Effective use of MSW molten slag as road materials

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1. Introduction

The incineration of municipal solid waste produces large quantities of bottom and fly ash, which has been disposed of primarily by landfilling. However, as landfills become undesirable other disposal methods are being sought. Safe and uniform slag containing low concentration of heavy metals is produced from electric resistance ash melting furnace with an original melting method. After being melted, the municipal waste solid incinerator ash became the slag that seems reducing the volume of waste more effectively than before, it can last the life of disposal site, and also the good quality molten slag can be widely utilized for road construction. In the paper, the molten slag being used in 2 ways was introduced. One is the molten slag added into lime/cement treated surplus Ariake clay to make use of it as a granular material or improve soft subgrade. The effective of using the molten slag to improve the unconfined compressive strength of surplus Ariake clay was discussed. Second, the molten slag and foamed waste glass were blended and try to make a light weight subbase or base materials. Compaction properties and CBR value of the blended mixtures were investigated in the study.

2. Materials and Testing

2.1 Materials

2.1.1 Surplus Ariake clay

Ariake clay, deposited around Ariake Bay, Kyushu, Japan is a kind of high sensitive soft clay with very high water content. Table 1 shows the properties of Ariake clay used in the study.

Table 1. Properties of Ariake clay

Nature water content %	110
Density of soil particle g/cm^3	2.56
Liquid limit %	141.6
Plastic limit %	54.1
Plastic Index	87.5
Sand	2.0
Silt	31.0
Clay	67.0
pH	7.6
Ignition loss (%)	12.8

2.1.2 The MSW molten slag

The municipal solid-waste molten slag was produced from molting of municipal solid-waste incinerator fly ash with over 1300^{o}C high temperature. And it was obtained from the municipal solid-waste incineration plant at Saga, Japan. The physical and chemical properties of molten slag are listed in Tables 2 and 3, respectively.

2.1.3 Foamed waste glass (FWG)

The process involved in production of FWG consists of crushing, mixing with some additives, melting and foaming in special furnaces. The new material has a porous structure with a rough surface. It is light but stiff. Two kinds of structure namely continuous and discontinuous are available. The FWG with a maximum size 10 mm restricted due to the size of the mold of the study, obtained from crushing by a compaction rammer on coarser grain having diameter of 40-70 mm. The properties of the coarse FWG are listed in Table 4.

Table 2,3 The physical and chemical properties of molten slag

Natural water content (%)	2~5
Density of soil particle (g/cm^3)	2.78
Gravel	11.0
Sand	86.0
Silt	2.5
Clay	0.5
Liquid limit (%)	NP
Plastic limit (%)	NP

Chemical compositions (%)	SiO_2	34.0
	Al_2O_3	26.0
	Fe_2O_3	3.0
	CaO	28.0
	MgO	3.3
	K_2O	1.2
	Na_2O	3.6
	Others	0.9
Ig. loss (%)		2.01

2.2 Test method

15% and 30% contents of the molten slag were used for the stabilization Ariake clay with then constant content of lime or cement. The specimen was placed in a cylindrical mold with 5 cm in diameter and 10 cm in height immediately after mixing by a small soil mixer. The mixture was still so wet at the time of preparation that a compaction method of hand vibrating was used to expel the entrapped air out of the samples as much as possible. Specimen sealed completely in the molds was subsequently cured in a curing room with temperature 20^{o}C and 90% humidity. Specimen was taken out from the molds for unconfined compression test after 7, 28 days curing.

Table 4. The properties of FWG

Dry unity density (g/cm^3)	0.40
Size of particle (mm)	2~9.5
CBR (%)	30.9
Compressive strength (MPa)	3.5

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The specimen combination of the molten slag and FWG blended mixtures was listed in Table 5. CBR specimen size is 10 cm in depth and 15 cm in diameter. A compaction machine was employed to compact the mixtures with different compaction ratio. After compaction, the specimens were immersed water for 4 days. The CBR test was carried out.

Table 5. Specimen combination

Mixtures	Mixtures ratio
Slag: FWG	100: 0
Slag: FWG	70:30
Slag: FWG	50:50
Slag: FWG	30:70
Slag: FWG	0:100

3 Test results and Discussion

3.1 Some effects on stabilize surplus Ariake clay

(1) water content

Fig.1 shows the water content reduction of Ariake clay after stabilized with 10% of lime or cement together with MSW molten slag at 7 days curing. Water reduction ratio of lime stabilization is greater than cement because CaO content of lime is higher than that in cement.

