Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 26-27, 2017

Development of Radioactive Concrete Waste Management Process during Decommissioning NPPs

*Cheol-Seung Cheon, David S. Kessel and Chang-Lak Kim**
KEPCO International Nuclear Graduate School, 658-91 Haemaji-ro, Seosaeng-myeon, Ulju-gun, Ulsan 689-882, Republic of Korea
**Corresponding author: clkim@kings.ac.kr, Tel:+82-52-712-7333*

1. Introduction

The decommissioning of Kori unit 1 is planned in the near future. It will be Korea's first dismantling experience of a commercial nuclear power plant (NPP). Radioactive waste management is an essential element for a successful decommissioning business because radioactive waste disposal cost accounts for a large portion of the total decommissioning cost. Concrete waste accounts for most of the decommissioning waste along with metallic waste. Most structures in the NPP, including the reactor containment building, are made up of concrete and become radioactive through activation and contamination. The application of appropriate technology to the situation may lead to significant volume reduction of radioactive concrete waste. In this paper a concrete waste management process for minimizing radioactive waste disposal has been studied.

2. Radioactive concrete waste treatment

2.1 Inventories and characteristics

Figure 1 shows the inventory of concrete waste generated from the decommissioning of Kori 1 based on the estimation of KEPCO E & C [1]. According to this data, concrete waste accounts for most of the decommissioning waste. However, 99.52% of concrete waste is clearance waste and radioactive concrete waste is less than 1%. Therefore, it is important to dispose of large amounts of non-radioactive concrete efficiently as well as treating radioactive concrete.

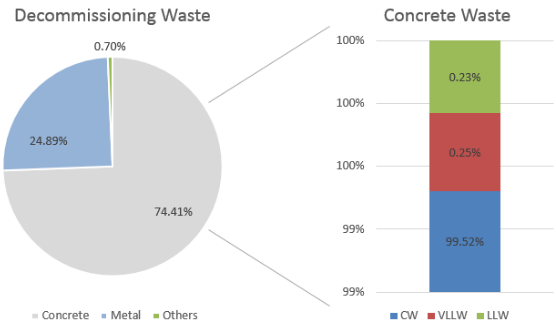

Figure 1. Estimated concrete waste inventory of Kori 1

2.2 Basic strategies

Most of the structures in the radiation controlled area are made of concrete. Most of them are non-radioactive concrete except for contaminated concrete such as reactor cavity and activated concrete such as biological shield. Waste generated from a radiation controlled area can be self-disposed by incineration, landfill, and recycling when the radiation level is below the clearance level. However, they are generally disposed in form of burial in a dedicated landfill. Therefore, the disposal cost of clearance waste is higher than general industrial waste and disposal procedure is stricter.

The selective removal of radioactive parts can be a good alternative in terms of disposal costs. According to this strategy, the remaining non-radioactive concrete structure can be dismantled after the radiation controlled area is released. By doing so, a large quantity of concrete can be treated as clean waste. This method can significantly contribute to reducing waste disposal costs.

For radioactive concrete active volume reduction efforts are needed. Radioactive concrete can be divided into activated concrete and contaminated concrete. In order to increase disposal efficiency, it is necessary to apply different treatment technologies for radioactive concrete depending on the situation.

2.3 Applicable technologies

2.3.1 Decontamination

Decontamination is the removal of contamination from areas or surfaces of facilities or equipment by washing, heating, chemical or electrochemical action, mechanical cleaning or by other means. The contamination of concrete will depend on the location and the history of the material and the contamination depth can be few mm to several cm. There is no single technique to address all kinds of problems. The selection of technologies depends on the type of facilities, the type of isotopes which are involved, the activity level of the equipment and parts which are concerned, the physical/chemical properties of the equipment/parts to be dismantled and of the radioisotopes and contamination layer.

2.3.2 Aggregate Separation [2,3]

Concrete is a structural material which generally consists of a binder (cement), water, and aggregate.

Most radionuclides in concrete mainly exist in the porous cement stones. Typically 30% of the concrete is porous cement and the remaining 70% is composed of dense aggregates such as quartz or limestone. If clean aggregates can be separated from the radioactive cement, significant volume reduction of radioactive concrete waste can be achieved. The aggregates separated from radioactive cement can be treated as a clearance waste after dose assessment.

Separation of concrete into its components gravel, sand and cement paste is based on the reduction of bond between the cement matrix and the aggregates. The bond can be reduced by temperature induced mechanical stresses. When the concrete waste is heated to approximately 300 ℃, the cement paste is made brittle by dehydration.

Figure 2 shows the aggregate separation process. The radioactive concrete waste is crushed for a size reduction. By the jaw crusher the input concrete is crushed to about 40 mm diameter parts. The crushed concrete parts are heated at about 300 to 700 ℃ in a furnace for 1 h. The heated concrete waste are crushed by ball mill for about 1 h. The processed product is separated into gravel aggregate (> 5 mm), sand aggregate (1-5 mm) and cement paste (< 1 mm) by sieving. According to the experiments carried out by KAERI, contamination level of the gravel and sand aggregates was remarkably decreased below clearance level after the process [2]. Volume reduction of the contaminated concrete waste was achieved by about 80% for the total contaminated concrete waste.

