The Status of LILW Disposal Facility Construction in Korea – 15158

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ABSTRACT

In this paper, we discuss the experiences during the construction of the first LILW disposal facility in South Korea. In December 2005, the South Korean Government designated Gyeongju-city as a host city of Low- and Intermediate-Level Radioactive Waste (LILW) disposal site through local referendums held in regions whose local governments had applied to host disposal facility in accordance with the site selection procedures.

The LILW disposal facility is being constructed in Bongil-ri, Yangbuk-myeon, Gyeongju. The official name of the disposal facility is called 'Wolsong Low and Intermediate Level Radioactive Waste Disposal Center (LILW Disposal Center)'. It can dispose of 800,000 drums of radioactive wastes in a site of 2,100,000 square meters. At the first stage, LILW repository of underground silo type with disposal capacity of 100,000 drums was completed by the end of June 2014.

The Wolsong Low and Intermediate Level Radioactive Waste Disposal Center consists of surface facilities and underground facilities. The surface facilities include a receipt and inspection facility, an interim storage facility, a radioactive waste treatment building, and supporting facilities such as main control center, equipment & maintenance shop. The underground facilities consist of a construction tunnel for transport of construction equipment and materials, an operation tunnel for transport of radioactive waste, an access shaft for workers, and six silos for final disposal of radioactive waste.

INTRODUCTION

In the Republic of Korea, commercial nuclear power plants (NPPs), research institutes, nuclear fuel manufacturing facilities, and spent radioisotopes (RI) is generating Low and Intermediate Level Radioactive Waste (LILW). The accumulated amount of LILW in South Korea's NPPs as of June 2014 is approximately 95,400 drums (hereafter, "drums" means "200 liter drum equivalents" unless specified otherwise). And together with those of research institutes, nuclear fuel manufacturer, general industry and medical sectors reached approximately 127,800 drums.

After the amendments to the Atomic Energy Act in 1986, the South Korean government has failed nine times to secure a disposal site from 1986 to 2004. In Dec 2004 National Policy and Principles by the Atomic Energy Committee was amended to separate the disposal between LILW and HLW.

In 2005 a new announcement to revise the disposal site selection procedure made Gyeongju-city as a candidate site. In January 2007, the Korea Hydro & Nuclear Power Co., Ltd. (KHNP) submitted an application to the Ministry of Education, Science and Technology (MEST), the national nuclear regulatory authority, for the first stage license that would authorize KHNP to construct and operate the Wolsong LILW Disposal Center. As entrusted by MEST, the South Korean nuclear regulatory body (Korea Institute of Nuclear Safety "KINS"), reviewed the license document and issued the construction & operation approval in July 2008.

In Jan 2009 Korea Radioactive Waste Agency (KORAD) was established to build a structure of mutual

control and balance by differentiating the producers of radioactive waste from their disposal operator, based on the “Radioactive Waste Management Act (2008)”.

Now, we could provide on the experiences while constructing the Wolsong LILW Disposal Center.

SITE SELECTION

We had painful past experiences for nearly two decades (1986~2005) to get site in South Korea. All nine attempts from 1986 had failed.

The causes of failure for Radioactive Waste Disposal Site are as follows. 1) Safety concerns about disposal facility, 2) Lack of transparency and stake-holder involvement in policy making, and 3) Lack of confidence to the proposed incentives by the government and nuclear industry

For above reasons, the Minister of Knowledge Economy (MKE) announced new approaches for site selection. Finally we’ve investigated thoroughly for LILW for site selection. The factors for success of site selection are as follows. 1) Separation of LILW and HLW, 2) Organization of site selection committee (SSC), 3) Free decision through resident's vote, and 4) Enactment of a special Act for hosting area support

As a result, the MKE organized the SSC in order to guarantee the transparency and fairness of the site selection process. The SSC, consisting of 17 civilian experts from diverse fields, managed and supervised the entire site selection process. In addition, the “Special Act on Supporting the Local County Around the low and intermediate level Radioactive Waste Disposal Facility” was legislated and announced on March 31, 2005 to stipulate support for areas hosting LILW disposal facilities, including special financial support, entry fees per drum, and relocation of the KHNP headquarters.

