The Possibility of Using Mixed Fly Ash and Cement as a Hindu Temple (*Pelinggih*)

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Abstract. The use of stone materials such as basalt stone and andesite stone is widely used in Hindu temples due to their benefits such as the composition and specific texture that can be sculpted. The need for stone materials is increasing along with the increased need for Hindu temples (Pelinggih) on the market. The major problem that is currently occurring is the availability of several types of stones is limited and the mining process of raw stone greatly affects the conditions of the surrounding environment. Thus based on this, it is necessary to study alternative environmental materials that can be used as Pelinggih. This research focused on studying the possibility of using mixed fly ash and cement in Hindu temples using qualitative methods. Fly ash by-product is usually made by mixing the material with cement and other materials. Fly ash is solid waste resulting from the combustion process in the furnace at power plants. Fly ash has cementitious and pozzolanic properties that react when mixed with cement and water. Fly ash by-product applications such as water treatment, ceramic industry, and fly ash for the improvement of degraded soil. Based on this study, it is possible to use mixed fly ash and cement to use as pelinggih.

Keywords: Hindu temple, material, mixed fly ash-cement.

1 Introduction

A Hindu temple or *Pelinggih* usually has ornaments with interesting shapes. Ornaments or decorative motifs are works of art that originate from forms in nature such as fire, water, clouds, rocks, plants, animals, humans, and other mythological creatures. Jana et al [1] explained various types of materials used in Hindu temples in Bali. The use of basalt stone in Bali can be traced from the construction o of *Padmasana Tiga* at *Penataran Agung Besakih* Temple which was built to replace the damaged *Padmasana* as a result of the eruption of Mount Agung in 1963. *Besakih* Temple which was the largest temple for Hindus now uses basalt stone as a finishing that has a hard texture and black color. From that moment, the use of basalt stone has spread widely in Balinese society, and the market demand for basalt stone is still growing. During the Dutch Colonial period, a castle was built in Karangasem with a European architectural style called Taman Ujung. At that time, molded concrete was used when making the reliefs or the ornaments using mixed cement and sand. The use of mixed sand-cement materials precast is still a favorite because the price is affordable compared to basalt stone. Fig 1 shows various types of materials used as *Pelinggih* in Bali.

Alam [2] explained that andesite stone is usually used as a temple material. because it has a composition and specific texture that can be sculpted. These rocks are usually found in

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tectonic subduction environments in areas with high volcanic activity, such as Majalengka, Cirebon, and Tulung Agung. There are generally two types of andesite stone motifs, namely plain and speckled. Plain andesite stone is formed due to sedimentation, and has a very high level of hardness (density) and low porosity, so the texture is very smooth. In general, this type of stone is dark or black. Due to its hard nature and small porosity, andesite stone does not get dirty easily. Several temples located in the Dieng area and around Magelang, such as Borobudur and Prambanan temples, use andesite stone materials. Another material that is often used to build temples is brick, which is made from molded clay, and then burned. This stone can absorb heat well. Red brick has been very commonly used as a building material in Indonesia, from ancient times to the present. The land used for making bricks is not just any land. The soil must be slightly clayey so that it can stick together during the printing process.

Fig. 1. Hindu Temple in Bali with Various Types of Materials.

The need for stone materials is increasing along with the increased need for *Pelinggih* on the market. The major problem that is currently occurring is the availability of several types of stones is very minimal and the mining process of raw stone greatly affects the conditions of the surrounding environment. Thus based on this, it is necessary to study alternative environmental materials that can be used in Hindu temples (*Pelinggih*).

2 Method

This research uses qualitative methods. Data were collected through literature studies, where the main sources of information were books, reports, and scientific articles about the possibility of using mixed fly ash and cement in Hindu temples.

3 Result and Discussion

3.1 Basalt Stone and Andesite Stone

Purwanto [3] explained that basalt stone tends to have a darker color than andesite which tends to be lighter. Besides that, the texture of basalt stone tends to be smoother and denser while andesite has a rougher and stiffer texture. Basalt stone has the main mineral compositions of pyroxene, olivine, and plagioclase while andesite rock has plagioclase, amphibole, and biotite. The texture of basalt stone can be smooth to rough with a black and

gray color, while the texture of andesite stone can also be smooth to rough with a greenish-gray color.

