009.

3 Results and Discussion

Workability of Foamed Concrete

The flow table test for all foamed concrete mixes obtained in the present study was performed and the results are shown in Figs. 2, 3 and 4a, b respectively. As presented in Fig. 2, the flow of the WPSA foamed concrete mix with density of 1800 kg/m^3 exhibits a lesser spread value than that of the foamed concrete with a density of 1400 kg/m^3. This result can be explained that higher density of foamed concrete required higher amount of cement content, thereby resulting higher proportion of replacing WPSA in the mixes. It is obviously shown that the flow value decreases when WPSA was included in the foamed concrete mix. This is thought to be due to the increase in WPSA content from 5 to 30 % addition level. This finding is in line with research work by Mozaffari et al. (2006) who indicated that incorporation of WPSA into concrete mix experienced a relatively high water demand due to its porous nature. Similarly, the flow values reduced consistently with increasing of FRCA replacement that were represented in Fig. 3. The probable effect to the reduction in flowability is mainly attributed to the very high absorption

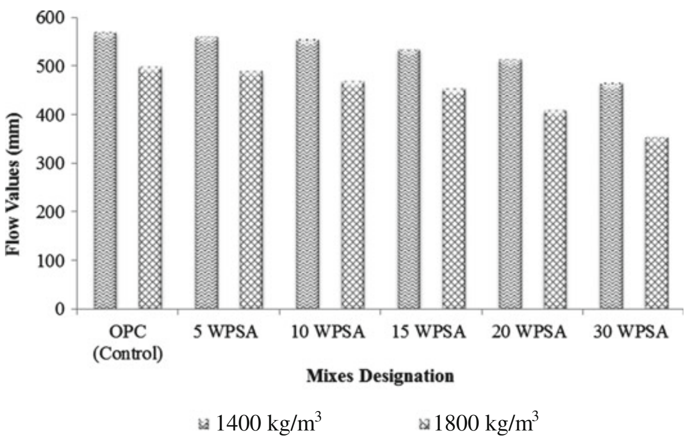


Fig. 2 The flow of spread (in mm) of WPSA foamed concrete for different density

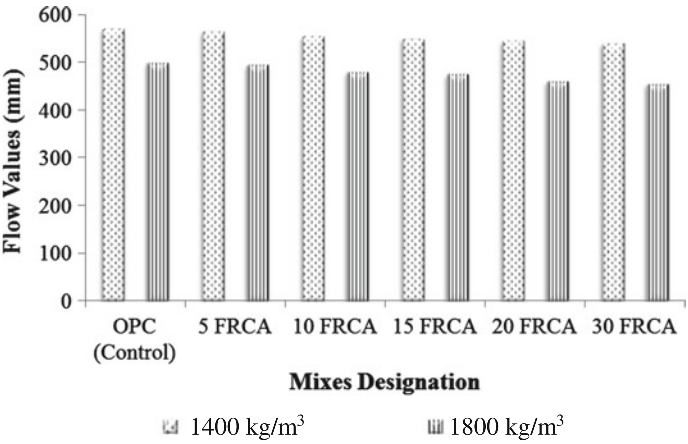


Fig. 3 The flow of spread (in mm) of FRCA foamed concrete for different density

capacity of FRCA and also its rough angular shape. As can be observed in Fig. 4a, b, the result portrays that the incorporation of WPSA and FRCA in concrete mixes provide flowability reduction as compared to plain foamed concrete. That result could be explained that the absorption of water by the WPSA and FRCA reduced the amount of water in the mixes. However, according to Neville (2002), a flow value of 400–650 mm was appropriate for all concrete mixes.

