Buffer Construction Methodology in Demonstration Test For Cavern Type Disposal Facility -9182

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ABSTRACT

A number of studies concerning a cavern type disposal facility have been carried out for disposal of low level radioactive waste mainly generated by power plant decommissioning in Japan[1]. The disposal facility is composed of an engineered barrier system with concrete pit and bentonite buffer, and planed to be constructed in sub-surface 50 – 100 meters depth. Though the previous studies have mainly used laboratory and mock-up tests, we conducted a demonstration test in a full-size cavern. The main objectives of the test were to study the construction methodology and to confirm the quality of the engineered barrier system. The demonstration test was planned as the construction of full scale mock-up.

It was focused on a buffer construction test to evaluate the construction methodology and quality control in this paper. Bentonite material was compacted to 1.6 Mg/m^3 in-site by large vibrating roller in this test. Through the construction of the buffer part, a 1.6 Mg/m^3 of the density was accomplished, and the data of workability and quality is collected.

INTRODUCTION

The cavern type disposal facilities for disposal of low level radioactive waste will be constructed in sub-surface 50 – 100 meters depth, and employs an engineered barrier system with a concrete pit and bentonite buffer.

The model of the sub-surface disposal with engineered barriers is shown in Figure 1. The engineered barrier system works to reduce migration of nuclide from disposal facilities through groundwater flow. The main engineered barriers are as follows[2]:

1) A buffer layer of bentonite material which reduces groundwater inflow through facilities

2) A low diffusion layer of cement material inside the low permeable layer, and which contains any groundwater that seeps from the inner diffusion area.

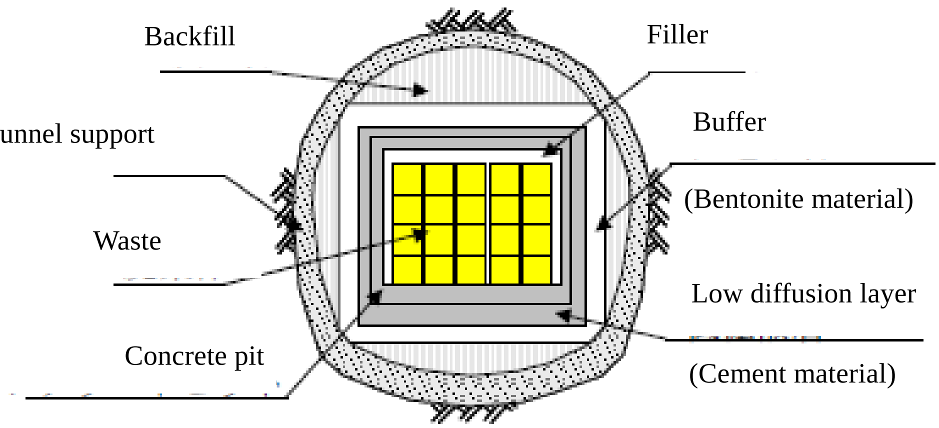


Figure 1 Model of sub-surface disposal facility[2)]

A basic test data has been mainly obtained by laboratory scale tests in preliminary studies for sub-surface disposal with engineered barriers. But construction methodology for cavern type disposal facility has not been validated. The performance of an engineered barrier system depends on construction methodology, so a demonstration test for sub-surface disposal facilities is required to choose and validate the construction methodology for the engineered barrier system.

Demonstration test for cavern type disposal facility has been commissioned by Ministry of Economy, Trade and Industry of Japan (METI) to be carried out by Radioactive Waste Management Funding and Research Center (RWMC) since FY2005. And this demonstration test has been carried out at a cavern in Rokkasho site with the support of Japan Nuclear Fuel Limited (JNFL). The construction test in-situ began in FY2007, and will be continued for a few years.

The buffer is located outside in an engineered barrier system, and compacted bentonite to 1.6Mg/m^3 at the drying effective clay density to ensure 5×10^{-13}m/s at permeability. The dispersion of density and smoothness of compacted plane is different by construction methodology. So the buffer quality depends on the construction methodology. On other hand, the construction methodology is limited for construction space in cavern. Therefore it is important to confirm characteristics of the construction methodology to establish the buffer quality in the test cavern[3)].

The bottom part of the buffer is located lower in the engineered barrier system, and is constructed after the construction test of backfill concrete at the bottom and side. Bentonite material is compacted on-site by vibrating roller. And the scales of bottom area are width 13.55m, length 16.10m, thickness 1.00m.