According to candidate site selection procedures, as depicted in Fig. 1, the local governors applied to host the disposal facility with consent from local councils. Then, in accordance with the results of the site suitability assessment, the MKE requested local governors to conduct the local referendums in appropriate regions in adherence with the Referendum Act. Based on the results of the local referendums, areas with the highest percentage of favorable responses would be selected as the final candidate site.

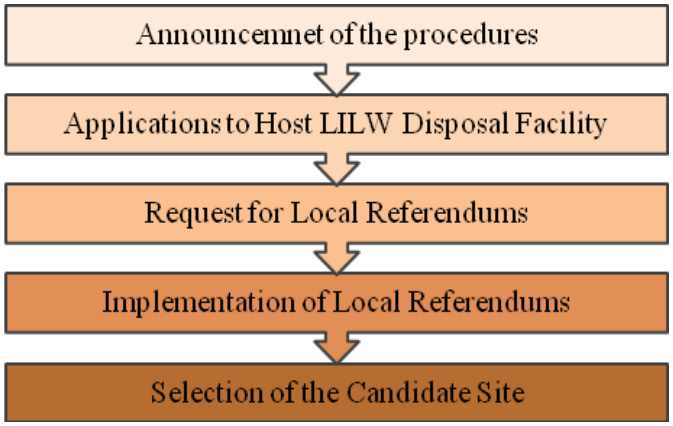

Fig. 1. Site Selection Procedures

The local governments that conducted local referendums were in the four areas of Gyeongju, Gunsan, Pohang, and Yeongdeok County. According to the results of the local referendums, Gyeongju was selected and announced as the final candidate site with 89.5% of favorable responses in the four areas given in Table I.

Finally, On January 2, 2006, the MKE designated that the prospective rural development area comprising the entire 49 Bonggil-li, Yangbukmyeon, Gyeongju, North Gyeongsang Province (approximately 2,140,000 m²) had been selected as the final candidate site for the LILW disposal facility (the MKE Notice No.2005-133).

TABLE I. Results of Referendums

	Gyeongju	Gunsan	Pohang	Yeongdeok
Number of voters	208,607	196,980	374,697	37,536
Number of actual voters	147,636	138,192	178,586	30,107
Percentage of favorable responses	89.5%	84.4%	67.5%	79.3%

WOLSONG LILW DISPOSAL CENTER

Overview

In order to implement the fundamental principles approved at the 253rd meeting of the AEC (17th December, 2004), the South Korean government decided on the construction of a disposal facility that could dispose of 100,000 drums for the first stage and would ultimately reach a total of 800,000 drums through gradual expansions. As for the first stage disposal method, the adoption of a rock cavern disposal facilities completed by June 2014 was decided.

The disposal facility layout for the initial disposal of 100,000 drums is depicted in Figure. 2. The Wolsong LILW Disposal Center consists of surface facilities and underground facilities.

Fig. 2. Layout of the Wolsong LILW Disposal Center

The surface facilities include equipment & maintenance shop, a receipt and inspection facility, an interim storage facility, a radioactive waste treatment building, and supporting facilities such as main control center, which are depicted in Figure 3. The surface facilities were constructed in July 2010 and now operated.

Fig. 3. Layout of the Wolsong LILW surface facilities ; a) Waste water treatment building, b)Garage, c)Equipment maintenance shop & warehouse, d)Radioactive waste receipt & storage building, e)Radioactive waste treatment building, f)Service building I, g)Service building II, h)Power supply building

The waste receipt/storage building in the site of the disposal facilities is in operation to receive the radioactive waste from NPP's which are required to secure additional storage capacity. At the end of June 2014, the waste receipt/storage building is storing and managing about 5,000 drums of LILW.

All nuclear power plants in South Korea are located on the coast. KORAD has constructed and now operates the ship, 'Cheong Jung Nuri', for the transportation of radioactive waste from nuclear power plants to Wolsong LILW disposal center. In 2010, 1,000 drums from Ulchin NPP site were transported to

the Wolsong LILW disposal center (see Figure 4).

