Utilization of Biomass Flyash in Cementitious Application

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Abstract. The use of biomass fly ash in concrete and composite materials is designed to ensure optimum use of fly ash and the development of the economic process. This report justifies the purpose of this project and why it is important for the environment and human health to use fly ash. The report also suggests how to use fly ash best and how to archive it.

1. Introduction
The increased environmental and resource protection activity led to a change in fuel use as a tool for thermal energy generation and the use of renewable environmental resources. The use of biomass fuel in particular to generate electricity [1-2]. The company PNG Biomass is now leading the way in using biomass to generate environmental energy. The Eucalyptus Pellita tree, usually found in the tropics, is the source of fuel. The tree can be grown before it is cut using the Pellita eucalyptus, and two boilers running turbines up to 30MW output are running. The trees are also regenerated, and trees are restored, which is the amount of carbon dioxide released into the air during photosynthesis.

However, the production of ash is one of the reverse repercussions of wood biomass use [2-3]. Ash is made to meet the requirements of standards that guarantee the safety and protection of people in the environment. It is not only a thermal by-product that threatens both climate and the environment. PNG Biomass is a subsidiary for the search of fuel. After the project started in 2013 in mid-2016, Oil Search Limited has taken over the project. The project aims to supply power to the Ramu grid for distribution to two 15kW Steam Turbines. In a Power Purchase Agreement with PNG Power Ltd, the company provides power to PNG Power in the case of an electricity shortage in its lines (PNG Power). The project is aligned to the 2050 vision of the PNG Government to have 80% or more of the total population of electricity supply.

The two Steam Turbines are fuel sources from chip wood of Eucalyptus Pellita, a tropical tree species. These trees are produced in a plantation near the plant site [4, 5], sustainable and locally. Because of its rainfall and its proximity to existing infrastructure, the Markham Valley is highly suitable for biomass production. Lee sealing roads are available, PPL has 132kV transmission lines to a nearby switching station via the plant and biomass power plant, 22kV construction power lines, and a new Lae port extension for material imports. It is mainly flat with underused Kunai grasslands with appropriate weather, rainfall, soil, the nearby Markham River water supply and low population density.

These conditions allow a secure supply of fiber (wood biomass fuel) supplies to large-scale plantations near the power plant, especially planted and sustainably managed. Only through planting degraded and under-utilized Kunai and exotic grasslands and the exotic, invasive woodland species, the project ensures that it does not contribute to deforestation with PNG or any negative food supply effect.
(like plant tree, gliricidia, and Leucaena). The plantations convert grasslands for the production and production of food to a multi-functional farming system.

Ash is a combustion product that is classified as an ash base, larger ash particles trapped by combustion in the flue gas fall onto the bottom of the burner. As mentioned in this context, fly ashes are produced in fine powder by pulverizing wood chips. The spherical shapes of these particles range from 0.5 mm to 300 micrometers [6-7] and are more refined than cement particles.

Increased use of biofuels in thermal power stations has also increased new ash production. The impact on air, water, and soils [7,8] lead to environmental concerns. The main problem is the release into and around the water of components in fly-ash, which may be harmful to the soil and jeopardize life. Other key components observed as dumping leaching in fly-ash sites were elements such as sodium (Na), calcium (Ca), manganese (Mn), silicon (Si). Consequently, if improperly managed, Ash poses a health and environmental threat. Metals can drain into the surface or underwater, destroy water life and pollute potable water. Plants can absorb metals that can become poisonous to domestic or wildlife. Plants can concentrate. Ash salts may contaminate land and inhibit soil cultivation. Ash can contaminate agricultural soils. When heavy metals are heavy ashes, they can influence environmental health (metals, dioxins can be harvested in worms' birds consume) [7,8] (Ash may be holding hands and food crops). This is also possible when the Ash is heavy metals and dioxins.

As a result of its environmental and human health effects, as already stated. Fly Ash's appropriate disposal and use are no new concern. Research into this subject has therefore already suggested innovative uses. Some include soil modifying, applying to specific products, and valuable applications.