The methodology of construction test for the bottom part of the buffer is reported in this paper and the characteristics about density are shown.

BUFFER CONSTRUCTION TEST

Construction methodology for buffer

Each part of buffer has unique condition for construction, so the test case at each part is selected. The test case for the buffer is shown in figure 2.

In the construction test for the buffer, the common bentonite material Kunigel GX is used. This is screening raw material of Kunigel V1 which is used in construction materials by 10mm diameter, produced in north east Japan the mean density value for the buffer is set at 1.6Mg/m^3 to obtain the required buffer permeability.

In the test case, each construction methodology for buffer can be roughly classified into two groups. One is construction by vibrating roller, and the other is by using bentonite blocks. The weight of vibrating roller or size of bentonite block is selected by conditions of construction area.

The bottom area is a relatively large construction, so large machine was adapted for the construction test. The side parts and upper area is narrow, and small vibrating roller was adapted to avoid damage in the nearby concrete pit[4)].

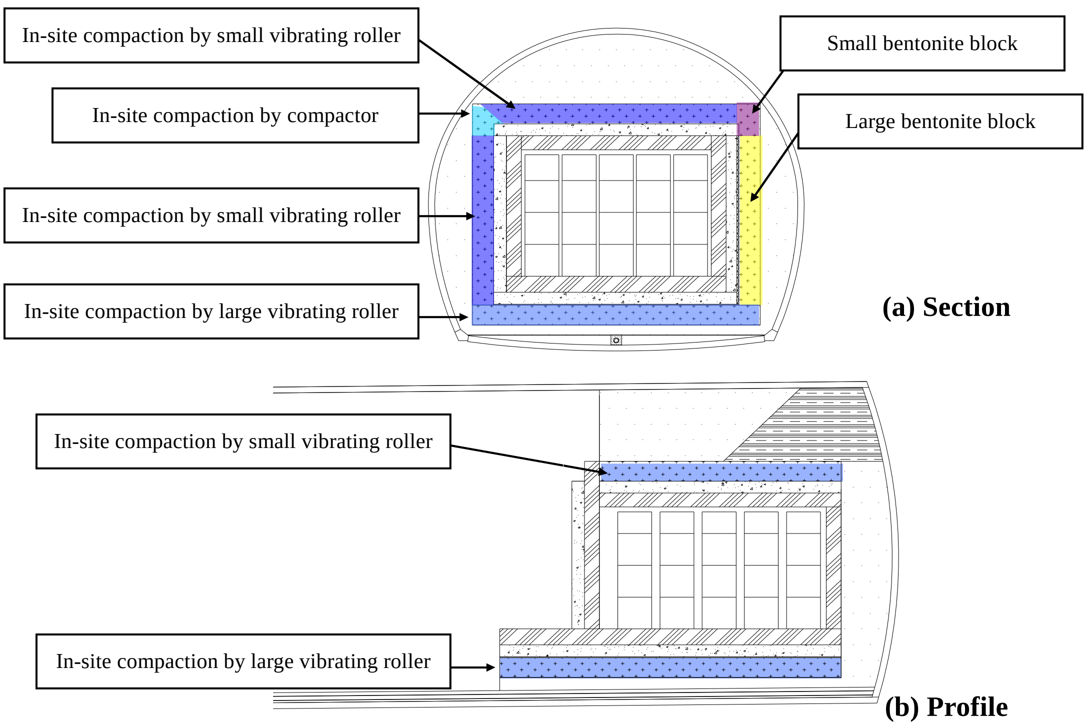


Figure 2 Construction methodology of buffer

Buffer construction test at bottom area

We were able to construct the bottom buffer area using large vibrating roller to compact efficiently, as the construction area is large and there is no diffusion layer for radioactive waste. The buffer thickness is 1.00m, and the thickness of bentonite layer is 0.10m, with 10 layers constructed.

Construction procedures related to spreading and compaction are repeated in the construction test. Therefore, it is important to confirm that the construction methodology included quality control through the construction cycle.

After the test plan of the bottom area buffer construction test was studied in FY2006, a buffer construction test at the lowest layer was carried out in FY2007 to validate construction methodology in the test. After the construction procedure is determined by the results at first layer the rest of layers are compacted. And the quality is measured by performance test at all layers. Based on the results of construction test and performance test, the quality of buffer will be evaluated for construction methodology and quality control[4].

