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Life Cycle Assessment of Eco-Cement

Tomonori Honda, Nguyen Xuan Hong, Ryoichi Yamamoto
Institute of Industrial Science
University of Tokyo
4-6-1 KOMABA MEGURO-KU, TOKYO 153-8505, JAPAN

Fax: 81-3-5452-6305, e-mail: tomonori@iis.u-tokyo.ac.jp

A shortage of landfill sites, destruction of natural habitats, and environmental pollution caused by land disposal of waste have recently emerged as social problems in Japan. In such a situation, various approaches are introduced to promote environmentally-friendly products by the enactment of Law on Promoting Green Purchasing and so on. The Ecocement was developed as the one. Ecocement is cement that uses municipal waste incineration ash and sewage sludge as main raw materials. The Ecocement is expected as an environmentally-concerned solution for a number of environmental problems caused by waste disposal. However, a problem of large amount of energy required for Ecocement manufacturing has been raised. Therefore, the environmental load quantitative evaluation of these cements is necessary. After the influence of waste had been taken into consideration, the Ecocement was evaluated by using LCA in this study. Moreover, environmental load of Eco-cement is compared with that of Portland cement.
Key words: cement, LCA, LIME, Incineration ash

1. INTRODUCTION

As a result of various improvements, the Japanese cement industry has attained significant energy savings in comparison with that of other countries. Furthermore, cement industries has been utilizing abundant wastes and by-products from other industries as raw material and fuels. The total amount of recycled material has exceeded 27,200,000 ton/year with a constant increase in the primary unit.

Additionally, Ecocement which was able to dispose more wastes was newly developed. Ecocement is produced with more than 50% raw materials coming from municipal waste incineration ash and some other waste materials such as sewage sludge. Ecocement and ordinary Portland cement are the similar qualities. (Ordinary Portland cement accounts for approximately 75% of the Japanese market.)

There are some questions in the manufacturing process. Can the generation of dioxin be controlled? How is the heavy metal in the incineration ash controlled? Dioxin and the heavy metal are controlled as follows by the manufacturing process of the Ecocement.

Then, in order to reduce heavy metals content, the plant is equipped with heavy metals extraction system. Heavy metals are gathered by bag filters, condensed and then sent to a refining plant to be reprocessed into usable metals.

The incineration of waste produces two types of ash bottom ash and fly ash. The bottom ash is collected from the bottom of a stoker type incinerator and, after quenching in water, can be treated to remove unsuitable materials such as metals and other foreign matter and fed into the cement kiln as a raw material. Fly ash is collected from the flue gases by a dust filter. Although only in small amounts, dioxins contained in the bottom ash are completely decomposed in the rotary kiln. Dioxins contained in the fly ash remain in the filter cake after the chloride washing process, leaving no dioxins in the effluent. The cake is fed to the rotary kiln together with the bottom ash, and therefore dioxins in the cake are also completely decomposed. During the manufacture of Ecocement, kiln temperatures reach 1350°C and therefore any dioxins are completely decomposed. The raw material which has come out from kiln is cooled quickly from 1350 degrees to 200 degrees so that the reproduction of dioxin should not happen. Consequently, the concentration of dioxins in the flue gas is below 0.1ng-TEQ/Nm3 which is the limit specified by Japanese waste management law. Dioxins are not detected in Ecocement. This process is greatly different from the Portland cement. In the Portland cement, heat is recycled. However, heat cannot be recycled with the Ecocement. Therefore the amount of the heavy metals outflow from the incineration ash was calculated.

In this research, the Portland cement and the Ecocement were compared by using LCA.

2. SYSTEM BOUNDARY

A system boundary covers seven stages, including the mining of resources, the transportation of cement and the service station. (Fig. 1) Inventory data include mineral and energy resources including wastes and by-products, and exhaust gas. it was not taken into account due to difficulties in data collection and their negligible impact that plant construction, the mining and transportation of imported materials to Japan. The emissions during plant construction are estimated to be negligible due to durable years and huge production.