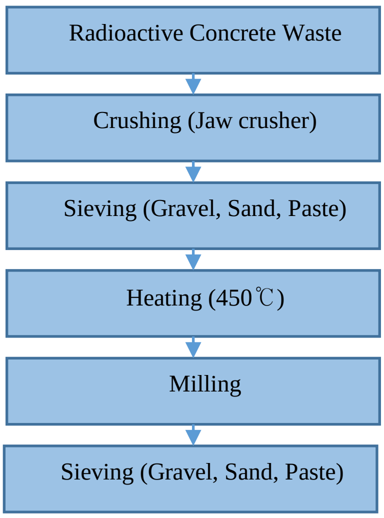

Figure 2. Mechanical and thermal treatment process for aggregate separation

2.3.3 Utilizing radioactive concrete to produce mortar for immobilizing LLW waste [4]

The method aims to ensure treating of concrete radioactive waste by reusing all debris resulted in the crushing process and manufacturing of filling mortar for solidification of other radioactive waste, using fine aggregates, cement powder and chemical admixture. It has been proved that modifying the amount of chemical mixture and the specific surface of the fine fraction, will determine a modification of the properties for fresh and hardened mortar.

After the aggregate separation, clean coarse and fine aggregates and radioactive cement paste will be generated. Among them, fine aggregates and cement paste can be used for manufacturing mortar for immobilizing LLW waste. Reusing radioactive concrete waste as a solidification material for other radioactive waste will lead to decreasing of the costs for final disposal.

2.4 Concrete waste management process

A concrete waste management process has been developed according to the concrete waste management strategy and applicable technologies. Figure 3 shows the process. When concrete waste is generated, radioactive assessment should be carried out first through sample analysis. If they are evaluated as radioactive waste above the clearance level, it is necessary to judge whether or not decontamination is possible. If decontamination is possible, appropriate decontamination techniques should be applied. If the radioactivity still remains after decontamination or decontamination is not possible, as in activated waste, the aggregate separation technique is applied. Separated coarse aggregates can be treated as clearance waste or disposed of according to radiation assessment. The remaining fine aggregates and cement paste after aggregate separation are used to manufacture mortar for immobilizing other LLW waste.

.

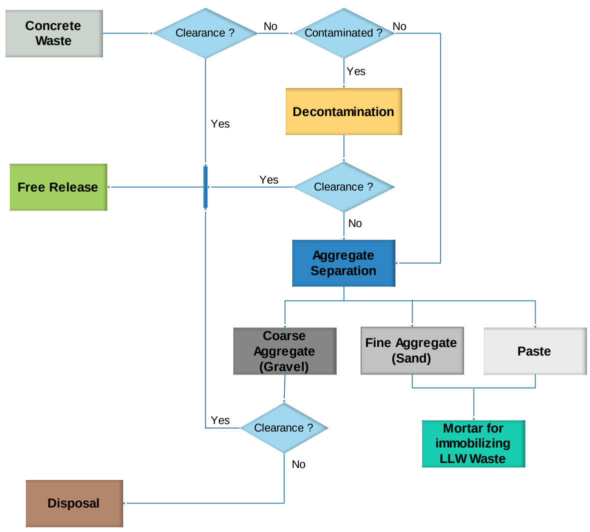

Figure 3. Concrete waste management process

3. Conclusions

Concrete waste accounts for most of the decommissioning waste and significant disposal cost savings are possible depending on the disposal strategy. For non-radioactive concrete structures, the strategy of dismantling after the release of the radiation controlled area was proposed. This strategy enables to dispose of large amounts of concrete as clean waste. For radioactive concrete, three treatment technologies have been introduced and a concrete waste management process has been proposed based on the technologies. This process will allow for systematic management of concrete waste and will significantly reduce disposal costs.

Acknowledgement

This research was supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KOFONS), granted financial resource from the Nuclear Safety and Security Commission (NSSC), Republic of Korea (No. 1305009). The work was also supported by the Research Fund of the KEPCO International Nuclear Graduate School (KINGS), Republic of Korea.

REFERENCES

[1] KEPCO E&C, Assessment of the Radiological Inventory for the Decommissioning of Kori Unit 1, 2014.

[2] B.Y. Min, et al., Separation of Clean Aggregates from Contaminated Concrete Waste by Thermal and Mechanical Treatment, Annals of Nuclear Energy, 2009.

[3] B.Y. Min, et al., Separation of Radionuclide from Dismantled Concrete Waste, Journal of Nuclear Fuel Cycle and Waste Technology, 2009.

[4] R. Deju, et al., Review on Radioactive Concrete Recycling Methods, Romanian Reports in Physics, Vol. 65, No. 4, pp.1485-1504, 2013.