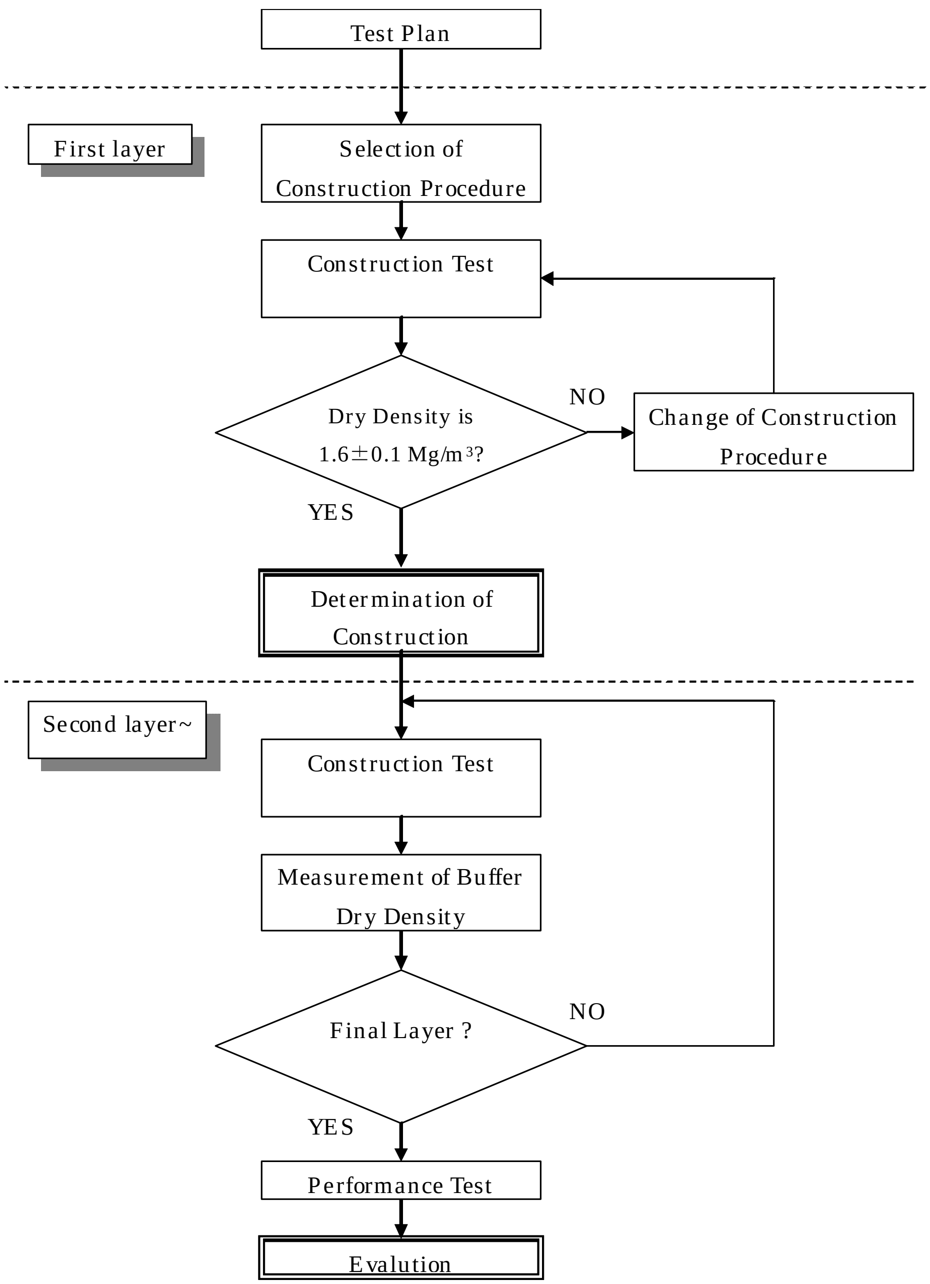


Figure 3 Flow Chart of Buffer Construction test

Testing condition of buffer construction test at bottom area

Construction methodology is selected in each area by construction conditions like the construction space, the size of machine for construction, the procedure for construction. At the bottom area, bentonite is mainly compacted on-site by using a large vibrating roller. Because of a narrow side area, bentonite is compacted in-site with a small vibrating roller. The construction areas are shown in figure 4. The construction machines used at each area are shown in table 1.

