New Kitakyushu Airport

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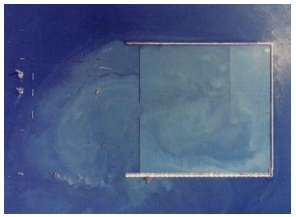
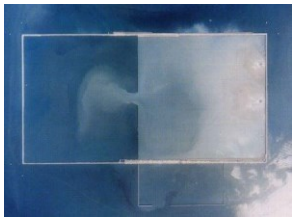
New Kitakyushu Airport opened on March 2006 was constructed on a manmade island which seats on a soft alluvial clay deposits. The Kanmon Strait between Honshu island and Kyushu island is one of the most important navigation channels for the Japanese economy and have been continuously improved and maintained since 1910. The airport island was originally a disposal pond for dredging of the navigation channel. The fill material for the island was, therefore, mostly dredged clay with extremely high water content. The project became really a challenge by ground improvement technologies.

August 1997

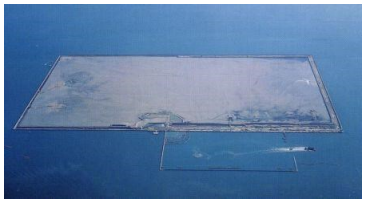
Airport Construction Decided in October 1994



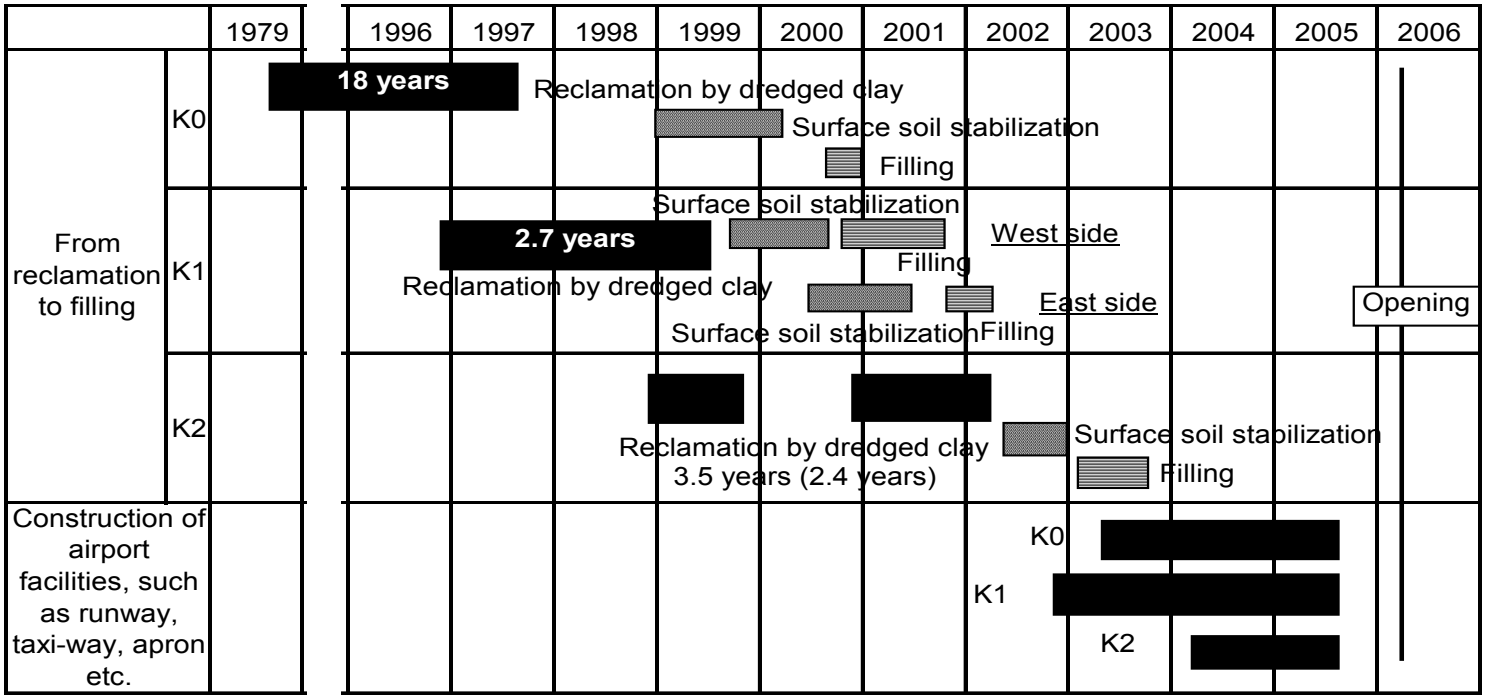
August 1979

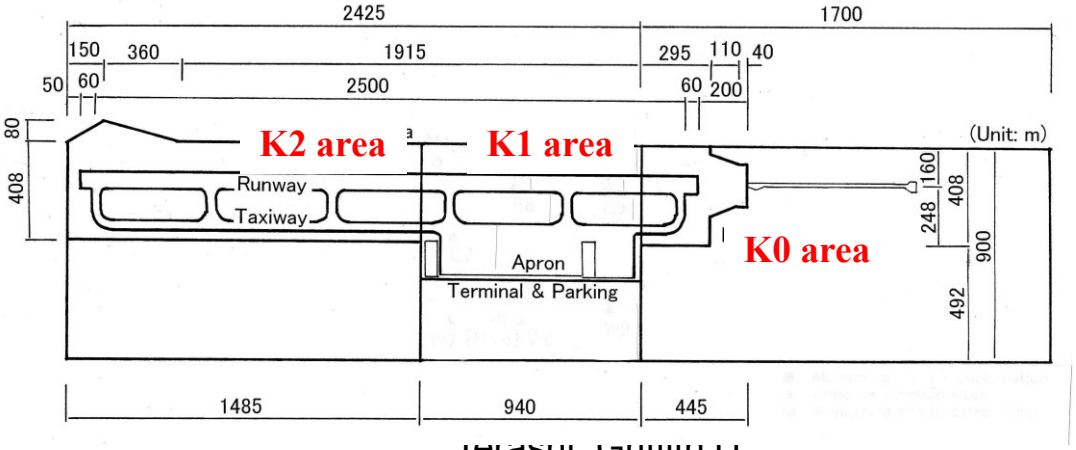


September 1982



March 1994





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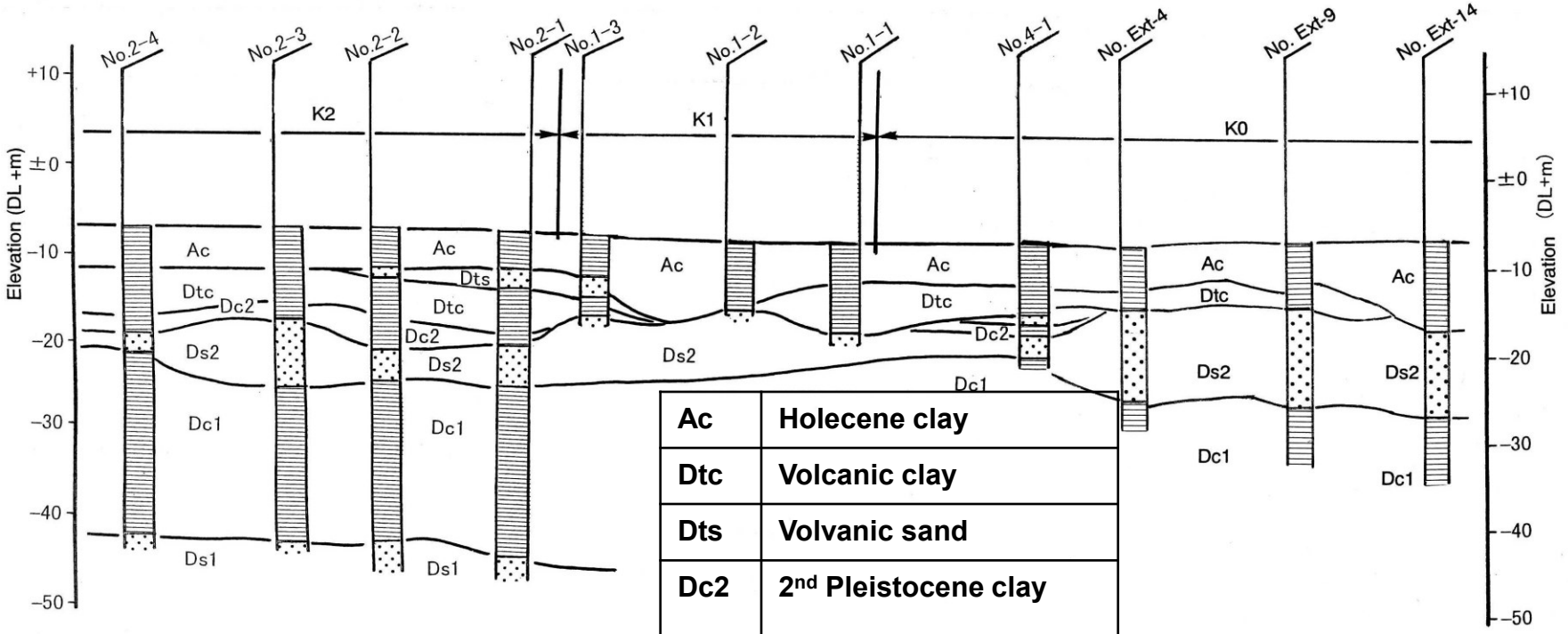