Influence of WPSA on Compressive Strength of Foamed Concrete

It is revealed that the compressive strength of the WPSA foamed concrete is observed to gain the strength lower than those of control specimens (OPC) in the range 2.36–18.60 N/mm^2, regardless of different densities of foamed concrete mixes. From Fig. 5a, it is shown that the strength of WPSA foamed concrete with 30 % level of replacement is found to be marginally lower than those of control specimens. It can be explained that WPSA used in this study has a significant amount of calcium content present in its composition that leads to its own hydration, thus resulting of increasing strength. Kinuthia et al. (2001) supported this explanation that WPSA contributes to the strength development by hydrating itself in the concrete mixes. However, the higher reduction in strength is noticed at 30 % WPSA replacement level for the 1800 kg/m^3 mixes as depicted in Fig. 5b. This result might be affected by the higher quantities of WPSA present in the concrete mixtures, as the lower cement content that disturbs the process of hydration within

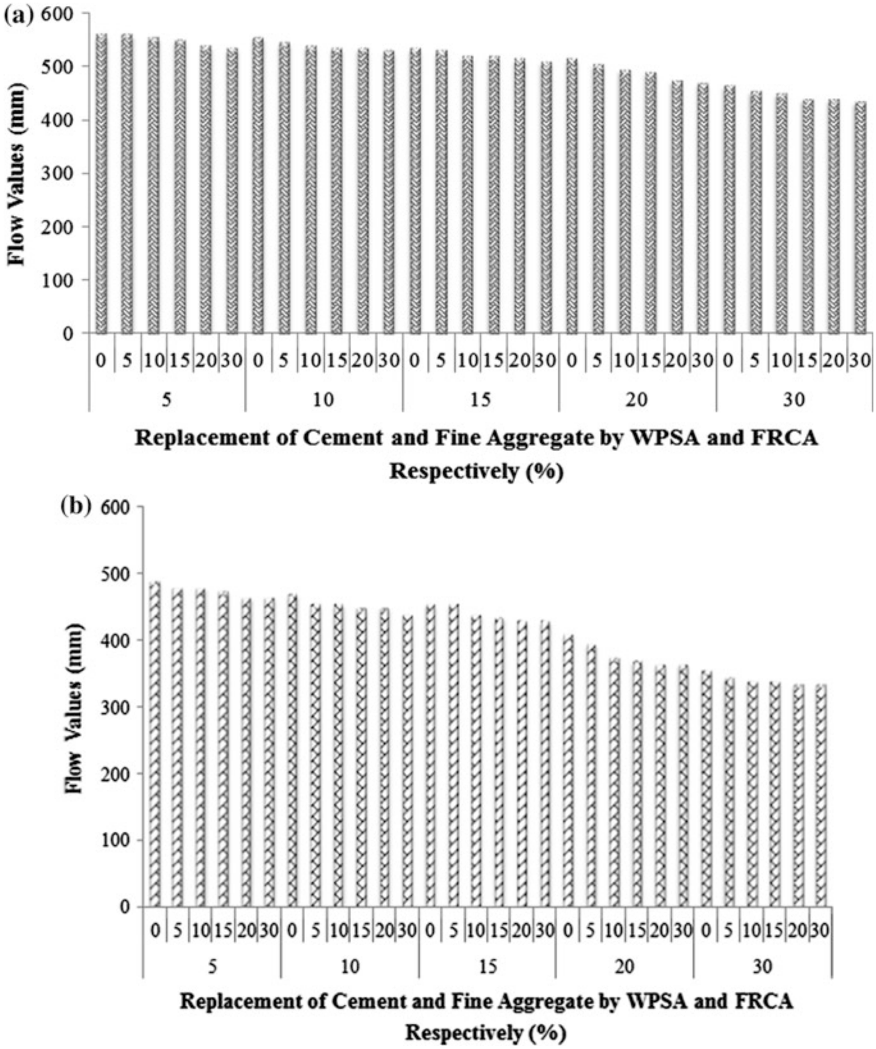


Fig. 4 The flow of spread (in mm) of combined WPSA and FRCA foamed concrete for different density **a** 1400 kg/m^3 and **b** 1800 kg/m^3

the foamed concrete matrix. Furthermore, WPSA derived from high carbon content which is indicated by loss of ignition (LOI) with 17.51 % compared to cement by the value of 1.33 %. Thus, the carbon content has absorbed water leading to reduction of water demand in the process of hydration which resulted in lower compressive strength.