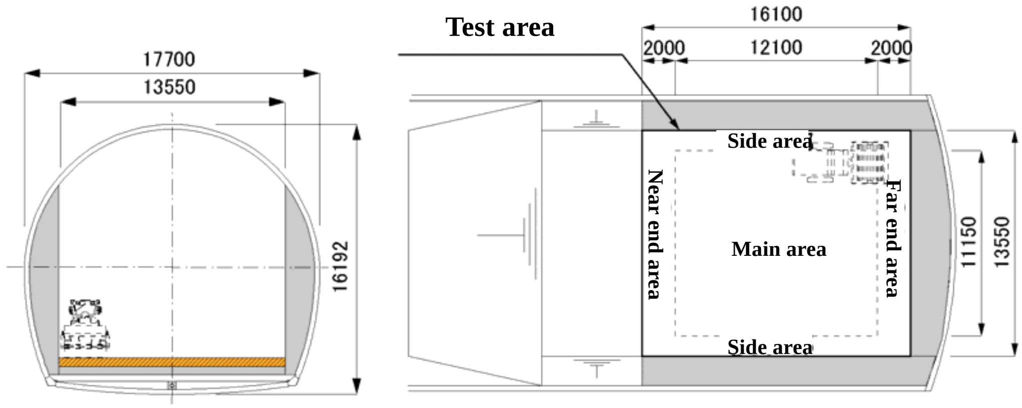


Figure 4. Construction area

Table 1. Construction machine

Step	Area	Machine		
		Type	Size (mm)	Weight (ton)
Spread	Except far end	Asphalt finisher	6,425*2,550,*3,100	21.0
Compaction	Side, Near end, Far end	Small vibrating roller	1,770*1,200*850	1.5
	Main	Small vibrating roller	2,625*1,290*1,570	2.5
		Large vibrating roller	6,250*2,530*2,975	19.7

Construction procedure

Bentonite (Kunigel GX) is added to water, with the target value of water content set from 19 % to 23 % (mean 21 %). The property of Kunigel GX is shown in table 2.

Table 2. Standard value of buffer material

Test item	Standard value
Grain size	Maximum 10mm
Water content	Under 10%
Plastic limit test	Under 30%
Methylene blue test	Over 63mmol/100g (45%)
Swelling test	Over 10 ml/2g

The construction procedure is as follows:

① At far end area (width approximately 2m), the bentonite is spread by manpower and mainly compacted by small vibrating roller. Manpower compaction using tamping rammer or vibrating compactor is tested in a few parts.

② At main area and side areas, the bentonite is spread by asphalt finisher. The width of spreading lane is approximately 4.5m.

③ At the near end area, the temporary bar is set to control horizontal movement.

④ Preliminary compaction by non-vibrating roller (weight is 2.5 ton) to get in the loose bentonite by large vibrating roller.

⑤ At the side and near end areas (width is approximately 2m each), compaction by small vibrating roller.

⑥ Primary compaction by large vibrating roller. At this step, the compaction without vibrating is carried out in order to avoid destruction by strong vibration. The number of primary compaction is 8 times.

⑦ Main compaction by vibrating roller. The tentative number of main compaction is 6 times, and the main compaction is going to add by the result of measurement of dry density.

The spreading by asphalt finisher is shown in figure 5. Construction by large vibrating roller at main area is shown in figure 6. Construction by small vibrating roller at side areas is shown in figure 7[5].

Figure 5. Spreading by Asphalt Finisher

Figure 6. Compaction by large vibrating roller at main area

Figure 7. Compaction by small vibrating roller at side areas

Construction test results

After the construction test for the first buffer layer, the buffer density has been confirmed by core sampling. The density has been calculated by weight and length of the core. The positions of sampling are shown in figure 8 below. These positions of sampling are divided into main area, side area, far end area, near end area and its boundary.

The density of the layer on-site compaction includes the difference between the upper and lower parts. Therefore some sampling cores are divided three parts, and each part has been measured in density to grasp the dispersion. The positions of sampling cores divided three parts were six points called s1-s3 and s7-s9.