- Evaluation of incineration ash

The environmental loading of ash were made to be zero

in past model. However, when we reclaim from the incineration ash, the environmental load is caused. Then, it thinks by assuming that the reclamation of the incineration ash was evaded in this research. Heavy metals in the incineration ash are as shown in Table. 1. The amount of the heavy metals outflow from the incineration ash was calculated.(Fig. 2)

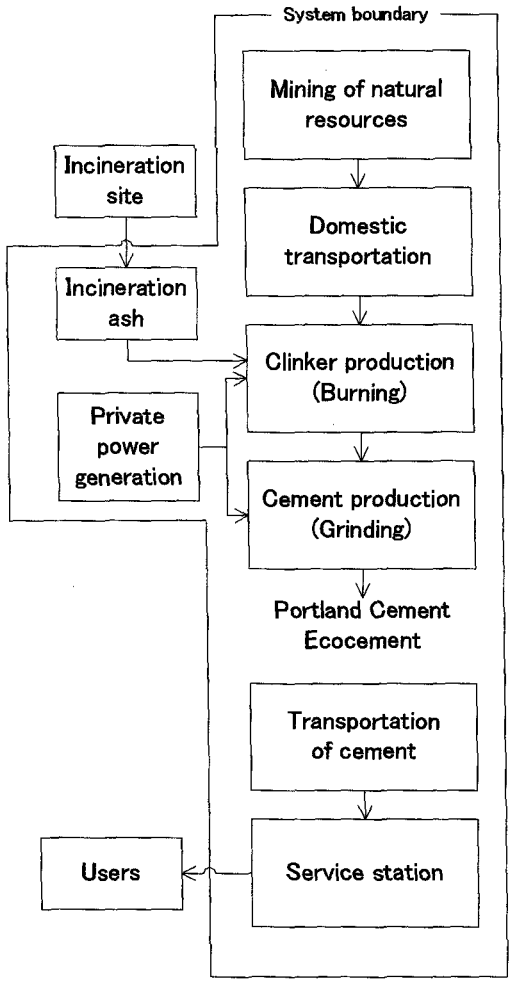

Fig. 1 System boundary

	Cd	Pb	Zn	Fe	Cu	Ni
	g/t	g/t	g/t	Kg/t	g/t	g/t
Plant A	2	1600	3600	68	2800	240
Plant B	2	2100	4300	76	3100	190
Plant C	2.3	530	2100		3700	
Average	2.1	1410	3333	72	3200	215

	Mn	Cr	Hg	F	Cl
	g/t	g/t	g/t	g/t	Kg/t
Plant A	1500	540	0.07	110	17
Plant B	1900	450	0.11	180	14
Plant C	900	530	0.01		
Average	1433	507	0.063	145	15

Table. 1 Inventory when it reclaims of incineration ash

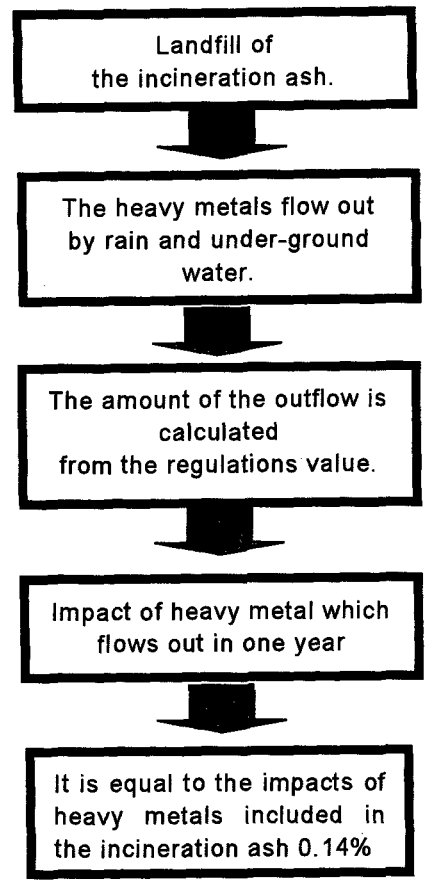

Fig. 2 Calculate method of incineration ash's outflow

3. LIFE CYCLE IMPACT ASSESSMENT METHOD

LIME (Life-cycle Impact assessment Method based on Endpoint modeling) was used as a life cycle impact assessment method in this study. LIME is a result of national project of life cycle assessment. LIME is broadly categorized into the following two approaches.

- Natural sciences approach that involves quantitatively evaluating to what degree the objects to be protected will actually be impacted by environmental load classification and specification methods
- The social sciences approach: the assessors perform studies to learn which of the protected objects subjected to environmental impact are important and how important they are weighting method to achieve integration

4. RESULTS AND DISCUSSION

The influence of the incineration process is large in a lot of items. The contribution of heavy metals in the incineration ash to carcinogenicity is very large. However, it is managed in the reclamation disposal place.

