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Utilization of mine tailings (waste) for improving environmental quality: a case study of community artisanal mining at Sekotong District West Nusa Tenggara Province Indonesia

Kabul Algifari[1], Joni Safaat Adiansyah[2,]*
[1,2] Muhammadiyah University of Mataram, Mine Engineering Department, Jl. KH. Ahmad Dahlan No.1 Mataram, Indonesia.

* Corresponding author: joni.adiansyah@ummat.ac.id
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Abstract. Tailing is one of the wastes that generated by mining activity and recorded around 14 billion tons worldwide. Artisanal mining is also producing tailing from its processing activity ('Gelondong' and 'Tong') and creates potential environmental impact associated with tailing management. One of the strategies to reduce the impact is by applying the tailing utilization strategy. This paper is aimed to assess the possibility of using tailing that generated by community artisanal mining activity for construction purposes (paving block). In order to achieve the aim, the laboratory analysis and case study are applied. Six paving blocks that consist of normal paving block, and 15% tailing paving block were prepared and tested its compressive strength. In addition, the tailing that used was generated by community artisanal mining at Sekotong District of West Nusa Tenggara Province. The result showed that the increasing compressive strength of normal paving block from day 14 to day 28 (ultimate) was 26% higher compared to tailing paving block. However, based on the SNI standard that these two types of paving block are categorized as quality B of paving block and could be used as parking pavement construction. Therefore, the 15% tailing paving block met with the SNI standard.

Keywords: *artisanal mining, paving block, tailing, compressive strength, Sekotong.*

1. Introduction

Tailings are materials that have no economic value after going through the ore processing stages (Yilmaz and Fall, 2017). Generally, tailings will be disposed of or placed in one place called a Tailings Storage Facility (TSF). There are various tailings placement systems applied by the mining industry, including land placement systems (dams), deep sea placement systems, and river/reservoir placement systems (Song et al., 2017; Wels and Robertson, 2003). Adiansyah and Rahmawati (2019) highlighted that the amount of tailings produced worldwide is around 14 billion tons. The existence of tailings in the mining world cannot be avoided because most of the rock resulting from mining will be in the form of waste, namely waste rock and processing waste. Physically, the tailings composition consists of 15% fine sand fraction with a diameter of 0.075 – 0.4 mm, and the rest is a clay fraction with a diameter of 0.075 mm where the main composition of the tailings produced generally depends on the minerals being mined (Riogilang and Halimah, 2009). Furthermore, tailings from gold mining generally contain inert (inactive) minerals such as quartz, calcite and various types of aluminosilicates, and usually still contain gold. Tailings from gold mining contain one or more toxic hazardous materials such as Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg), and Cyanide (Cn). Some of the metals in the tailings are heavy metals which are included in the scientific category of hazardous and toxic materials (B3). In addition, minerals with high sulfur content in tailings are often a potential source for acid mine drainage.

Rapid population growth will certainly correlate with the need for infrastructure and facilities to support daily activities such as housing, offices, schools, markets and others. The construction industry needs the support of natural resources which have the potential to cause damage to forests, agricultural land, and of course the depletion of natural resources. One effort to overcome this problem is to increase the use of tailings as a building material. The development of building materials from tailings would not only support development needs but also solve environmental problems and can be categorized as ecological building materials. The studies of mine tailing utilization were found in some literatures such as sand (Riogilang and Halimah, 2009), building materials and ceramics (IMM, 2008), concrete (PTFI, 2006). However, none of the current studies found focuses their study on tailing that generated by community artisanal mining activity.

One of mining activities that generate tailing is community artisanal mining where all mining operations including mining, processing, and tailing are managed by community. Commonly, there are no advanced technologies applied and the main chemical usage for processing plant is mercury, and cyanide (Adiansyah, 2018; Rahmawati and Adiansyah, 2020). One of artisanal mining locations is found in Sekotong District of West Nusa Tenggara Province, Indonesia. Two types of processing technology are currently applied, namely Gelondong, and Tong. These processing plant would produce tailing that dumped into area (land) close to processing plant. The tailing disposal into land (with no engineered tailing dam) is potentially creating an environmental pollution. Reducing tailing volume could be one of strategies to prevent the massive environmental degradation.

