Application of a Logistical Simulation Model to Planning of Soil Washing Process

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1. Introduction

Soil washing is one of the decontamination techniques to remove radioactive materials from the surrounding soil of nuclear power plants in the soil remediation stage. The nature of this work is repetitive and requires significant resources, and it has uncertainty due to lack of domestic experience.

However, modeling the soil washing process using the simulation tools at the planning stage can make the process more predictable and more efficient. This study suggests the application of a discrete event simulation model to the site remediation work, especially the soil washing process.

2. Soil Washing Process

2.1 General

Soil washing is an ex-situ, water-based remediation process that removes surface contaminants of soils by separation and treatment of soils. Soil washing is based on the principle that contaminants are generally bound more tightly to the fine soil particles (silts and clays) and not to larger grained sand and gravel [1].

In other words, soil washing is used to separate contaminated fine particles and wash water from the washed coarse particles. A low ratio of silt and clay in the soil will generally reduce the solid waste requiring disposal as radioactive waste. Soil washing must be used with other treatments, such as precipitation, filtration and/or ion exchange. Through the operation, the contaminated residuals (fine particles and washing solution) are treated or disposed of, and the cleaned soil is returned to the site and reused as backfill.

2.2 Procedure

The soil washing process is normally accomplished by physical methods depending on the soil particle size. Fig. 1 below illustrates the general soil washing process.

Soil washing systems usually consist of the following 6 units: [2]

i) Pretreatment
ii) Separation
iii) Coarse grained treatment
iv) Fine grained treatment
v) Process water treatment
vi) Residuals management

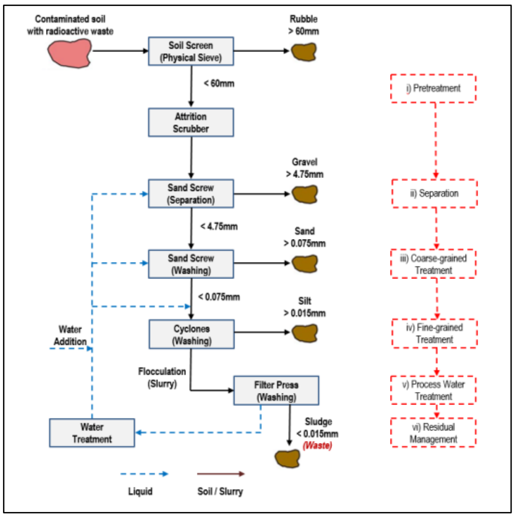

Fig. 1. Soil Washing Procedure.

3. Simulation Model using Flexsim

3.1 Flexsim

A soil washing process was modeled and simulated using the Flexsim software which is widely used in industries such as material handling, manufacturing, logistics, transportation and mining [3].

FlexSim enables implementation of discrete-event simulation (DES). In a DES model, specific events affect the state of system at a specific point in time. DES can be applied to the soil washing process and used as part of site remediation project planning.

3.2 Input Data

The input data used in the soil washing simulation model are the soil excavation rates and the particle size distribution of the soil.

The soil particle size distribution obtained from current soil remediation studies at the Kori nuclear power plant site [4] was used in the simulation model as a source of input data for the soil washing system. Table 1 specifically lists raw data and input data by soil particle size.

Table **1**. Input Data of the Model

Parameters	Raw Data		Input Data	
	Type	Value	Type	Value
Excavation Rate	-	-	-	15.0 ton/hr

Particle Size of Soil	Gravel (>4.75 mm)	6.3%	Gravel (>60 mm)	1.0%
			Gravel (60~ 4.75 mm)	5.3%
	Sand (4.75~ 0.075 mm)	83.4%	Sand (4.75~ 0.075 mm)	83.4%
	Silt & Clay (<0.075 mm)	10.3%	Silt (0.075~ 0.015 mm)	3.9%
			Clay (<0.015 mm)	6.4%
Cleanup Process Rate	-	-	-	10.0 ton/hr

3.3 Simulation Model

The soil washing procedure is modeled based on the conceptual design of process in Fig. 1, and the process rate and logic are programmed based on input data in Table 1. In the model, soil at the project site is the logistics target. The Flexsim model allows 3D visualization of the throughput of soil through the process and detailed flow of soil within the soil washing system. Furthermore, detailed processing data can be shown and extracted as numerical tables or graphical charts.

Fig. 2 shows a screen shot of the 3D simulation model in Flexsim at 5 hours of operation. The excavated soil is fed to the feed hopper on the left side of figure, and the soil that has been cleaned by operation is sent to each sink according to the grain sizes such as rubble, gravel, sand, silt and sludge/clay(waste). Wash water is circulated in the water system placed in the upper part of the figure, and a certain portion of the wash water is discharged into the sink as process waste.

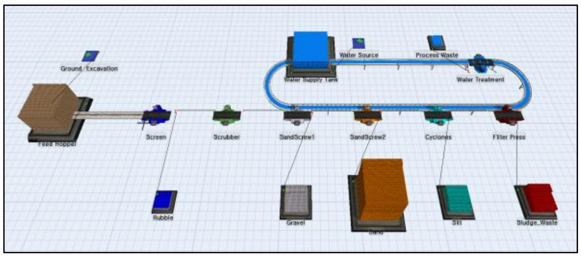

Fig. 2. Logistical Simulation of Soil Washing Process.

3.4 Result

Through the simulation, we can see the visualized soil washing process and throughput. Once the simulation starts, 15 tons of soil per hour are supplied to the feed hopper and the soil washing system operates at 10 tons per hour. Due to difference between the soil excavation rate and process rate, soil stock is increased in the feed hopper. Table 2 contains the process results after 5 hours of operation. The results show that the amount of process output is approximately close to the input data, which means that the simulation is correctly modeled based on procedure in Fig. 1 and is operating correctly according to the intended logic.

Table **2**. Simulation Results at 5-hour-operation

Queue	Rubble	Gravel	Sand	Silt	Sludge	Total
Processed Soil (ton)	0.537	2.666	41.685	1.946	3.134	49.968
Ratio	1.07%	5.34%	83.42%	3.89%	6.27%	100%

4. Conclusion

In this study, we investigated the applicability of a simulation model of soil washing process used in the site remediation project. Although safety against dose exposure is the primary concern in soil remediation, efficient allocation of resources and efficient waste management including volume reduction are also the main objectives in the soil remediation process.

These objectives can be achieved by use of logistical simulation model in the planning stage. Detailed input data are required for more accurate and optimized planning, and it is expected to obtain practical operating data through the management of various properties and parameters in the model.

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