1.1 Soil Amendment
Wood ash can be implemented by increasing the pH of soil on certain land (liming), but this depends on the constituents of ash waste [8,9] for improving crop production. Further assessed conditions include planned soil pH change resulting from ash liming; the capacity of waste chemical compounds to leach into groundwater; interactions with the surface waters from riverbeds; Practices of ash storage and bio toxic impact on specific habitats.

1.2 Concrete Product
Fly ash has many advantages as an ingredient in concrete. Fly ash can chemically assist in binding concrete. Fly ash can enhance the physical flow of wet concrete through the application of concrete. The use of non-renewable products also decreases fly ash (i.e., limestone and sand). It also contributes to CO2 emissions reduction [9,10]. This is important. Other beneficial use of road building, such as slag, could be feasible [9,10].

1.3 Products of Fly Ash Concrete
Flashes are essential to minimize human health and environmental impact in producing concrete products, including reducing emissions and flashing. Flashes are important. The best use of fly ash is probably still possible. But the use of biomass ash is unusual. Different factors, including the fuel, the oven temperature, pressure, and handling conditions, are present for the different fly cylinders. Biomass ash is essential for comparison in concrete products. Previous studies showed that the main components of biomass are identical to that of carbon fly ash. (The fly ash concrete products are the most common). Includes SiO2, Al2O3, Fe2O3, and MgO [10,11], with the principal components. Furthermore, biomass ash in concrete products of blended cement was found to reduce CO2 emissions and improve strength, workability, and durability.

1.4 Biomass of Fly Ash
Fly Ash could pose several risks to the environment if not properly handled and disposed of; its implications include; environmental leaching of heavy metals, health problems when the air contains suspended ash particles. Various applications for woody fly ash biomass can be found by utilizing the fly ash in partial applications, composite products, rubber and plastic fillers, and rare earth mining in the
field of cement and mortar substitutions. However, the best application of fly ash depends on its chemical and physical properties [10, 11] and its economic side.

1.5 Application of Cement
It is suggested that ash is used for the best application of mass biomass wood (Eucalyptus Pellita) based on the economy of the production and performance of fly ash for various applications. Fly ash is based on fly ash, reducing current waste from combustion and providing waste management technology to control potential contamination from fly ash. The application is also a technique for waste management. Other advantages in addition to the direct benefit of fly ash for cement applications are the decreased emissions of cement. However, it is not the idea to remove the ordinary Portland cement entirely but rather replace fly ash with some of the ordinary Portland cement. Consider whether the fly ash is cemented.

1.6 Ordinary Cement of the Portland
Types of cement are binders and are materials used for the building which bind, reinforce, and bind to other materials. The tradition of producing types of cement is by calcinating a calcination process known as calcination by releasing a carbon dioxide molecule from calcium carbonate to form calcium oxide, or quicklime, by small amounts of other matter (such as terrestrial). The processes of calcination generate types of cement. It is then mixed with the other materials included in the mixture. It is then moved into a powder with the resulting hard substance called "clinker" to produce the most common type of cement ‘Ordinary Portland Cement (often referred to as OPC).

2. Response Surface Methodology
The pH was defined by ASTM 1512-05. Boiling water of 4 grams was added for 50 ml and boiled for about 3 minutes, while the pH meter was measured.

2.1 Content of Humidity
The humidity content of ASTM Method 2216-10 was determined. We weighed two grams of sample, put it in the muffler furnace for 1 hour at 650°C, and then reformed it in the dryer. Weigh and record the weight of the tube after cooling down to room temperature. The sample was then transferred to the crisp and placed in a standard oven for 24 hours at 105 ± 5°C. The sample was taken 24 hours later and set to cool in the desiccator. Weighing the sample with the sink and calculating the humidity content as an equation:

\[ m = \frac{W_{raw} - W_{dry}}{W_{raw}} \times 100\% \]

Where,
- \( m \) = moisture
- \( W_{raw} \) = Raw FA mass, g
- \( W_{dry} \) = Dry FA weight, g

| Sample ID | pH Value | Moisture content (%) | Bulk density (g/cm³) |
|-----------|----------|----------------------|----------------------|
| 1         | 1.48     | 4.06                 | 0.3                  |
| 2         | 1.46     | 0.99                 | 0.2                  |
| 3         | 1.49     | 1.57                 | 0.3                  |