Fig. 4. The Wolsong LILW Disposal Center's first receipt

The underground facilities consist of a construction tunnel for transport of construction equipment and materials, an operation tunnel for transport of radioactive waste, an access shaft for workers, and six silos for final disposal of radioactive waste.

At first, six silos will be constructed approximately 80~130 meters below sea level (see Figure 5), 25 m in diameter and 50 m in height with a disposal capacity of 100,000 drums (approximately 16,700 drums per silo)

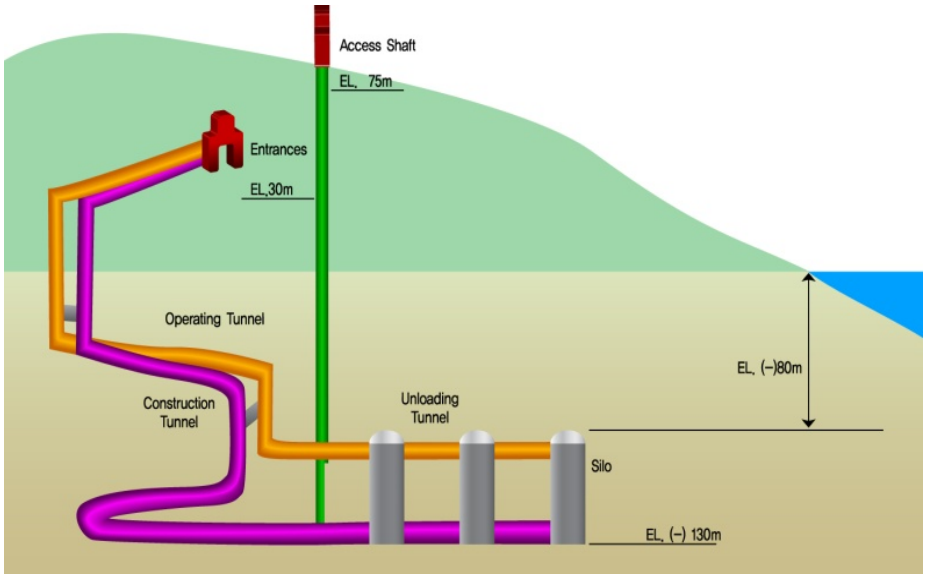

Fig. 5. Cross section view of the underground facilities

Among the underground facilities, excavation for the construction tunnel, operating tunnel and access shaft began in August 2008 and excavation of disposal silos started in February 2011. As of the end of Dec 2012, the excavation and concrete lining processes are finished for the construction tunnel (1,950 m), operating tunnel (1,415 m) and access shaft (207 m). The excavation of the unloading tunnel (360 m) was completed at June 2012.

Construction

The construction and operation license for the LILW disposal facility was issued in July 2008. Construction began in August. Preoperational inspection by the KINS began in September. Preoperational inspection for the LILW disposal facility is intended to check the appropriateness of the corresponding construction, performance and overall operation preparation status.

Layout

All disposal silos are reinforced with shotcrete and concrete lining. Most waste packages are packed using disposal concrete containers and subsequently disposed of in the disposal silos. The engineered barrier system of the disposal silo consists of disposal container, backfills, and a concrete silo. The conceptual drawing of the post-closure phase of disposal silo is shown in Figure 6.

LILW will be disposed of separately in 6 silos depending on the size and characteristics of the waste in order to maintain disposal container integrity and minimize the empty gap between packaging containers. For loading efficiency, 16-Pack (4x4) disposal containers for 200-liter-drums and 9-Pack (3x3) disposal containers for 320-liter drums are used. The waste drums are placed inside the disposal containers, which are handled with remote equipment such as a crane.