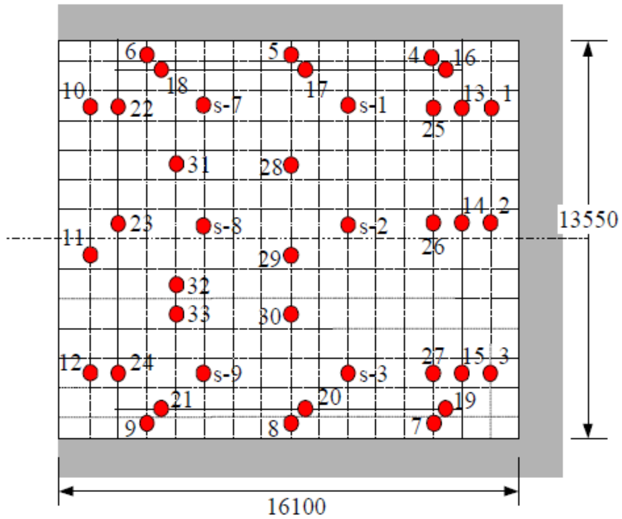


Figure 8. Positions at core sampling for dry density

The results of dry density by sampling core are studied all data. A dry density histogram for all sampling cores is shown in figure 9(a). The target value of dry density is set from 1.5 Mg/m^3 to 1.7 Mg/m^3. The mean is set 1.6 Mg/m^3. The results on 39 samples are as fellows.

- Average value of dry density is 1.669 Mg/m^3.
- Maximum value of dry density is 1.714 Mg/m^3.
- Minimum value of dry density is 1.567 Mg/m^3.
- Number of core exceeding the upper limit is 4 (10% of cores).
- Number of core exceeding the lower limit is 0 (0% of cores)

Therefore 90% of the samples have been within the density target value. This result will be useful for quality control at future construction processes.

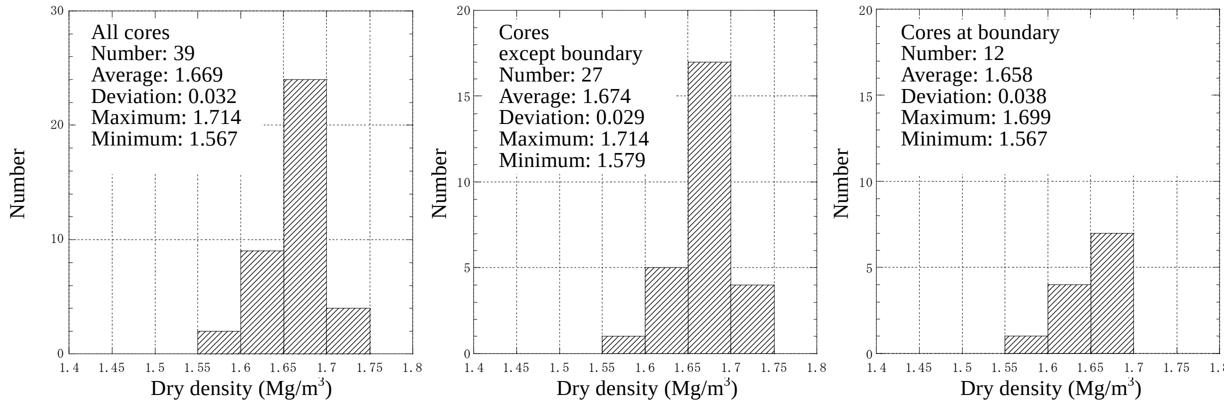
It is thought that the dry density is different at boundary and the others. So sampling core is divided into two groups. The histogram on dry density of cores, except samples at boundary, is shown in figure 9(b). The histogram on dry density of cores on samples at boundary is shown in figure 9(c). The results are as follows.

- For cores, except samples at boundary, the average value of dry density is 1.674 Mg/m^3 and the difference for all samples is 0.005 Mg/m^3 (0.3%).
- For cores of samples at boundary, the average value of dry density is 1.658 Mg/m^3 and the difference for all samples is -0.011 Mg/m^3 (-0.7%).

Because the difference of dry density has been minimal, the effect it has is negligible on construction methodology at the boundary.

