Vertical Expansion of Hazardous Waste Landfill, by Utilizing Bottom Ash from Coal Fired Power Plant as 24m High Retaining Wall Geogrid Construction Material

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ABSTRACT

Obtaining land for landfill construction works always been a major challenge for the authorities to provide. It will be much tedious to obtain land to dispose hazardous waste. In Malaysia stringent regulation required to be complied especially EIA approval. Location required to be far from residential settlement, water catchment site, etc. In this project, the hazardous waste landfill site has reached the design life span. Due to logistic problem of transferring the entire hazardous waste processing facility to new site, the current land-space were revisited and reviewed carefully for the possibility of landfill vertical expansion. Planing for re-engineering works required to consider the up coming future waste such as clinical waste, increase in new intake of hazardous waste and also intake of bottom ash (residue from coal fired power plant). These new type of waste also required to be landfill into different cells for monitoring of leachate generation as required by Department of Environment. Furthermore for the economical scale of performing the vertical landfill expansion construction works, the new air spaced created required to have life span of not less than 25 to 29 years. Therefore in order to create the air space required high retaining walls were required to be constructed at perimeter of the existing landfill site. Due to the huge quantity of bottom ash to be received for land filling works, suitable use of the bottom ash were planed to avoid taking up the air spaced created for much higher economical value waste (hazardous and clinical waste). Hence the bottom ash were proposed to be used to constructed 24m high retaining wall for the length of about 1200m, with suitable lining to contain the bottom ash waste and also provide adequate leachate collection system. This paper address the technical and design aspects considered for the vertical expansion of existing hazardous landfill and also how bottom ash were used for the construction of 24m high geogrid retaining wall. Also this paper will discuss the aspect of leachate and storm water management system adopted for the project.

Keywords: Geogrid Retaining Wall, Hazardous Waste, Bottom Ash, Landfill Vertical Expansion, Leachate and Storm Water Management.

1. Introduction

Obtaining land-space for land-filling purpose has always been a challenge for environmental engineering as well as landfill engineering works. Hazardous waste requires highly safe, protected, and environmentally safe measures required to be taken into consideration for the land-filling purpose. Most of the countries across the world have implemented stringent laws and regulation on handling the hazardous waste. The coal fired power plant bottom ash is one of the waste that has been classified as hazardous waste. Bottom ash is the waste product produced from combustion of coal for electricity power generation in coal-based thermal power plants and it's dark grey or black, sand-like material that collected at the bottom of the boilers of the power plant. Utilization of coal bottom ash could prevent landfilling works for the coal fired power plant and perform cost reduction mechanism on engineered recycling activities and ultimately reduce cost for construction activities especially vertical landfill expansion and construction works. Landfill vertical expansion is a good option for expansion of land-filling space apart of on getting more horizontal space. Re-engineering mechanism should be considered for the hazardous waste and re-utilization of readily avaiable material should be taken into consideration for the landfill vertical expansion works. The utilization of bottom ash in construction projects can save energy, reduce the need for virgin raw materials. By recycling and utilization of bottom ash, projects can enhance green sustainable construction activities by reducing their carbon footprint. Detailed technical and design aspects in regards to the use of the bottom ash for the construction of 24m high geogrid wall will discussed further. The bottom ash utilization mainly considered to be used for four types of construction activities, namely of Geogrid wall construction using bottom ash :

1. Bottom ash as containment bund
2. Bottom ash as daily cover of waste
3. Bottom ash for densification of waste especially clinical waste.

2. Engineering Value of Bottom Ash

Some of European economies has used the bottom ash as their secondary construction material as it's substitution value to the sand-like materials. In Belgium, bottom ash has been used as gravels in road construction and similar usage. Countries like Germany utilize bottom ash to the maximum for road construction, noise protection walls, and other technical applications.

3. Properties of Bottom Ash as Construction Material

The physical and chemical composition of bottom ash from nearby coal fired power plant are shown in the **Table 1 and Table 2** respectively. Based on results of particle size distribution **Figure 1**, the particle size distribution indicates the coal bottom ash, falls in the range of fine sand to course sand and gravel. It shows about 97% sand sizes and 3% is fine or silt, instead from the coefficient of uniformity and coefficient of curvature, the bottom ash can be classified as medium graded sand. Based on the result of physical properties, it shows that coal fired power plant bottom ash classified as medium weight material due to the specific gravity is about 2.06 ~ 2.33.