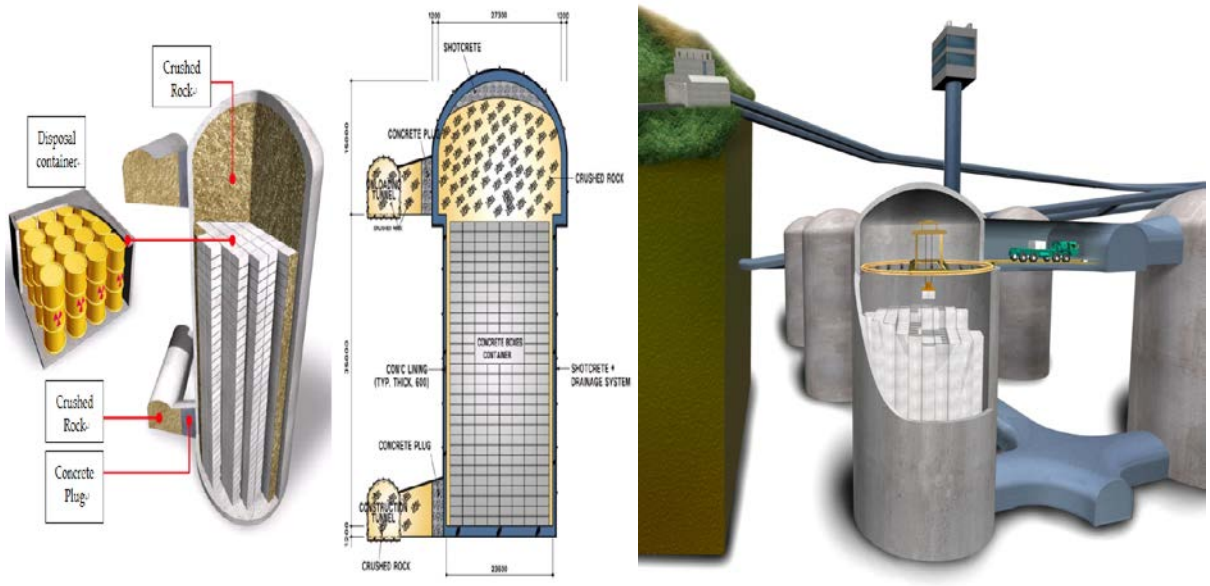

Fig. 6. Concept of disposal silos after closure

Regulatory Guidance

To comply with the requirements in permit or license conditions according to the Nuclear Safety Act, during the construction of the LILW disposal facility for the installer of disposal facilities, the NSSC (Nuclear Safety and Security Commission) carries out the preoperational inspection. If violations occur, the Minister of the NSSC immediately orders the installer of disposal facilities to take corrective actions and complementary measures so as to secure the safety of disposal facilities. The KORAD is in charge of the safety management.

The Wolsong LILW disposal center is designed such that it maintains their structural and functional integrity during normal as well as abnormal operating conditions. Therefore, the design and construction of Wolsong disposal facilities shall be based on proven engineering practices. In addition, equipment and components installed at Wolsong disposal facilities is designed such that they can be regularly tested and inspected to confirm that they can continue to be used safely.

Safety Assessment Results

To show the long term safety, the assessment is carried out in various scenarios. The results of the safety assessment meet the regulatory criteria. At the preliminary phase the expected dose which takes the estimated probabilities of different cases into account is 0.004 mSv/y less than the regulatory limit (0.1 mSv/y). : Preliminary phase dose rate : 0.004 mSv/y

Therefore, the disposal of the low and intermediate waste in the Wolsong LILW disposal facility can be considered acceptable.

Excavation for Silos

The excavation method especially for large underground structure like silos should be determined with consideration for items related to safety of structures such as sizes of excavation sections, degree of self-supporting of rock mass itself and constructability of excavation methods and economic feasibility, etc. For successful excavation of large underground structure the stability just after excavation (without installation of ground support) should be guaranteed. In case of large excavation section, excavating a whole section in one step can reduce constructability in transportation of excavated materials and installation of ground support and furthermore may make a collapse of underground structure with weak or unfavorable ground condition.

Therefore, a whole excavation section needs to be divided into several sections and excavated in consideration of stability and constructability of underground structure.