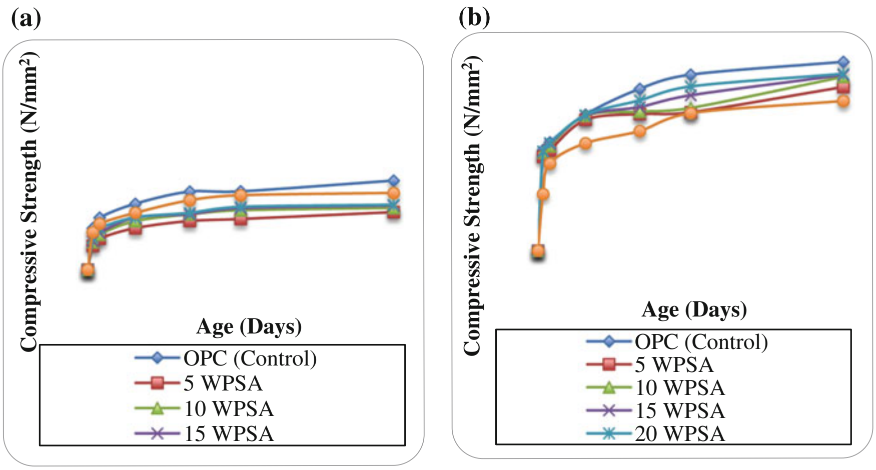


Fig. 5 The compressive strength of foamed concrete made of different WPSA content for densities **a** 1400 kg/m^3 and **b** 1800 kg/m^3

Influence of FRCA on Compressive Strength of Foamed Concrete

It can be observed that there is a substantial improvement in the strength properties of foamed concrete when sand was replaced by fine portion of recycled concrete aggregate. From Fig. 6a, it can be seen that the compressive strength for 1400 kg/m^3 foamed concrete varies from 4.13 to 11.25 N/mm^2. Interesting to note that, as the

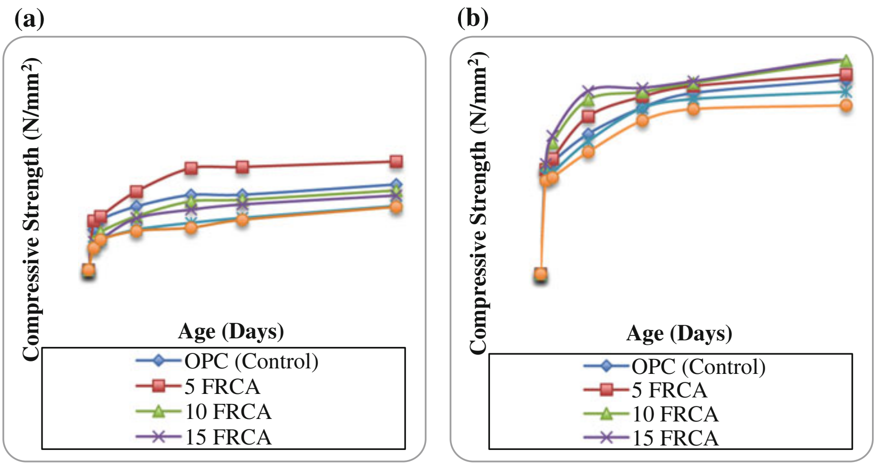


Fig. 6 The compressive strength of foamed concrete made of different FRCA content for densities **a** 1400 kg/m^3 and **b** 1800 kg/m^3