The cement manufacturing process is discussed. Heat in the kiln process is recycled in the case of Portland cement production. It is necessary to decompose the dioxin generated in the incineration ash in the case of

eco-cement. The radiation heat of the eco-cement is large. [Fig. 4] (However, two cement plants should note that the scale is quite different.)

The impact assessment result was shown in Fig. 5. The outflow of the heavy metals from the incineration ash was not considered in the past. However, when outflow from heavy metals in incineration is taken into consideration, the environmental loads can be greatly decreased. Cement is used for about 20 years usually. The environmental load with the heavy metal is not generated for this period. Therefore, it understood that the environmental load of the total becomes minus. And, the environmental load of the eco-cement when thinking about the use for 20 years became -31.1 Pt. However, there is a problem also in the eco-cement. The size of plant is very small now compared with the plant of the Porto land cement. Therefore, the factory of the eco-cement is inefficient of energy. If the production of the eco-cement will increase in the future, the improvement of the energy efficiency can be expected. Therefore, if a large amount of eco-cements are manufactured, human health damage can be decreased. However, Resources Consumption deteriorates.

5. CONCLUSION

Environmental management tasks on an added significance with ages. It was able to be shown that manufacturing the Ecocement was effective as a method of disposing of waste by this study. Moreover, it has been understood to be able to decrease human health damage by manufacturing the Ecocement. On the other hand, Energy efficiency of eco-cement manufacturing deteriorates because process to control dioxin generation which does not exist in Porto land cement manufacturing exists when eco-cement manufacturing is compared with Porto land cement manufacturing.

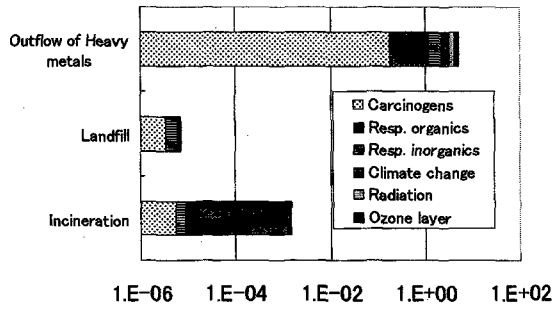

Fig. 3 Human health damages

	Portland cement	Ecocement
Lime stone	1081.35	788.2
Ash	63.73	547.3
Heavy oil	3.7	143
Black diamond	77.7	
Kg/ton-cement		

Table. 2 Cement's inventory data

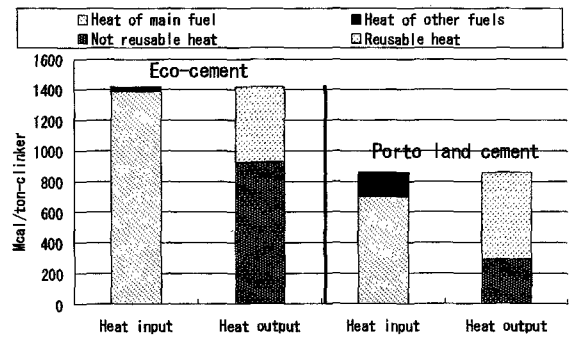

Fig. 4 Energy for manufacturing cements

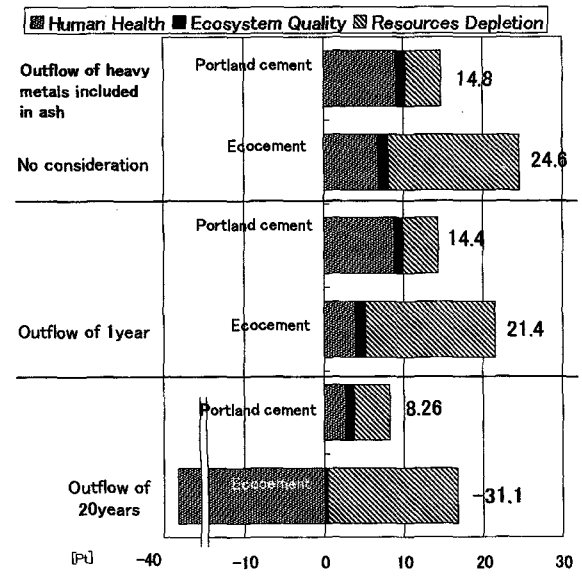

Fig. 5 Total environmental load

6. ACKNOWLEDGEMENT

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