The site for Wolsong LILW disposal facility in Gyeongju, South Korea has such a complicated ground (rock) condition that makes a lot difficulty in construction of silos. Due to this unfavorable condition of rocks, it was considered to plan, design and construct a tailor-made excavation method according to rock condition than to apply a consistent method without considering variables. For the excavation of silos, the several excavation methods of domestic and overseas underground structures were studied case by case and we have made excavation plans as follows especially considering ground conditions of silos. The dome is a critical part for silo construction. Since the shape of dome is different from that of general tunnel and access shafts we had challenges to determine modified excavation methods suitable for conditions of site.

Management of the Excavated Materials (Soil/Rock)

During the construction of Wolsong LILW disposal facilities the excavated materials (soil and rock) are brought from the excavation process for underground structures like tunnels and silos and buildings like ground facilities, etc (see Figure 7,8).

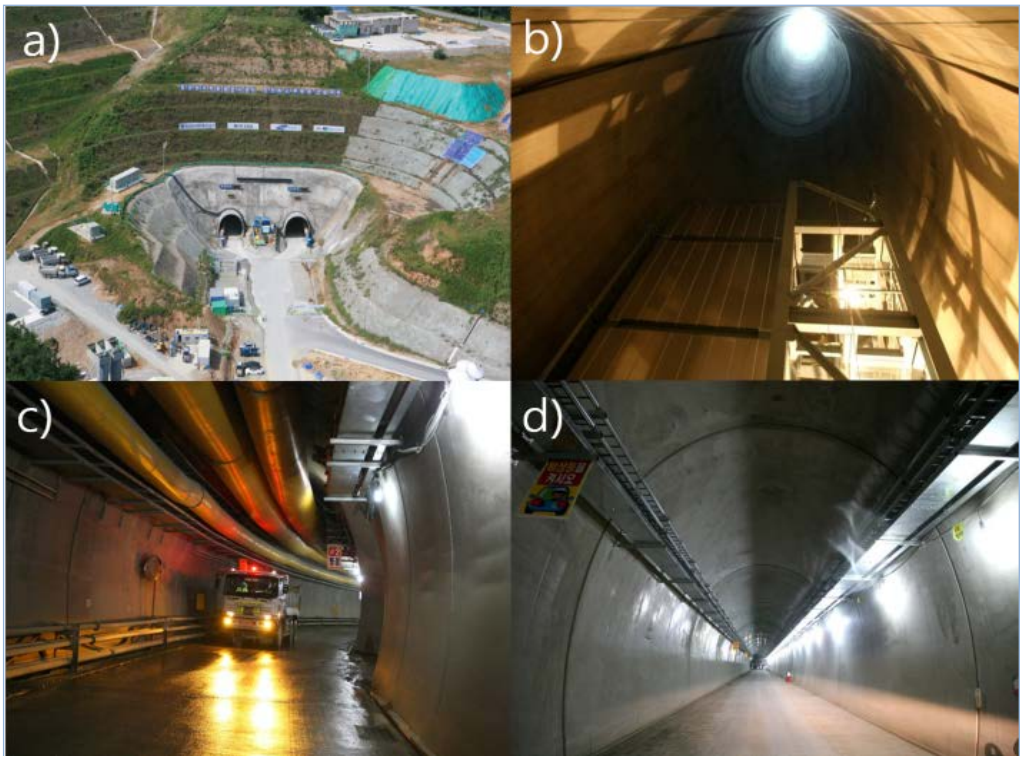

Fig. 7. The view of Construction ; a)Portal, b)Shaft entrance, c)Operation tunnel, d)Construction tunnel

Fig. 8. Silo construction

The excavated rock is used as embankment materials for roads or side backfill materials for buildings. Especially competent rock from blasting excavation of tunnels is used for concrete production materials or riprap of harbor construction and the remainder is piled up on the spoil area. The excavated soil is piled up on the spoil bank or used for support to civil societies near the site if requested. The excavated rock is piled up on spoil area in site because the excavated rock will be used as backfill materials for tunnels and silos when the Wolsong LILW disposal facilities are closed.

Construction Activities

All concrete work shall be performed in accordance with ACI, ASTM Codes and Standards to keep the integrity of silo concrete and the function of engineering barrier during the post-closure institutional control period as well as the operation period. The main construction activities are as follows.