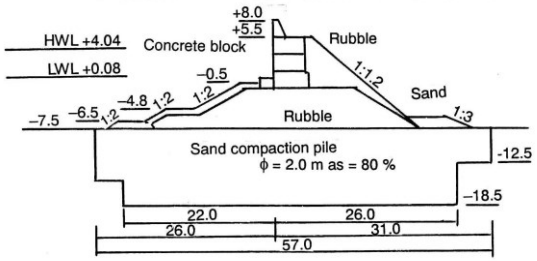
Soil Profile at the airport island site

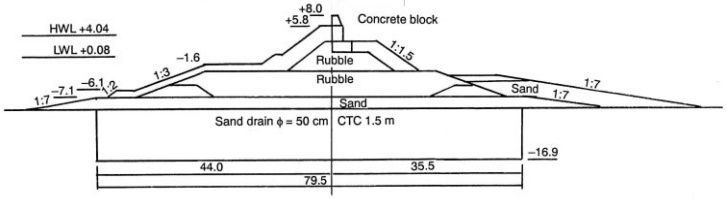


Ac	**Holecene clay**
Dtc	**Volcanic clay**
Dts	**Volvanic sand**
Dc2	**2nd Pleistocene clay**
Ds2	**2nd Pleistocene sand**
Dc1	**1st Pleistocene clay**
Ds1	**1st Pleistocene sand**

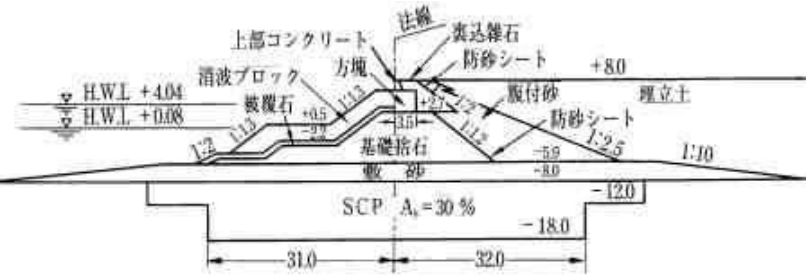
Water depth is around 10 m. The thickness of surface Holocene clay layer that poses geotechnical problems changes 4 to 10 m.



