Ground Improvement Techniques in Land Reclamation

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Ground Improvement Techniques

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  - Tokyo/Haneda International Airport

Concluding Remarks
Kansai International Airport
- Land Reclamation with mountainous soil
- Sand drain method
### Land Reclamation with Mountainous Soil
- **Kansai International Airport** -

<table>
<thead>
<tr>
<th>Phase</th>
<th>Area</th>
<th>Total of Seawall Length</th>
<th>Reclaimed Sand</th>
<th>Ave. Seabed Depth</th>
<th>Ave. Estimated Settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st phase</td>
<td>510 ha</td>
<td>11.2 km</td>
<td>180 Mm³</td>
<td>-18 m</td>
<td>11.5 m</td>
</tr>
<tr>
<td>2nd phase</td>
<td>545 ha</td>
<td>13 km</td>
<td>250 Mm³</td>
<td>-19.5 m</td>
<td>18 m</td>
</tr>
</tbody>
</table>
Geotechnical condition

Water depth: from 18 to 20 m.

Alluvial layer:
- thickness: 20 m to 25 m
- normal consolidation condition
- natural water content of 80% to 120%
- $q_u$ increases with depth.

Dilluvial layers:
- over-consolidated Pleistocene clay,
- OCR value of around 1.3
construction scheme

AGS(HK) One day Seminar on Reclamation
Seawall dike

Nov. 29, 2014

Reclamation
In the beginning, total of 1.5 m thick sand mat layer was created uniformly over the seabed by means of sand spreading barges. The sand mat layer should be constructed in two or three steps to prevent local ground failure due to undulation of the layer.
Ground improvement

2. SDs installation

diameter: 40 cm
spacing: 2.5 m x 2.5 m in square grids
depth: - 45m
more than 120 million SD barges at site
Land reclamation
Land reclamation
Land reclamation
Settlement measurements

The settlement prediction:
- about 8 m for the Holocene layer
- about 10 m for the Pleistocene layer.
New Kitakyushu Airport
- Land Reclamation with dredged soil
- PVD drain method
LAND RECLAMATION WITH DREDGED SOIL
- NEW KITA-KYUSHU AIRPORT -

Airport island: 4,125m * 900m
Area: 373ha
Runway: 2,500m
Construction period: 1994 to 2006
Open: March 2006
Ground condition
Construction scheme

- Reclamation with dredged clay
- Surface soil stabilization
- Filling
- Construction of airport facilities
- Residual settlement after opening
- Designed elevation
- Opening
- Filling of sand mat
- Fill
- Sand mat
- Dredged marine clay
- Reclaimed layer
- Existing seabed
- Time
Construction of seawall dike

Seawall dike

Sand Compaction Pile Method

Cross section of seawall dike

SCP (as=30%)

reclaimed fill

gravel
Dredged soil at Kanmon Channel

<table>
<thead>
<tr>
<th></th>
<th>gravel</th>
<th>coarse sand</th>
<th>sand</th>
<th>silt</th>
<th>clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 2mm</td>
<td>&gt; 0.42mm</td>
<td>&gt; 0.074mm</td>
<td>&gt; 0.005mm</td>
<td>&lt; 0.005mm</td>
</tr>
<tr>
<td></td>
<td>0.0 – 11.9%</td>
<td>0.4 – 9.7%</td>
<td>2.8 – 30.7%</td>
<td>2.3 – 20.3%</td>
<td>43.8 – 87.1%</td>
</tr>
</tbody>
</table>
Vertical drain technique

0.9 million PVDs, total length of 18,000km
Settlement Prediction and Measurement

PVD improvement:
- width: 10cm
- thickness: 0.5cm
- spacing: 1.4m
The measured settlement data for individual layer was consistent with each prediction. At 660 days, the total settlements were varied from 450 to 540 cm. Another settlement of about 250 cm is expected in future.
Construction of facilities

lower subgrade layer

upper subgrade layer

Construction of terminal building
Central Japan International Airport
- Land Reclamation with cement treated dredged soil
- Pneumatic flow mixing method
Land reclamation with dredged soil with cement treatment

- Central Japan International Airport
Land reclamation with dredged soil with cement treatment
- Central Japan International Airport -