Concrete production, conveying and placing, consolidation of concrete

Cold and hot weather concreting, curing, finishes and repair, etc. for concrete lining

Environment Friendly Complex (KORADIUM)

At the Wolsong LILW disposal center, KORAD is building an 'Environment Friendly Complex (KORADIUM)' with the theme of nature and science for restoration of damaged sites and ecological conservation, and it will become a tourist attraction in Gyeongju as an environment-friendly facility where everybody wishes to visit. (see Figure. 9)

Fig. 9. Layout of the Environment Friendly Complex

The environment friendly complex consists of the 'Four Season Flower Garden', Kiosk of Perception', "Dynamic Deck', 'Light Theme Park' as well as a visitor center, and open air performing theatre. The area of the complex is about 50,000 m².

Radioactive Waste Transport Ship

The KORAD prepared the carrier, container and vehicles for the transport of radioactive waste and

shipped 1,000 drums of LILW from the Ulchin NPP to the disposal facility using the carrier (Cheong-Jung Nuri) and stored them in the waste receipt/storage building of the Wolsong LILW disposal center after obtaining the alteration permit and passing the preoperational inspection for partial operation. It also transported about 1,500 drums of the LILW from Wolsong NPP to the Wolsong LILW disposal center by land and stored them in the waste receipt/storage building. The KORAD has 5 radioactive waste transportation trucks (15t) and 300 transportation containers.

The Cheong-Jung Nuri is safely designed and constructed in compliance with international standards of IAEA and International Maritime Organization (IMO) as well as domestic standards such as the Ship Safety Act and the AEA and was approved by the Ministry of Land, Transport and Maritime Affairs (MLTM). The safety of the ship and the appropriateness of the operation procedure were confirmed through inspection by the KINS. The Cheong-Jung Nuri is equipped with the latest navigation equipment such as collision prevention radar and an automatic ship identification device that prevents ship collision. In addition its double hull structure is designed to avoid sinking and damage to radioactive waste containers even under emergency situations.

Radiation shielding boards are also installed on freight holds to which radioactive waste is loaded to block the leakage of radiation to the outside. Radiation monitors are installed on major points of the carrier to check for radiation leakage in real time. The entrance to the cabin is designed to prevent the intrusion of outside personnel by using a security system that opens the door through an identification procedure using fingerprint recognition technology. The carrier is operating the emergency response plans and radiation protection plans it established to cope with unexpected accidents during shipment such as fire, collision, sinking, typhoon and tsunami. It also operates routine training for the crew to understand thoroughly the emergency response procedures and methods.

SPECIFICATIONS	
Length	78.6 m
Width	15.8 m
Gross Tonnage	2,600 tons
Speed	12 kn
Engine	3,264 HP
Capacity	Max. 1,520 Drums

Fig. 10. Cheong-Jung Nuri

CONCLUSIONS

Despite nine failures of site selection for nineteen years, the painful experiences were delivered to new approaches for success. The first LILW disposal facility, called ‘Wolsong LILW disposal center’ is hosted at Gyeongju in South Korea and completed by June of 2014.

The Wolsong LILW disposal center was considering the site characteristics such as geology, earthquakes, meteorology, and hydrology as well as other manmade disasters to enable supplementing and improving site characteristics. Furthermore the Wolsong LILW disposal center was designed to maintain their structural integrity with minimal maintenance and repair activities during the post-closure institutional control period.

By appling a multi-barrier concept, the design, installation and operation of the disposal facility shall be complied with the site closure and stabilization; thus, the performance objectives for the post-clousure period shall be met.

Safety is the most important fundamental objective of the national radioactive waste management program in South Korea. Much effort has been devoted to construct the Wolsong LILW disposal center.

The Korea Radioactive waste Agency (KORAD) is continuing the efforts toward the successful implementation of the national radioactive waste management projects, including improvement of the safety and reliability of the Wolsong LILW disposal center.

The KORAD will play essential roles in the development of the nuclear industry as the main energy resource for green development by building a management system satisfying global standards and by enhancing safety, professionalism and transparency of the management of radioactive waste as an independent organization.

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