FRCA content was replaced at 5 % level, the compressive strength attained is higher than that of control specimens with the value of 5.05, 5.52, 8.12, 10.56, 10.69 and 11.25 N/mm^2 at 3, 7, 28, 60, 90 and 180 days, respectively. This result demonstrated that the inclusion of FRCA provided greater strength enhancement than mix without FRCA. However, the compressive strength decreased from 0.54 to 0.93 as compared to that of control when a higher replacement level namely 10–30 % was adopted. The trend depicted in Fig. 6b implies that foamed concrete is sensitive to the presence of FRCA with respect to curing time. It can be observed that the ratio of compressive strength at different replacement levels of FRCA marginally reduces as the density of the foamed concrete increases. According to Fig. 6b, the 1800 kg/m^3 foamed concrete exhibits the ratio of strength from 0.86 to 0.99 which is almost similar to control specimens as compared to the density of 1400 kg/m^3 concretes whose ratios are much lower with respect to similar series of FRCA employed. Based on the findings obtained, 15 % FRCA concrete mixes attained the highest compressive strength whose values are 11.21, 14.10, 18.70, 19.02, 19.71 and 22.12 N/mm^2 for 3, 7, 28, 60, 90 and 180 days, respectively. However, when further substitution level was over 20 %, the strength of 1800 kg/m^3 FRCA foamed concrete specimens tends to reduce marginally. It might be due to the presence of a large volume fraction of porosity governed by FRCA that affected water demand in producing the product of cement hydration. Besides, this situation is true according to another researcher that the replacement levels of FRCA were suggested to remain at or below 30 % of fine aggregates content (Obla et al. 2007).

Influence of Combined of WPSA and FRCA on Compressive Strength of Foamed Concrete

The result of the compressive strength of 1400 and 1800 kg/m^3 foamed concrete containing different levels of WPSA with 0, 5, 10, 15, 20 and 30 % incorporation of FRCA by 0, 5, 10, 15, 20 and 30 % to cement and sand content is presented in Figs. 7a–e and 8a–e, respectively. Obviously, it can be seen that the ratio in compressive strength to those of plain foamed concrete for WPSA and FRCA consistently decreases as replacement level of WPSA increases from 5 to 30 % with combination of FRCA. In this case, the strength of concrete mix composed of 30 % WPSA and 30 % FRCA is close and equivalent to those mixes without WPSA and FRCA addition for both densities. The graph depicts that the compressive strength seems to increase as the ratios of FRCA increased. These significant strength increases were due to the pozzolanic reactivity and presence of good interfacial bonding between paste and FRCA. This result was also confirmed by Berndt (2009) who claimed that the interfaces between old mortar and new paste remained intact to contribute to good interfacial bonding, thus resulting in higher strength. The mix incorporation of 10 % WPSA with the highest replacement level of 30 % FRCA as shown in Fig. 7b demonstrated the optimum compressive strength with the values