No.	Hazardous Organics	Concentration		Remarks
		Sludge (mg/kg)	TTLC (mg/kg)	
1.0	SVOC Pentachlorophenol	<1	17	Complied to requirement
2.0	Herbicides 2,4 Dichlorophenoxy acetic acid 2,4,5 – Trichlorophenoxypropionic acid	<1 <1	100 10	Complied to requirement
3.0	VOC Trichloroethylene	<0.5	2040	Complied to requirement
4.0	Pesticides and PCBs			Complied to requirement
	Aldrin	<0.5	1.4	
	Chlordane	<0.5	2.5	
	DDT, DDE, DDD	<0.5	1	
	Dieldrin	<0.5	8	
	Endrin	<0.5	0.2	
	Heptechlor	<0.5	4.7	
	Kepone	<0.5	21	
	Lindane	<0.5	4	
	Methoxyclor	<0.5	100	
	Mirex	<0.5	21	
	PCBs	<0.5	50	
	Toxaphene	<0.5	5	
5.0	Dioxins (2,3,7,8 – TCDD)	<0.001	0.1	Complied to requirement
6.0	Furan (2,3,7,8 – TCDF)	<0.001	0.1	Complied to requirement
7.0	Organic Lead	-	13	Not analysed due to instrument brokedown

Table 1. Analysis on Hazardous Organics

No.	Hazardous Organics	Concentration	
		Sludge (mg/kg)	TTLC (mg/kg)
1.0	Silver (Ag)	1.8	500
2.0	Arsenic (As)	29	500
3.0	Barium (Ba)	265	10000 (1%)
4.0	*Beryllium (Be)	4.6	75
5.0	Cadmium (Cd)	4.3	100
6.0	Cobalt (Co)	63	8000
7.0	Chromium (Cx)	89	2500
8.0	Chromium Hexavalent (Cr^{6+})	0.4	500
9.0	Copper (Cu)	37	2500
10.0	Molybdenum (Mo)	1.4	3500
11.0	Nickel (Ni)	124	2000
12.0	Antimony (Sb)	<2.8	500
13.0	Selenium (Se)	12	100
14.0	*Thallium (Tl)	<2.9	700
15.0	Vanadium (V)	238	2400
16.0	Zinc (Zn)	15	5000
17.0	Mercury (Hg)	<0.5	20
18.0	Lead (Pb)	253	1000

Note: TTLC – Total Threshold Limit Concentration

Table 2. Analysis on Hazardous Inorganic (Oven Dried)

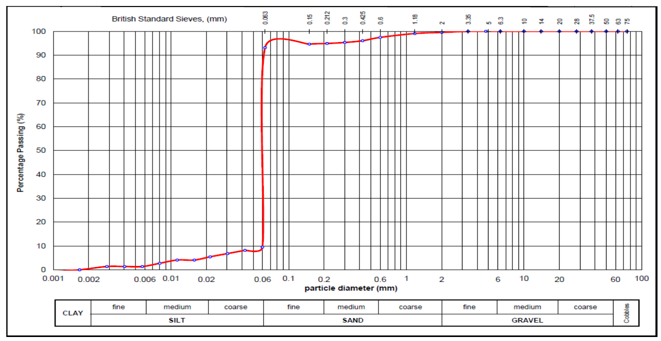

Fig. 1. Particle Size Distribution of Coal Fired Power Plant Bottom Ash

Chemical Constituents	Chemical Composition of Coal Bottom Ash (%)
Silicon Dioxide (silica), SiO_2	46.60
Aluminium trioxide, (Al_2O_3)	30.30
Iron oxide, (Fe_2O_3)	6.44
TiO_2	3.31
Calcium Oxides (free lime) CaO	0.68
Potassium oxide (K_2O)	0.50
Sodium oxide (Na_2O)	0.26
Magnesium oxide (MgO)	-
Sulphate (SO_3)	0.09
L.O.I	0.64

***Note** : L.O.I = Loss on Ignition

Table 3. Chemical Composition of Bottom Ash (BA)

Table 3 shows the concentration of chemical compositions results of coal bottom ash and the coal bottom ash classified as class-F fly ash accordance to ASTM C618. The coal bottom ash describe as siliceous and aluminous materials that possess little or no cementatious value consisting a little quantity of Calcium Carbonate (CaO) lower than 10%. Based on ASTM C618, the total combination percentage composition of silicon dioxide (SiO2), aluminina oxide (Al2O3) and iron oxide (Fe2O3) more than 70 percent. The coal bottom ash considered as non self-cementing ash because having pozzolanic properties and no or small quantities of self-cementing properties sources of calcium and magnesium ions.