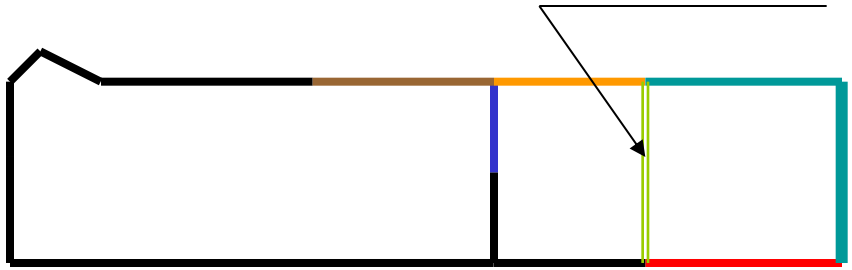
Concrete block + Sand Compaction Pile (80% replacement)

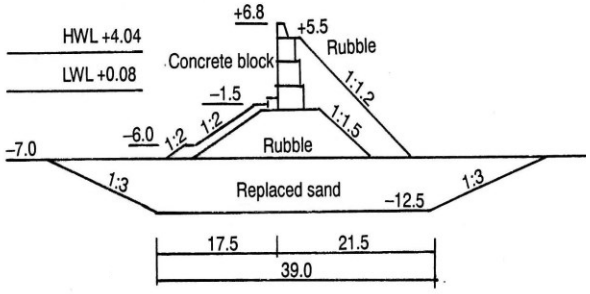


Sloping rubble mound + Sand Drain

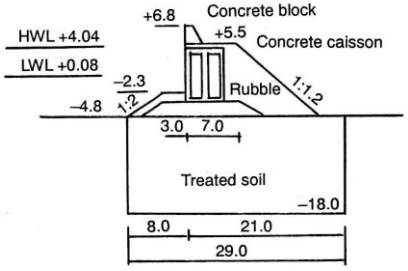


Rubble mound + Sand Compaction pile (30%)