Therefore, the aim of this study is to assess the possibility of using tailing that generated by community artisanal mining activity for construction purposes (paving block).

2. Method

This section would describe the stage of research, materials and tools used. The tailings that collected from community artisanal mining at Sekotong District, West Nusa Tenggara Province were naturally dried by using the ambient heat temperature. The dried tailing was then mixed with other materials, namely sand, water, and tailing to produce a final product (paving block) as presented in Fig.1. Two types of paving block would produce were normal paving block, and tailing paving block (15% tailing content).

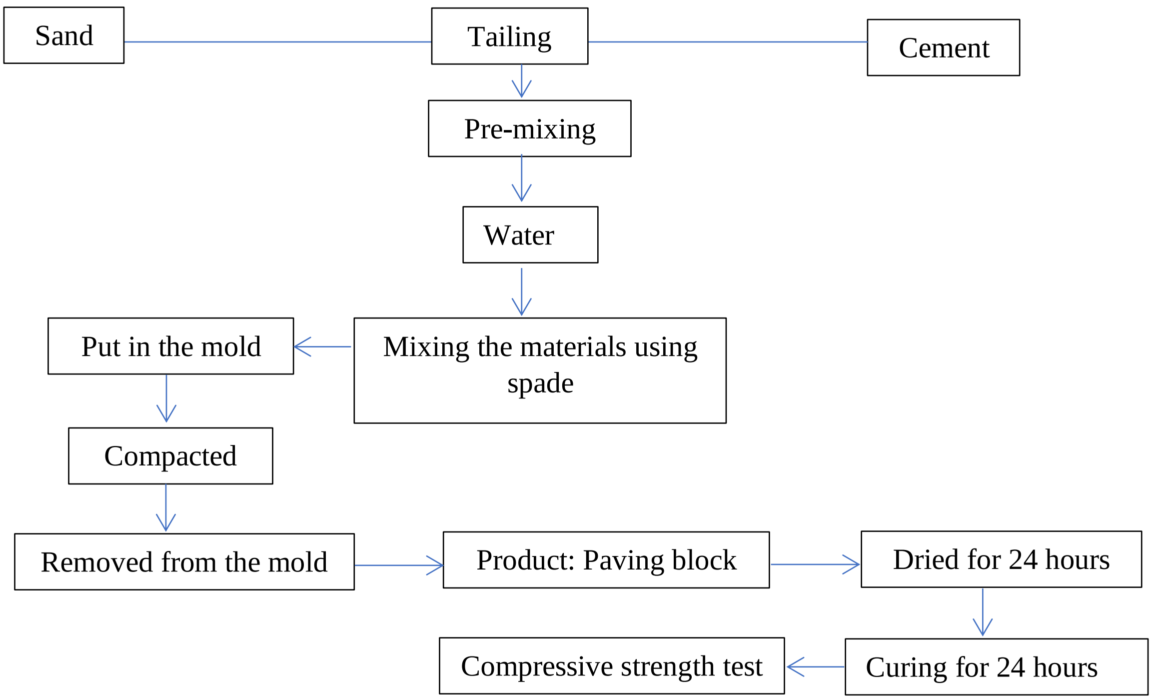

Fig. 1. Research Flow Diagram

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2.1.Materials and tools

In order to compare the compressive strength between normal paving block and tailing paving block, six paving blocks testing sample were prepared. The materials composition of paving block testing sample are presented in Table 1.

Table 1. Materials composition

Material	Normal paving block	Tailing (15%) paving block
Cement (Kg)	3.00	2.55
Sand (Kg)	6.00	6.00
Tailing (Kg)	-	0.45
Water (Lt)	1.30	0.75

Normal paving block consisted of two main materials which were sand, and cement where the tailing paving block would be added with 15% of dried tailing. Some tools that used for this experiment were molding, weighting, spade, and mixing bin as presented in Fig.2.

a) Molding

b) Weighting

c) Spade

d) Mixing bin

Fig. 2. Tools used

2.2.Laboratory testing

The compressive strength testing by using hydraulic compressive strength machine (Fig.3) was conducted at Construction and Material Testing Center of Public Work Office West Nusa Tenggara Province where total of six paving block samples were tested. Compressive strength is the ability of concrete to accept compressive forces per unit area. The compressive strength of concrete identifies the quality of a structure. The higher the desired structural strength, the higher the quality of the resulting concrete.