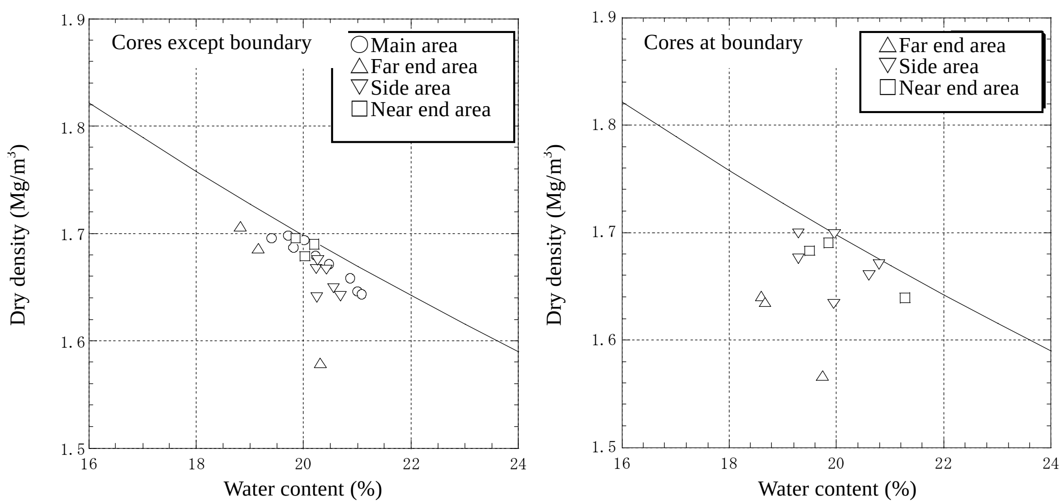
On the other hand, the relation between water content and dry density of cores, except samples at boundary, is shown in figure 10(a). The relation between water content and dry density of cores of samples at boundary is shown in figure 10(b). Moisture content has been calculated by dry and wet weight of the cores. In these figures, the curve at no porosity is added. Most cores have been compacted in high density.

Regarding the variation of dry density by depth, the relation between depth and density of cores is shown in figure 12. It has been proven that the dry density at the upper part is bigger than lower one. But every dry density was within range of target value[6) .



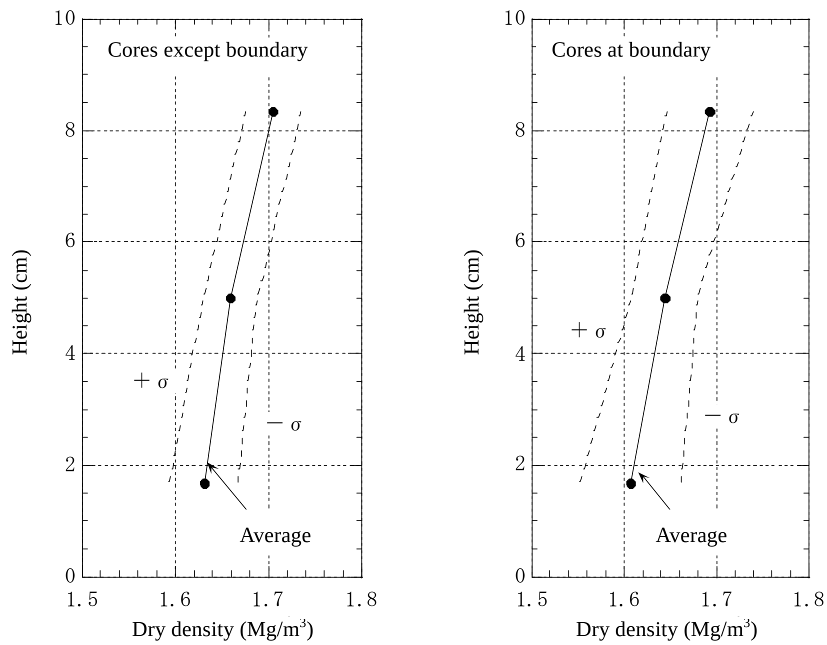
(a) All cores (N=39) **(b) Cores except boundary (N=27)** **(c) Cores at boundary (N=12)**

Figure 9. Dry density histogram



(a) Cores except boundary (N=27) (a) **Cores at boundary (N=12)**

Figure 10. Relation between water content and dry density



(a) Cores except boundary (a) **Cores at boundary**

Figure 11. Relation between depth and dry density

CONCLUSION

The buffer construction test has been conducted since FY2007 to validate construction methodology and quality control. Additionally, the buffer construction test has been carried out at first layer to confirm the procedure. At the result, the construction methodology that spread bentonite by asphalt finisher and compact on-site by large vibrating roller has been confirmed. On the other hand, the dry density of buffer after construction has ranged in 1.6±0.1 Mg/m^3 set for target value.

Now that the plan of buffer construction test has been reviewed, the remaining buffer construction tests will be continued from this time. After the buffer construction tests, laboratory tests will be carried out to investigate mechanical and hydrogical characteristics, and the evaluation for construction methodology and quality will be carried out. These results will enable the use of the confirmation of construction methodology and quality control in future.

ACKNOWLEDGEMENT

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