4. Propose Mechanism on Utilization of Bottom Ash

Based on the physical and chemical properties of coal fired power plant bottom ash, it is required to contain the bottom ash with suitable liners membrane as part of engineering element. Hence for the usage of coal bottom ash produced from thermal power plant is proposed to be used for;

- **Figure 2** : Utilization for geogrid wall construction
- **Figure 3**: Utilization as containment bund
- **Figure 4**: Utilization as daily cover
- **Figure 5**: Utilization to densification of waste

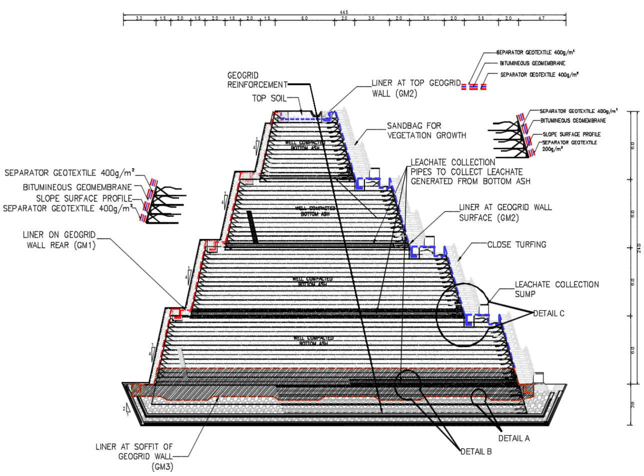

Fig. 2: Case 1 – Propose utilization of bottom ash for geogrid wall construction

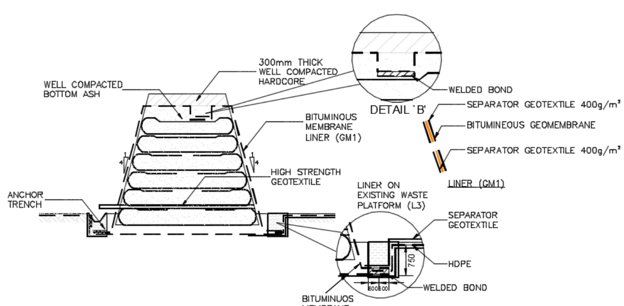

Fig. 3. Case 2 – Propose utilization of bottom ash as containment bund

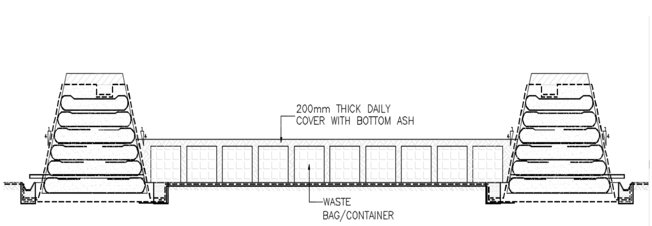

Fig. 4. Case 3 – Propose utilization of bottom ash as daily cover of waste

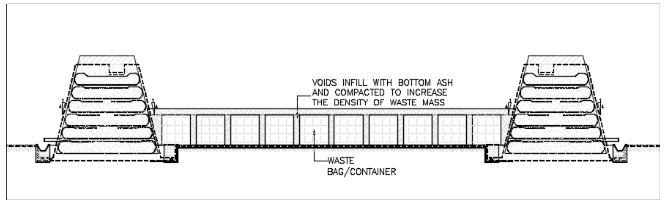

Fig. 5. Case 4 – Propose utilization of bottom ash for densification of waste especially clinical waste.And if temporary storage required, the bottom ash will be placed in landfill cell only

As for **Figure 2 -** Case 1 and **Figure 3 -** Case 2, the geogrid wall and containment bunds are proposed to be contained fully by utilizing specially designed, Reinforced Elastomeric Bitumen Geomembranes. The geomembranes's elastomeric modified bitumen blend allows it to remain flexible over time, quickly conform to substrate contours and withstand settlement changes. The blend is reinforced with two layers of polyester, making the membrane less susceptible to punctures. The non woven polyester geotextile reinforcement layer protects against mechanical punctures and enhance flexibility. The membrane lightly sanded side provide, frictional resistance against sliding. A layer of polyester film at bottom protects the geomembrane from subgrade effects. Placement of the membrane by simple torch welding helps to eliminate seam leakage problems. Torch welding using propane gas torch does not special equipment. Details of containment system adopted for geogrid wall is shown in **Figure 6.**

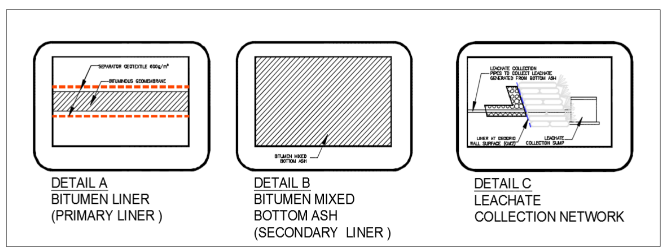

Fig. 6 shows how the geogrid wall constructed using bottom ash are secured from contaminating the environment using various lining system.