Fig.3. Hydraulic compressive strength machine

The compressive strength value of paving blocks is obtained from standard testing with the test object used in the form of a rectangle with a length of 20 cm, a width of 10 cm and a height of 6 cm as presented in Fig.4. The compressive strength of each specimen is determined by the highest compressive stress (f'c) achieved by the 28-day-old specimen due to the compressive load during the experiment (Syarifuddin, 2018).

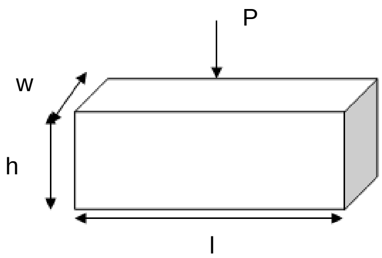

Fig.4. The sampling object

The formula used to get the value of the compressive strength of concrete based on experiments in the laboratory is as follows (Antono, 1995):

$$fc' = \frac{P}{A} \quad (1)$$

Where:

fc' = Compressive strength (MPa)

P = Compressive load (N)

A = Area of testing object (mm^2)

There are four standards of paving block based on its compressive strength that mentioned on SNI 03-0691-1996 (SNI, 1996) where the compressive strength would be as a main indicator to determine the purposes usage of particular paving block as presented in Table 2.

Table 2. Compressive strength standard based on SNI

Quality	Average Compressive Strength (MPa)	Purposes
A	40	Road pavement
B	20	Parking pavement
C	15	Pedestrian pavement
D	10	Garden or other purposes

Note: National Standard of Indonesia (SNI)

3. Results and Discussion

This chapter would discuss the compressive strength that resulted from laboratory test and compared the results with National Standard of Indonesia (SNI) associated with paving block standard.

3.1.Compressive strenght and comparison

The compressive strength of two paving block types increased gradually in line with the age of paving block where the ultimate strength for normal paving block and tailing paving block were 48.5 MPa and 28.1 MPa respectively (see Table 3). The normal paving block has ranged compressive strength from 33.9 MPa to 48.5 MPa and the tailing paving block compressive strength ranged from 18.9 MPa to 28.1 MPa. It can be concluded that the normal paving block has higher compressive strength compared to tailing paving block due to difference of cement percentage.

The increasing compressive strength of normal paving block from day 14 to day 28 (ultimate) was 26% higher compared to tailing paving block. However, based on the SNI standard that these two types of paving block are categorized as quality B of paving block and could be used as parking pavement construction.

Table 3. Compressive strength testing result

Code ID	Sample dimension (cm)	Total testing area (cm^2)	Days of testing (days)	Load (kN)	Tension (Kg/cm^2)
PN-7	20 x 10	200	7	666	339.66
PN-14	20 x 10	200	14	589	300.39
PN-28	20 x 10	200	28	666	485.23
PT-7	20 x 10	200	7	372	189.72
PT-14	20 x 10	200	14	485	247.35
PT-28	20 x 10	200	28	485	281.08

Note: PN = Paving Normal; PT = Paving Tailing

The compressive strength of tailing paving block meet with the SNI standard and widely possible to applied for supporting the construction project. In addition, the percentage of tailing could be also increased to reduce the cement content that would reduce the price of paving block.

4. Conclusion

Tailing is non-economical material that could be dumped into environment (refer to regulation standard applied) or utilized for mixture material. One of the activities that generated bulk volume of tailing is mining where community artisanal mining is one of mining activities with less attention given. Indonesia has so many artisanal mining location that spread out in some provinces including West Nusa Tenggara. The artisanal mining activity has also created environmental problem such as tailing management that currently simply dumped close to the ore processing activity.

The utilization of tailing is one of the solutions to reduce the potential environmental impact of tailing disposal from artisanal mining in Sekotong District of West Nusa Tenggara Province. The study shows that tailing is able to use as a mixture material to produce the paving block where tailing paving block meet with the SNI compressive strength standard class B.

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