Influence of local rice husks ash on compressive strength of normal-strength concrete

B A L Fanggi¹,* , M Moata², A Mata¹, F Liem¹, T Woenlele¹, S Ndun¹ and J Lada¹

¹ Civil Engineering Department, Politeknik Negeri Kupang, Kupang, Indonesia
² Dry Land Farming Management Department, Politeknik Pertanian Negeri Kupang, Kupang, Indonesia

*butje.loukfanggi@pnk.ac.id

Abstract. It is well known that rice husks ash can be used as cementitious material. However, different climate and geographical conditions could provide different quality of the ash. Therefore, this study aimed to investigate the effect of different percentage of rice husk ash (RHA) taken from Oesao village in Nusa Tenggara Timur-Indonesia on compressive strength of normal-strength concrete. Eight specimens with diameter of 150 mm and height of 300 mm made of normal-strength concrete with replacement of 0%, 5%, 10%, 15% of Portland cement with RHA were cast, prepared, and tested until failure. It is found that the maximum strength was observed on specimen with replacement of 10% of the ash.

1. Introduction

Portland cement is the main material for concrete. However, to produce 1 tons of the cement, it is released 1 tons of carbon dioxide to atmosphere due to the use of fossil fuel such as coal. Therefore, the ecology of the earth is significantly influenced by the concrete industry which employs cement [1].

To minimalize the use of cement, one effort has been done by many researchers which is by using rice husk ash (RHA) as cementitious material that can replace some percentage of cement in concrete [2]. This effort has taken lot of attention from the researchers around the world because RHA are made from rice husks where this material is an agricultural residue that pose an enormous disposal problem and environmental load.

Rice husks ash (RHA) has high content of Silica (SiO2) which is more than 85% [3-7]. Therefore, it has pozzolanic effect. Even though RHA itself doesn’t has any binding characterises like cement, but due to hydration of cement that produces Calcium hydroxide, the reactive silica in RHA reacts with the Calcium hydroxide that produces CHS gel which lead to get higher strength concrete than ordinary concrete [2].

Research on concrete with partial replacement of Portland cement in Indonesia with RHA has been performed by some researcher [8-12]. Suprasman and Ermiyati conducted testing on mortar made of RHA [8]. They found that mortar made of 15.0% of RHA experienced maximum compressive strength compared to other specimens made of other percentages of RHA. Abdian and Herbudiman reported the test on concrete made of 5%, 10%, 15% and 20% with 1% of Superplasticizer [9]. They reported that concrete made of 10% of RHA exhibits largest compressive strength. Rahardja et al. reported the study on high-strength concrete made of 0%-15% of RHA [10]. They observed that specimens made of 10% of RHA experienced higher compressive strength than other specimens with or without RHA. Solikin
and Susilo performed test on concrete made of 12.5% of RHA [11]. They reported that specimens with 12.5% of RHA experienced larger compressive strength than specimens without RHA. Nugraha et al. [12] reported an experimental study on compressive strength of concrete made of 5%, 10%, and 15% of RHA. They found that the less RHA used, the greater compressive strength was observed.

It can be seen from the previous description that the maximum compressive strength was observed on specimens made of different percentage of RHA. One of the reason behind the phenomenal can be addressed to the different climate and the geographical conditions where the RHA comes from as reported in Habeeb and Mahmud [13]. Therefore, it is needed to conduct researches that involve local RHA in concrete, for example from a village in Nusa Tenggara Timur, Indonesia where the village is known as the rice production village, to examine the performance of concrete with replacement of cement with some percentage of the local RHA from Oesao Village. However, such research is not available in publication until now.

2. Method

2.1. Test specimens and materials
A total of 8 specimens were prepared and tested under concentric compression. Each specimen had a diameter of 150 mm and a height of 300 mm. Two nominally identical specimens were tested for each unique specimen configuration. Details of the specimens are shown in Table 1.

| Specimen   | Percentage of rice husk ash (%) | Percentage of cement weight (%) |
|------------|---------------------------------|---------------------------------|
| RHA-0(1)   | 0.0                             | 100.0                           |
| RHA-0(2)   | 0.0                             | 100.0                           |
| RHA-5(1)   | 5.0                             | 95.0                            |
| RHA-5(2)   | 5.0                             | 95.0                            |
| RHA-10(1)  | 10.0                            | 90.0                            |
| RHA-10(2)  | 10.0                            | 90.0                            |
| RHA-15(1)  | 15.0                            | 85.0                            |
| RHA-15(2)  | 15.0                            | 85.0                            |