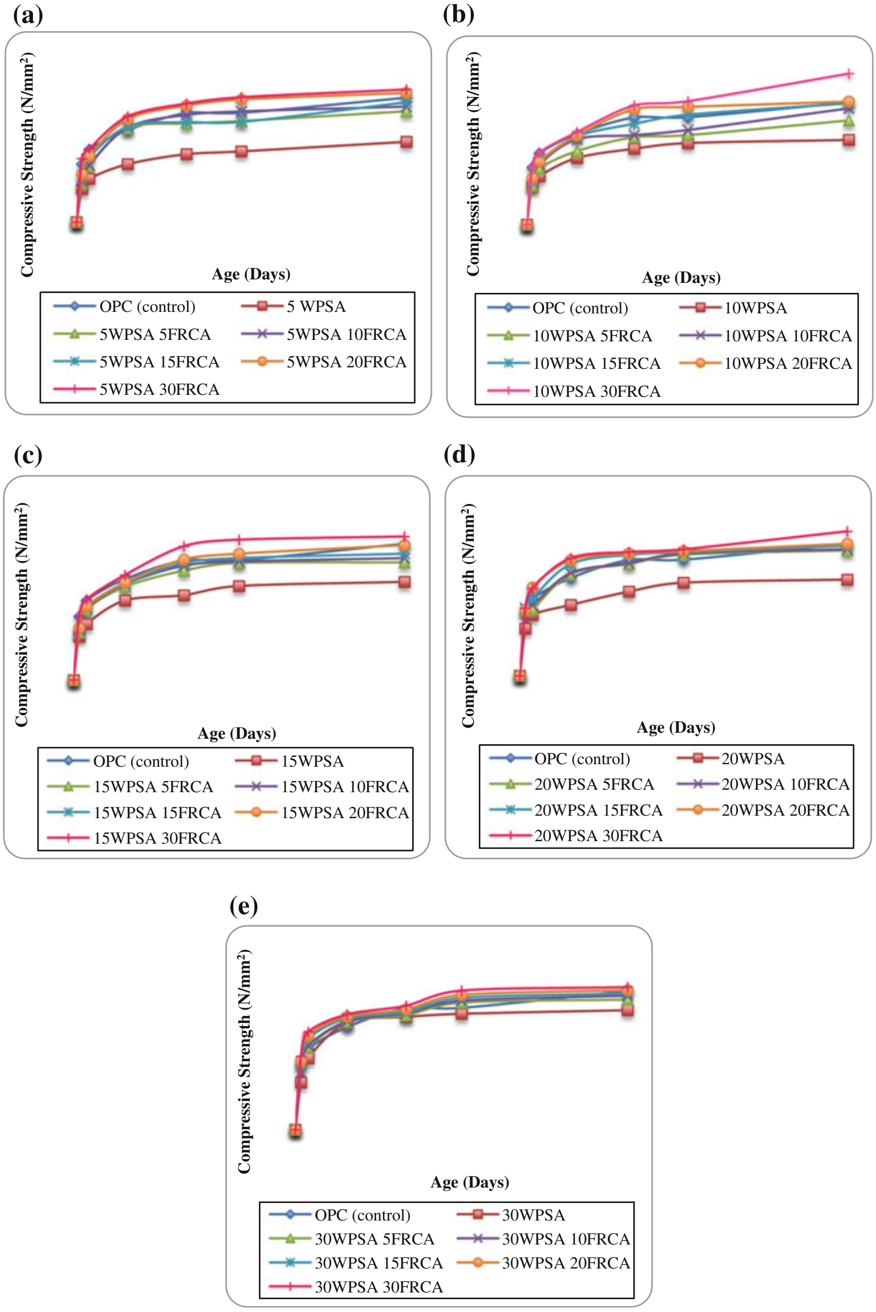
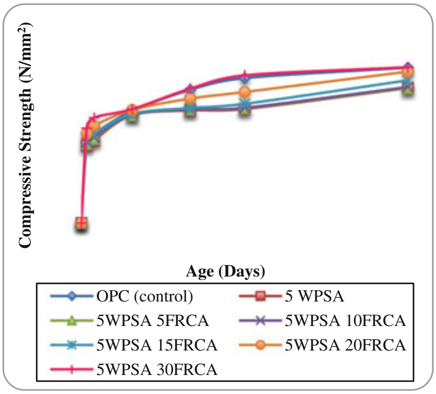
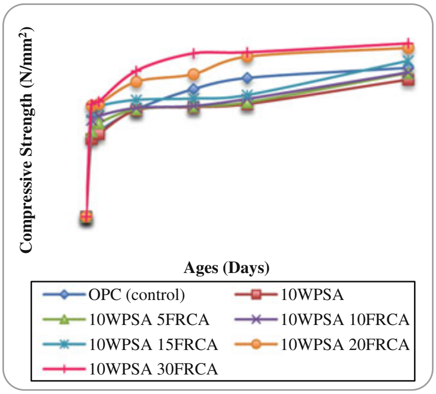