2.2 Flyash Content
The application of fly ash uses fly ash, which reduces the actual amount of waste produced by combustion and provides waste management technology for controlling possible contamination from fly ash. The application is also a technique for waste management. Other advantages in addition to the direct benefit of fly ash for cement applications are the decreased emissions of cement.
Where

\[ Total\ Ash,\% = \frac{D - B}{C - B} \times 100\% \]

Table 2. Total test results for fly ash.

| Sample ID | Weight of the Crucible (B) | Weight Total Prior to Heating (C) | Total weight following heating (D) | Residue % | Average % | Loss % | Total % |
|-----------|-----------------------------|----------------------------------|----------------------------------|-----------|-----------|-------|--------|
| 1         | 13.2730                     | 14.2273                          | 13.4401                          | 17.51     | 17.61     | 82.49 | 100    |
| 2         | 07.0239                     | 08.1010                          | 07.2146                          | 17.70     | 82.30     | 100   |
| 3         | 12.8329                     | 13.8668                          | 12.8626                          | 02.87     | 97.13     | 100   |
| 4         | 13.2759                     | 14.2169                          | 13.3015                          | 02.72     | 97.28     | 100   |
| 5         | 12.7904                     | 13.7940                          | 12.9372                          | 14.63     | 85.37     | 100   |
| 6         | 12.8397                     | 13.8377                          | 12.9843                          | 14.49     | 85.51     | 100   |

Figure 1. (a, b) preheating, (c, d) heating fly ash. The materials required for the testing are included in the fly ash sample and regular cement from the Portland, sand, and gravel. Besides, deionized mixing water and concrete product treatment water [11].

3. Results and Discussions

3.1 Coal Fired Fly Ash
Powdered burning coal is a powerful by-product of fired coal power plants. This is the unbranded residue that happens when the coal is finely ground at or above 75 percent and then removed from the hot area. Fly-ash is composed of 10-40% non-fuel impurities (for example, clay, shale, quartz, feldspar, dolomite, Silestone), depending on the source and grade, [11,12]. Fly Ash is non-fuel flue gas impurities after the complete combustion of high furnace temperatures of volatile and carbon flows. Over and under the
oven is collected fly ash. As ash of fly, mechanical and electro-static connectors are used to manage the mentioned flue gas stream, while the denser, unbranded material flows to the base of the stove and is mainly called ash of fly.

At present, it is estimated that worldwide fly ash production amounts to 600 million tons [11,12]. Ashes as fresh concrete characteristics, such as quality, size, shape, strength, and color, depend primarily on collecting new concrete and temperature of carbon burning [11-13]. The fitness of fly ash for concrete use depends on the fly fineness.

The results tabulate the warpage value for each run with the specified variable parameters condition obtained from the DOE. The selected variable parameters condition was set and simulated in the AMI 2013 software.

3.2 Fired Fly Ash Eucalyptus Pellita

In testing the use of Eucalyptus Pellita, the wood chips are first taken, and fly ash collected because PNG Biomass has not been produced yet. The fly ash collection is included. The fly ash collection consists of the wood chips being burned in small quantities into a furnace, and the ash collected utilizing the oven furnace combined with the filtration equipment. The filtration device disconnects Flyash particles from the burning process smoke.

We have designed and assembled a filter system to filter the smoke's fly ash following measures taken to collect biomass from the fly ash. The filtering device consisted, as illustrated below, of an internal sisaling paper cut off from the smoke of the container on the base of the plastic water bottle. Flywire covered the open end of the container. At the end of the process, two tasks were performed by a fan: to absorb heat and suck heat from or from hot smoke from the chimney through or from the container and to cool the fan.

However, fly ash was not collected as flyash particles did not seem to stick to the flywire used as the filtration cloth. Moreover, just as oil seemed, what was found in the filtration device. Further progress was not, therefore, possible in testing the cementing characteristics of the fly ash. The cementing properties of the hydrate heat measurement, workability tests, a compressive strength test, density, water absorption analyses, and abrasion tests should then be tested if the ashes are to be supplied later date.