Rice husks were taken from a rice milling in Oesao village. It is about 35 kM from the city of Nusa Tenggara Timur, Kupang. The husks, then, were burned using a burner bucket that proposed by Allen [14]. The burner consisted of two buckets made of 24 stainless steel wire mesh. The inner bucket had diameter of 250 mm and height of 900 mm. The outer bucket had diameter of 600 mm and height of 900 mm. The inner bucket was located at the center of the outer bucket. The husks were put between the two buckets and burned using scratch paper which are put inside the inner bucket. The burner was kept in fire for 2 hours. The rice husks then can be burned by itself. The rice husks ash was collected and grounded after 24 hours of combustion. The burner can be seen in Figure 1.
A Los Angeles abrasion machine was used to grind the ash as reported in Zain et al. and Abalaka and Okoli [15,16]. Due to the lack of the rod bar that proposed in Zain et al. and Abalaka and Okoli [15,16], 20 Galvalume pipes were used instead. The diameter of the pipe was 19 mm and the length was 500 mm. The ash was grounded for 90 minutes, instead of 30 minutes as suggested in Zain et al. and Abalaka and Okoli [15,16]. The ash then was sieved and it was measured that 37% of the ash was through sieve no 45 micron which is higher than the requirement which is 12% [15, 16]. The grounded RHA is presented in Figure 2.

The specimens were prepared using a single mix with the target strength of 20 MPa at the 28 day of testing. The percentage of the RHA and the amount of the cement used in the specimens are presented in Table 1. The mix consisted of crushed stone as the coarse aggregate, with a nominal maximum size of 10 mm. Superplasticizier was added to the mix at 1% of the binder content by weight.

2.2. Testing procedures
The specimens were tested under axial compression using a 1,000-kN capacity servo-hydraulic universal testing machine. The loading was applied with load control at 3 kN per second until specimen failure. Prior to testing, all specimens were capped at both ends to ensure uniform distribution of the applied load to the specimens. An axial load-deformation curve was recorded and performed during the test using a computer monitor. The loads were used to calculate the compressive strength of the specimen.
while the recorded deformations were used in the calculation of the strains along the height of the specimens.

3. Results and discussion

3.1. Failure of specimens
Figure 3 shows the condition of the specimens at the end of test. It can be seen that all the specimens failed due to crushing of concrete. It was observed that the specimens made of RHA experiences excessive crushing compared to the one that made without RHA. It was also observed that all the failed specimens that made of RHA produced loud noise which is observed higher on the one that get highest compressive strength.

![Images of specimens]

Figure 3. Failure of specimens.

3.2. Compressive strength
The compressive strength of the specimens was calculated by dividing the axial load resisted by the concrete (P) with the cross sectional area of the concrete (A).

Table 2 shows the test results of all specimens. It can be seen that all the specimens made of RHA experience higher compressive strength than the one that made without RHA. The table shows that highest compressive strength was observed on specimens made of 10% of RHA. The finding can be attributed to the quality of the ash where it was observed that some of the ash was found in black colour which indicated that the ash was not proper burned.
Table 2. Compressive Strength of the specimens.

| Specimen   | Area, A (mm²) | Load, P (kN) | Compressive Strength, f<sub>c</sub> (MPa) | Ave. f<sub>c</sub> (Mpa) |
|------------|---------------|--------------|-----------------------------------------|--------------------------|
| RHA-0(1)   | 17662,5       | 348,94       | 19,76                                   | 21,47                    |
| RHA-0(2)   | 17662,5       | 409,34       | 23,18                                   |                          |
| RHA-5(1)   | 17662,5       | 570,94       | 32,32                                   | 32,75                    |
| RHA-5(2)   | 17662,5       | 585,89       | 33,17                                   |                          |
| RHA-10(1)  | 17662,5       | 620,77       | 35,15                                   | 35,15                    |
| RHA-10(2)* | 17662,5       | 455,43       | 25,79                                   |                          |
| RHA-15(1)  | 17662,5       | 504,08       | 28,54                                   | 30,88                    |
| RHA-15(2)  | 17662,5       | 586,59       | 33,21                                   |                          |

* Specimen was excluding due to problem in concrete manufacturing

4. Conclusions
This paper has presented the results from an ongoing experimental study on the compressive strength of normal-strength concrete made with partial replacement of cement with Rice Husks Ash. Eight specimens were manufactured and tested under compression to investigate the effect of different percentage of RHA on the compressive strength of normal-strength concrete. Based on the test results presented in this paper, the following conclusions can be drawn:

- All the specimens made with replacement of cement with RHA experienced larger compressive strength than the specimens made without RHA.
- The specimen made with replacement of cement with 10% of RHA exhibits larger compressive strength than those specimens made with other percentage of RHA or without RHA.