(2) q_u of lime-slag and cement-slag stabilization

It has been proved that a coarser size fraction from fly ash will decrease the liquid limit, increase plastic limit of the clay. That is to say, increasing coarser size in the clay will increase the strength of the clay. Figs. 2 and 3 show strength of lime-slag and cement-slag stabilization on Ariake clay after 7 and 28 days curing. We found that adding with molten slag can increase the strength, especially for cement stabilization, but over the optimum content of slag will reduce the strength.

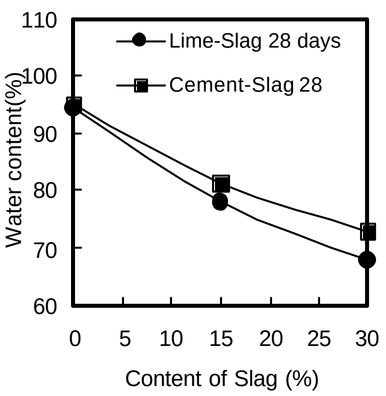

Fig1.Water content and content of slag

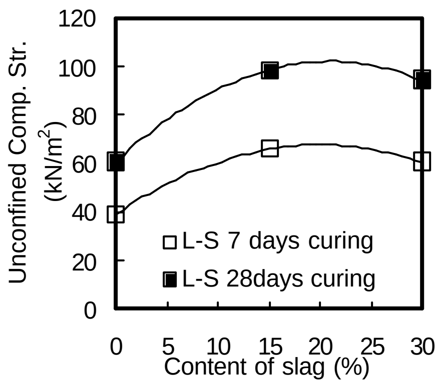

Fig 2. Strength and content of slag (lime)

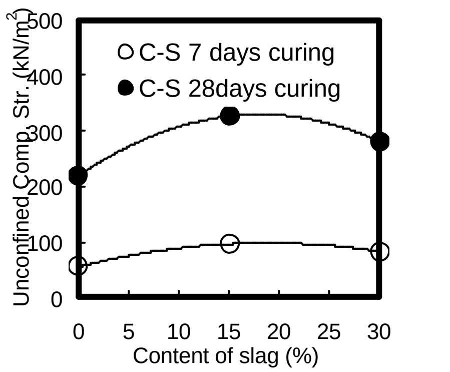

Fig 3. Strength and content of slag (cemen

3.2 Some effects on blending with Foamed waste glass as light weight material

Fig4 shows the relationship between dry density and the content of slag. Almost dry density of mixtures of slag and FWG are small than 1 g/cm^3 and CBR value are bigger than 30%, as subbase or base materials, its light self-weight can reduce settlement on soft subgrade. Fig5 shows the relationship among compaction ratio, content of slag and CBR value. Increasing content of slag can increase CBR value. With increasing content of slag, compaction ratio is more effect on the CBR value. The mixtures of slag and FWG can keep CBR value than slag and FWG individually. The optimum ratio of slag and FWG in the mixtures is from 0.5 to 0.7.

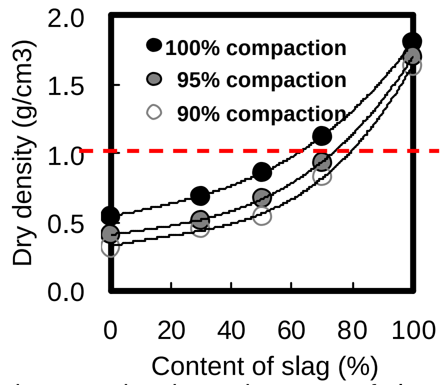

Fig4. Dry density and content of slag

4. Conclusions

When the molten slag is used to improve Ariake clay, adding with molten slag can increase the strength, especially for cement stabilization, but over the optimum content of slag will reduce the strength. When the molten slag is used to blend with FWG as light weight material in road construction, increasing slag can increase CBR value. It is proved that the molten can be widely utilized for road construction.

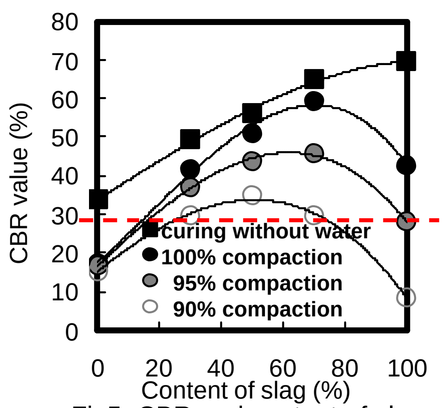

Fig5. CBR and content of slag

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