Fig. 7 a–e The compressive strength of 1400 kg/m^3 foamed concrete made of different WPSA and FRCA content

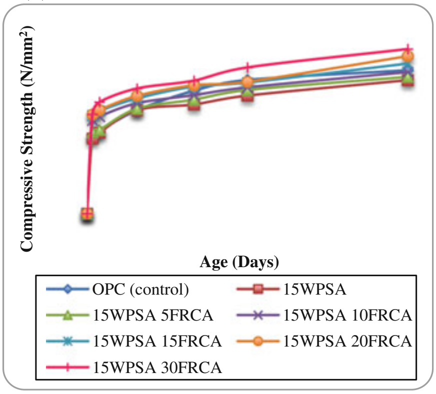
(a)



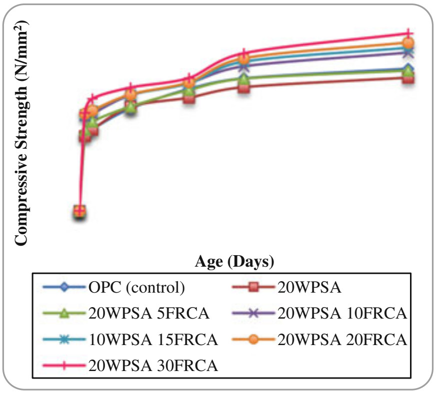
(b)



(c)



(d)



(e)

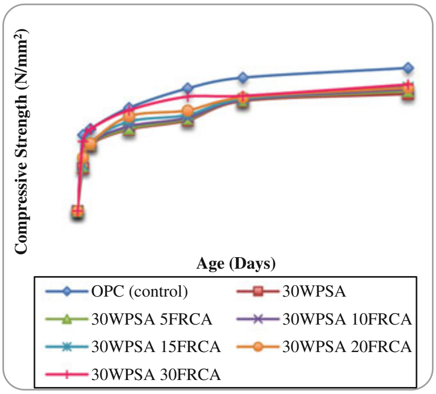


Fig. 8 a–e The compressive strength of 1800 kg/m^3 foamed concrete made of different WPSA and FRCA content from 4.22 to 10.95 N/mm^2. However, as shown in Fig. 8d, the highest compressive strength gained for the integration of 20 % replacement levels of WPSA and 30 % FRCA as compared with corresponding mixes.

4 Conclusion

Based on the results of this investigation, the following conclusions can be drawn:

1. The presence of proportions of WPSA from 5 to 30 % attained lower compressive strength as compared to that of control foamed concrete for density 1400 and 1800 kg/m^3.
2. The replacement of Portland cement by 30 and 20 % WPSA revealed a maximum compressive strength over the corresponding mixes for density of 1400 and 1800 kg/m^3 respectively.
3. The addition of FRCA does significantly increase the compressive strength at the optimum replacement level which was 5 and 15 % FRCA as compared to control for density 1400 and 1800 kg/m^3.
4. For both densities, blending WPSA and FRCA shows comparable and higher compressive strength over the plain foamed concrete.

Acknowledgements The authors would like to extend their gratitude to the technical staff at the Faculty of Civil Engineering, the Universiti Teknologi MARA for their support. The authors also thank Malaysian Newsprint Industries Sdn Bhd (MNI) for the supply of the **WPSA** samples. Financial support from the Research Management Institute (RMI), Universiti Teknologi MARA is greatly appreciated.