3.2 Red Brick

Somantri [4] describes red brick as a type of building material made from molded clay and then burned at high temperatures so that it becomes hard and reddish. The advantages of red brick material are that it is a building material that is easy to obtain, affordable, and heat resistant. The disadvantages of red brick material are that it absorbs water, triggers the growth of fungus, and has less compressive strength than natural stone

3.3 Fly Ash

Fly ash is solid waste resulting from the combustion process in the furnace at power plants (Fig 2) which is then carried out by the combustion residue and captured using an electrostatic precipitator. Alterary and Marei [5] explained that the by-product of combustion includes bottom and fly ash, boiler slag, and flue gas (Fig 1). Aziz et al [6] explained the characteristics of fly ash such as a) particle size that passes sieve No 200 (0.074 mm) ranges from 60 – 90%; b) The color of fly ash can vary from gray to black depending on the amount of carbon content, the lighter the lower; (Fig 3) c) The main components of fly ash are silicon (Si), aluminum (Al), iron (Fe) and calcium (Ca) with variations in carbon content. According to ASTM C618 [7] fly ash is divided into two classes, namely class F fly ash and class C. The main difference between the two ashes is based on the amount of calcium, silica, aluminum, and iron content in the ash. Although class F and class C are strictly marked for use in fly ash that meets ASTM C618 specifications, these terms are more commonly used based on the origin of coal production or CaO content.

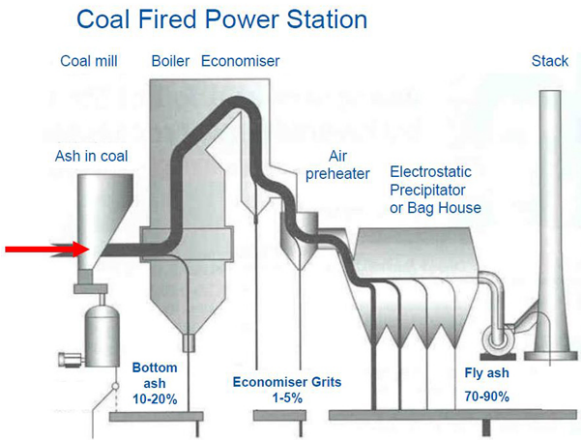

Fig. 2. Coal Combustion Process [8]

Fig. 3. Fly Ash Material [8]

3.4 Fly ash Product

Evendi et al [9] studied that the addition of fly ash can increase the compressive strength of the brick. According to this study, the increase in compressive strength is because of the reaction between the silica content in fly ash and free lime in the cement hydration process. Besides that, the much smaller coal fly ash granules make the brick denser because the voids between the aggregate granules are filled with coal fly ash so that it can minimize the existing pores and utilize the pozzolanic properties of fly ash to improve the quality of the stone. Haryati [10] studied that fly ash class F can be used as a replacement of aggregate for making lightweight bricks during its pozzolanic properties. Alterary and Marei [5] explained that fly ash can be used in the concrete industry using fly ash-based geopolymer as a new alternative in the field of construction. Other applications of fly ash such as water treatment, ceramic industry, and fly ash for the improvement of degraded soil. Fig 4 shows the product made from fly ash. Fly ash by-product is usually made by mixing the material with cement and other materials. Chindaprasirt [11] resulted in a compressive strength of 30.6 MPa in the composition of fly ash (40%), portland cement (60%), and a constant water-to-binder ratio of 0.35.

Fig. 4. The Product from Fly Ash

4 Conclusion

The literature studies found that fly ash can be used in Hindu temples (pelinggih) by mixing with cement and other materials. Fly ash is solid waste resulting from the combustion process in the furnace at power plants. Fly ash has cementitious and pozzolanic properties that react when mixed with cement and water. Based on this study, it is possible to use mixed fly ash and cement to use as pelinggih. The proportion of the fly ash in the mixture can affect its properties. Fly ash can be classified as class C and class F. Each type of fly ash has different properties.

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