3.3 Strength of Flyash

Since the best ratio for fly ash substitution is essential to identify in the mixture, three different test sets of varying fly ash percentages are suggested. The substitution of cement by 40 percent and the third sample with a proportion to be replaced according to the first two samples begins with a 20% cement replacement with fly ash. The objective is to establish a balance to be returned in which the cement properties of the concrete product are optimally balanced.

As an alternative to standard Portland cement, the principal elements of the Euquyptus Pellita fly ash can be compared. Other studies may also show the improved characteristics of biomass ash replacement of ordinary Portland cement [14], as shows in figure 2. Figure 2a) depicts a fly-ash concrete compressive strength, which is higher than fly-ah without a concrete product and reduces the fly-ash concrete more than fly-ash cement permissible figure 2(b)

![Figure 2a](image1.png)  ![Figure 2b](image2.png)

Figure 2. (a) Typical strength gains of fly ash concrete, (b) Permeability of fly ash concrete [14].
3.4 Fly Ash Characteristics
As illustrated in figure 3, Fly Ash has been analyzed for Elemental Dispersive Spectroscopy (EDS) and Electrical Microscope (SEM) scan. The EDS elemental mapping shows that V, Mg, S and Ca, Si and K levels are higher for both samples. In both examples, SEM refers to porous structures.

![Figure 3](image)

**Figure 3.** Sample 1 and sample 2 EDS-SEM analysis (a) and (b) respectively.

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3.5 Feasibility
The application's practicality is determined primarily by its cementing capacity. Its usefulness varies, which means that it is not suitable for buildings if its early strength is low. The feasibility study was carried out by comparing Eucalyptus Pellita with other woody fly ash biomass compositions. Pellita Eucalypt is flying ash. If there are similarities in the composition and design of fly ashes, they share the same Cementing capacity.

3.6 Plant Design for Production
For this application, the design of a suitable cement production plant must be designed to cover the application of fly ash in cementitious applications. A conventional cement factory consists of the following components: cement and flies ash transfer plant, a cement silo storage area, water tanks, a mixing plant, and an operator's room; and a cold bottle, as illustrated in figure 4. The following design proposes a system option that satisfies the current paper requirement—a developed method done for this application. The system consists of six separate sections in the cement plant.

The unit that receives new stocks of standard Portland concrete and flyash mixed into the mixer is the unit that supplies cement. The new cement and flyash are supplied to the silo of cement and flyash. This silo serves to store the OPC from the suppliers and, if necessary, to put it into the blender. The current boreal water tanks installed for the power plant are these boreal water tanks. For the mixing process, water comes from these bore tanks. The mixer is the area in which every compound is mixed; all ingredients in the concrete mixture are mixed. The cold bin has been used to collect all the parts.
3.7 Concrete Industry's sustainable development

The cement industry is well known to play a significant role in developing countries economic growth. But it also contributes significantly to greenhouse gas [10–13]. The CO₂ levels are currently growing at an alarming level, and immediate steps must be taken to reduce the increase in the temperature, which can prove destructive to the environment and the planet. China yields approximately 60% of world cement production. In 2014 China's cement industry generated 2,48 billion tonnes, equivalent to 1,77 tonnes/capita and 137,4 gr of GDP per USD [8-13], due to high pressures in urbanization and industrialization and economic stimulation. For cement industries to develop sustainably, waste materials are needed to produce this type of construction material. Cement substitution is functional with fly ash because only 25 percent of cement substitution with fly ash significantly increases strength. Instead of being disposed of, it can be incorporated into concrete in the coal, and the thermal sector that faces high costs for disposal of fly ash can reduce waste cost. We can manufacture sustainable building concrete [9-15].

4. Conclusions

This study helps enhance the quality of most production industries. The use of carbon fly ash for cement production is widely used and has proved successful. The results also show that the composition of the ash and the pellita fly ash of the eucalyptus indicates that they share similar properties and can be used interchangeably as cement additives. We could not carry out our laboratory tests to measure concrete
compared strengths to the fly ash additive because we were unable to obtain eucalyptus pellita ash from our laboratory burning in the agricultural department. In stating this fact, the fly ash from the Eucalyptus pellita cannot be determined entirely and determined as an additive in a cement application. Fly ash should be available to be tested as a recommendation. As the fly ash is made up of part by part of the tree used as fuel, tests must be performed as a substitute for fly ash.

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