**Phase I**
- Runway: 3,500 m
- Plane area: about 470 ha

**Future**
- Runway: 2 * 4,000 m
- Plane area: about 700 ha

**Estimated airport demand (per year)**

<table>
<thead>
<tr>
<th></th>
<th>Passengers (million)</th>
<th>Cargo (million tons)</th>
<th>Take off (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>8</td>
<td>0.43</td>
<td>0.13</td>
</tr>
<tr>
<td>Future</td>
<td>10</td>
<td>0.53</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Land reclamation

Reclamaiton by mountainous soil (approx. 61.8 million m³)
   by dumping, shooting
Reclamation of dredge soil (approx. 8.2 million m³)
   by PNEUMATIC FLOW MIXING METHOD

approx. 4.3 km

airport facility site

approx. 1.9 km

mountainous soil

airport facility site

dredge soil

regional development site

mountainous soil
PNEUMATIC FLOW MIXING METHOD

Diagram showing the process of pneumatic flow mixing with labels for:
- Pneumatic barge
- Stabilizing agent supplier barge
- Placement barge
- Improved ground
- Pipe line
- Soil transport barge
- Sea revetment
- Compressed air
- Clay plug
- Soft clay
Construction scheme

Reclamation with cement treated dredged clay  Construction of airport facilities

Height of seawall  Filling

Seawater level  Height of seawall

Elevation

Cement treated dredged marine clay

Existing seabed

Time

Treated soil:

\[ q_{uf} = 157 \text{ kN/m}^2 \]

Mixing ratio: 54 to 60 kg/m³

No ground improvement is necessary
Execution plan

- Pneumatic barges
- Cement supplier barges
- Placement barge

Diagram showing the execution plan with relevant water levels and barges marked.
facility

soil transport barge, pneumatic barge & cement supplier barge
facility
placement barge

improved ground
placement barge
Mixing control system

- Measured water content
- Screen
- Water pump
- Sieve
- Mixing batch
- Flow meter
- Pump
- Measured flow volume
- Measured density
- Compressed air
- Cement slurry
- Pump
- Measured slurry volume
- Calculating and controlling amount of cement
- Cement supplier barge
- Pneumatic barge
- Cement supplier barge
- Measured slurry volume
- Flow meter
- Density meter
Tokyo/Haneda International Airport
- Land Reclamation with cement treated dredged soil
- Sand drain method and Pneumatic flow mixing method
The man-made island is located between the mouth of Tama River and the main sea route to Tokyo Port. In order to minimize the adverse influence to the water flow of Tama River, the west part of the runway is a steel-jacket-platform structure while the other is a reclamation land. As the east part of the reclaimed land is anticipated to obstruct a part of the main sea route, the main sea route has to move rotationally about 16 degree to the east, which requires additional dredging work. The dredged soil is stabilized with cement for reclamation of the island.
Land reclamation in C-runway

beneficial use of dredged soil

"Haneda Mayonnaise Layer"  
water content > 150%

Fabri-packed sand drain method was applied for assuring stability of drain

PVD method was also applied for further speed up consolidation.
Land reclamation in D-runway
- construction of sea dike -
construction scheme

[Diagram showing construction scheme with labeled components: Reclamation with treated dredged clay, Filling, Construction of airport facilities, Residual settlement after opening, and layers such as Treated dredged clay, Sand mat, Existing seabed, Fill, Treated clay, etc.]

long term settl.
Land reclamation

- Pneumatic flow mixing method -

Pneumatic flow mixing method
mixing condition:
water content:
cement content
target strength:
Land reclamation
- Pneumatic flow mixing method -
Land reclamation
- construction at junction -
Land reclamation - construction of steel jacket -

- 平成20年9月16日に総数198基のうち、66基の据付を無事に完了。
- 引き続き、ジャケットの据付・床版の設置を急ピッチで進めていく。

※1 船舶航行用に外周護岸に開口部を設置
※2 資材投入ボリュームに対する比率
※3 1基目のジャケット据付は、H20.1.9
CONCLUDING REMARKS

- Several ground improvement techniques are briefly introduced for different materials: mountainous soil, dredged soil and cement treated dredged soil.

- Many land reclamation constructions will be conducted with various types of reclamation material in future.

- I expect that this lecture will be useful and helpful for you reclamation projects.