Monitoring plan were also proposed for the project using;

1. Groundwater monitoring well
2. Inclinometer to monitor slope stability and also stability of the wall

5. Design Details of Vertical Expansion

The cross sectional detail and the plan view of the landfill vertical expansion and various liner system implement are shown in **Figure 7.** Various types of liners were used for containment works namely bitumen liner as primary liner and bitumen mixed bottom ash as secondary liner.

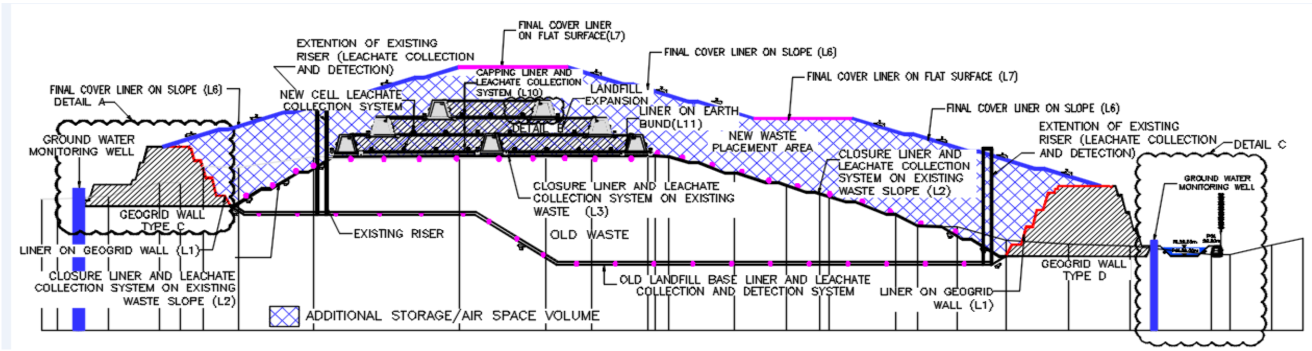

Fig. 7. Typical cross section of landfill with layers of layers and series of leachate collection network and groundwater monitoring well and location bottom ash placement and the additional storage volume obtained.

6. Source to Storage Cycle of Bottom Ash

The environmental protection works carried out from the source of the bottom ash at thermal power plant until to the landfill cell. Mechanically design truck will be used as the transportation vehicle to the storage area at landfill as the transportation vehicle to the storage area at landfill as shown in **Figure 8.**

In case of an emergency during transportation from source to landfill storage of bottom ash, there will be an Emergency Response Plan will be carried out as shown in **Figure 8**. The source to storage cycle is shown in **Figure 8.**

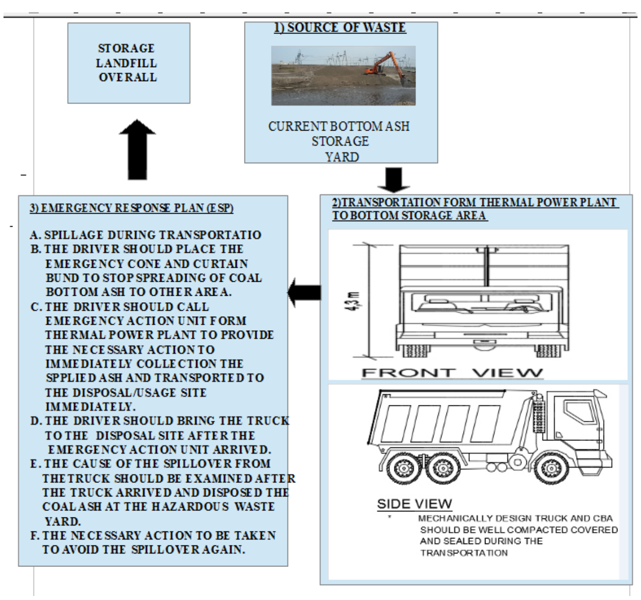

Fig. 8. Source to Storage Cycle of Bottom Ash

7. Conclusion

The undertaken vertical expansion of landfill project, the project owner were able to:

1. Reduce the footprint required for land-filling works
2. Reduce cost of construction by utilizing the bottom ash as construction materials
3. Develop new approach or landfill lining system

The key objective of reducing carbon footprint, utilizing waste for construction and maximizing land use were achieved in the project.

8. References

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