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Chapter 2
Investigation of Cutting Edge Radius Effect in Macro-machining and Micro-machining

Juri Saedon, Noor Aniza Norrdin, Mohd Azman Yahaya, Mohd Shahir Kasim and NorHafiez Mohamad Nor

Abstract Chip formation is a dynamic process that is often nonlinear in nature. A chip may not form when the depth of cut is less than a minimum chip thickness. This paper presents an investigation of cutting edge radius effect in macro- and micro-machining of AISI D2 steel via simulation using ABAQUS software. Through the arbitrary Lagrangian–Eulerian FE modeling approach, the chip growth, chip formation, and cutting force were investigated under three criteria such as $a/r < 1$, $a/r > 1$, and $a/r = 1$. The results from this simulation can provide useful information for choosing reasonable cutting edge to improve surface integrity and prolong cutting tool life in macro- and micro-milling operation. It is found that the chip is formed at $a/r > 1$ while material extrusion performed under $a/r < 1$. The investigation on the cutting force found that value of a/r ratios greatly affects the cutting force. The cutting mechanism in micro-milling is similar to macro-milling due to the process undergoes both ploughing and shearing mechanism.

Keywords Chip formation · FEA · Cutting edge radius · Minimum chip thickness

J. Saedon · N.A. Norrdin (✉) · M.A. Yahaya · N. Mohamad Nor
Faculty of Mechanical Engineering, Universiti Teknologi MARA,
Shah Alam, Selangor, Malaysia
e-mail: nr.aniza@yahoo.com

J. Saedon
e-mail: juri41@yahoo.com

M.A. Yahaya
e-mail: yahayama@yahoo.com

N. Mohamad Nor
e-mail: norhafiez@yahoo.com

M.S. Kasim
Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia,
Durian Tunggal, Malaysia
e-mail: shahir@utem.edu.my

N.A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014)*, DOI 10.1007/978-981-10-0534-3_2

1 Introduction

AISI D2 hardened tool steel is a high chromium, high carbon, tool and die steel with hardness in the range 54–62 HRC used for cold working operations. It has a high strength, very high resistance to cracking, and high resistance to softening and wear. Most recently, there are large amounts of work on hardened tool steel material toward the implementation of replication technology for mass production of miniaturization parts and components. But machining of hardened tool steel materials in manufacturing of moulds for replication technologies are mostly challenging. This is due to unpredictable tool life, premature of tool failure and differences in process mechanisms compared to macro-milling. Therefore, a good finite element model (FEM) simulation of machining AISI D2 would be very useful to optimize the machining process and led to reduce its costs, machining time saving, improved the quality and quantity.

In order to present the main differences in chip formation due to the scaling-down from macro- to micro-milling, a short review of the current state of the art in chip formation and minimum chip thickness in micro-milling is carried out. Then the FEM developed is presented and the results will be comparing to those found in the literature. The chip formation mechanism was studied quantitatively via FEM approach.

2 Comparison Between Micro-milling and Macro-milling

The effect of cutting edge radius was the significant contrast in cutting process between macro- and micro-machining methods. In macro-cutting, the cutting edge radius of carbides tools might be considered to be sharp as the uncut chip thickness is significantly larger than the cutting edge radius, see Fig. 1a. However, in micro-cutting, the uncut chip thickness is frequently smaller than the cutting edge

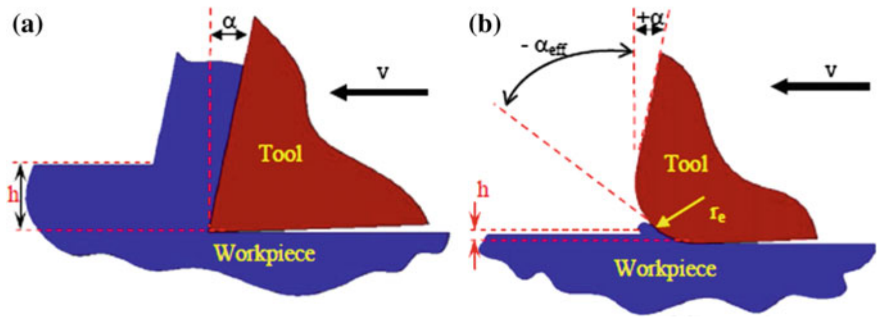

Fig. 1 Effect of cutting edge radius to chip thickness in macro-cutting (**a**) and micro-cutting (**b**) (Saedon et al. 2013)