Acknowledgement
The authors would like to thank for financial support provided by Politeknik Negeri Kupang (DIPA Politeknik Negeri Kupang T.A. 2017 No. Kontrak 40c/ PL23.PPK.PNBP/PL/2017).

References
[1] Reddy D V 2008 Rice Husk Ash as a Sustainable Concrete Material for the Marine Environment Sixth LACCEI Int Latin American and Caribbean Conf for Eng and Tech June 4-6
[2] Babu T S R and Neeraja D 2016 Rice Husk Ash as Supplementary Material in Concrete—A Review Int J of Chem Tech Res 9 5 pp 332-337
[3] M Jamil, A B M A Kaish, S N Raman, and M F M Zain 2013 Pozzolanic contribution of rice husk ash in cementitious system Const. and Build. Mater. E 47 pp 588-593
[4] A I Gupta and A S Wayal 2015 Use of Rice Husk Ash in Concrete: A Review J of Mechan and Civil Eng 12 4 pp 29-31
[5] M N N Khan, M Jamil, A B M A Kaish, and M F M Zain 2014 An Overview on Manufacturing of Rice Husk Ash as Supplementary Cementitious Material Australian J of Basic and Applied Sci 8 19 pp 176-181
[6] A N Givi, S A Rashid, F N A Aziz, and M A M Salleh 2010 Contribution of Rice Husk Ash to the Properties of Mortar and Concrete: A Review J of American Sci 6 3 pp 157-165
[7] S N Raman, T Ngo, P Mendis, and H B Mahmud 2011 High-strength rice husk ash concrete incorporating quarry dust as a partial substitute for sand Const and Build Mater 25 7 pp 3123-3130
[8] E Suprasman 2006 Kuat tekan mortar dengan penambahan abu sekam padi sebagai pengganti
sebagian semen *Spektrum* 4 2 pp 197-205

[9] R M Abdian and B Herbudian 2010 *Pengaruh kehalusan dan kadar abu sekam padi pada kekuatan beton dengan kuat tekan 50 MPa* (Konf Nas Tek Sipil (KonTeks 4))

[10] S Raharja, S As’ad, and Sunarmasto 2013 *Pengaruh Penggunaan Abu Sekam Padi Sebagai Bahan Pengganti Semen terhadap Kuat Teken dan Modulus Elastisitas Beton Kinerja Tinggi* *Matriks Teknik Sipil* 1 4 pp 503-510

[11] M Solikin and Susilo 2016 *Pengaruh pemakaian abu sekam padi sebagai cementitous terhadap perkembangan kuat tekan beton* The 3rd University Res Coloquium pp 35-40

[12] Y Nugraha, F Saleh, and H. Prayuda 2017 *Studi Eksperimental Kuat Teken Beton Menggunakan Variasi Bahan Tambahan Abu Sekam Padi dan Zat Adiktif Bestmittel 0,5% Sinergi xx x* pp 1-8

[13] G A Habeeb and H Bin Mahmud 2010 *Study on Properties of Rice Husk Ash and Its Use as Cement Replacement Material Mater Res* 13 2 pp 185-190

[14] M Allen 2017 *The manufacture of a cement extender from rice-husks using a basket-burner*, (online), Available: http://www.journeytoforever.org/farm_library/RiceHusks.pdf, accessed date: September 10, 2017

[15] M F M Zain, M N Islam, F Mahmud, and M Jamil 2011 *Production of rice husk ash for use in concrete as a supplementary cementitious material* *Const. and Build. Mater* 25 pp 798-805

[16] A E Abalaka and O G Okoli 2013 *Strength Development and Durability properties of Concrete Containing Pre-Soaked Rice Husk ash* *Const Sci* pp 4-12