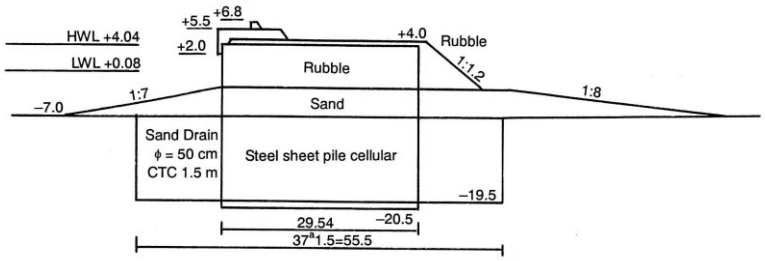




Rubble mound + replacement



Concrete Caisson + deep mixing



Cellular cofferdam + Sand Drain

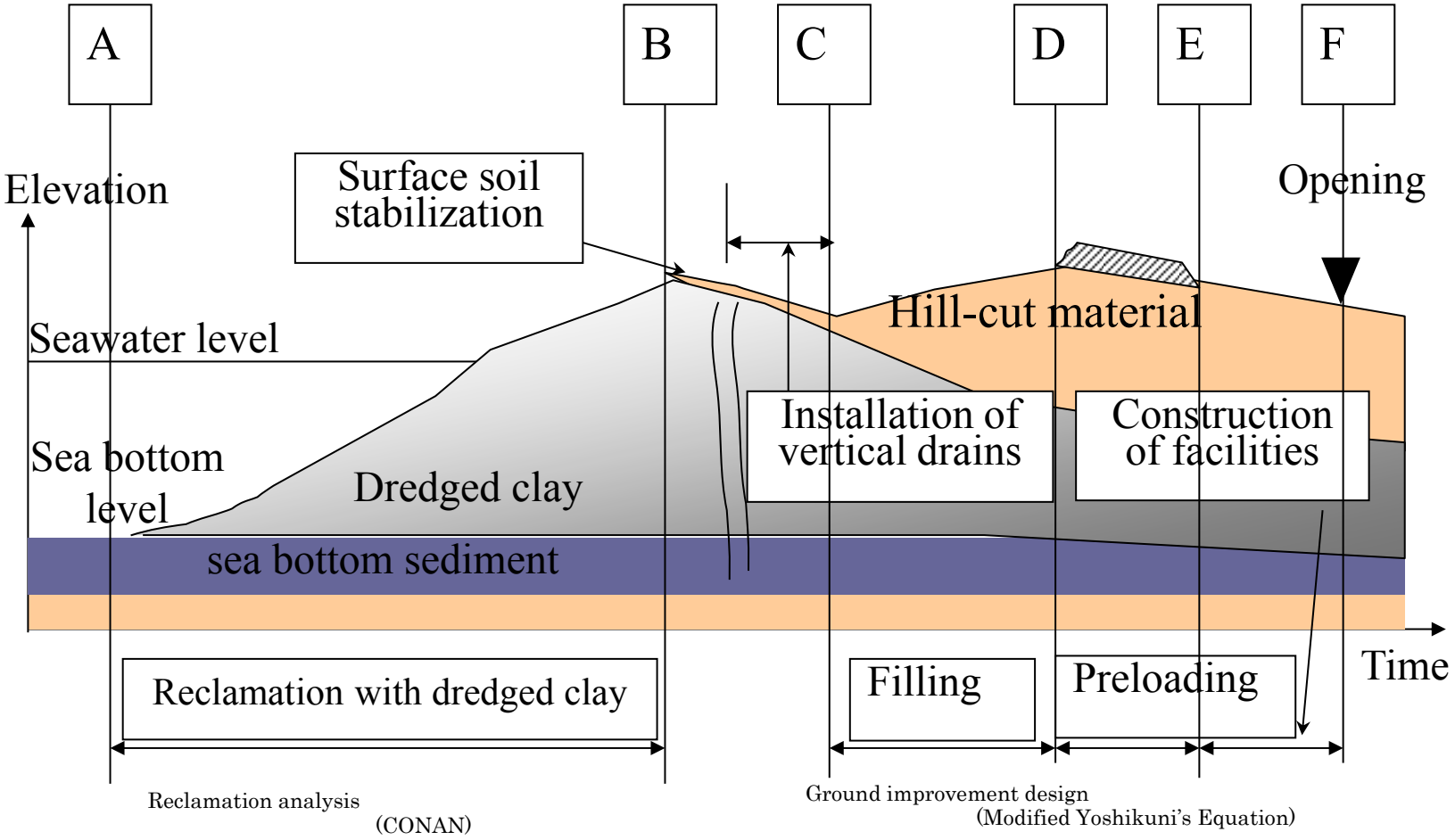
Various GI techniques used for seawall construction

Key issues in the sea wall construction

- Holocene clay layer should be improved to maintain the stability of seawall.
- Best combination of the sea wall structure and the ground improvement depend on a variety of factors; height of seawall depending on the wave direction, function of sea wall, thickness of soft layer, allowed construction term, and availability of the technology.
- The seawalls of earlier phase were designed in the middle of 1970s and those in the latter phase were designed in the late 1990s. The ground improvement technologies selected in the project somewhat reflect the development of GI technologies in the quarter century.

- Traditional Replacement method
- Preloading with vertical drain
- Sand Compaction Pile method with high replacement
- Sand Compaction Pile method with low replacement

Reclamation to the construction of airport facilities



Discharge of dredged clay

Extreme soft clay ground with surface dry crust

Pouring water for sand mat placement

Placement of sheet & hydraulic placement of sand mat

Ground Improvement of reclaimed land

Filling by hill-cut material

Consolidation of reclaimed clay under the fill

Uneven settlement of reclaimed soil

After taming the total and uneven settlement, R/W construction start

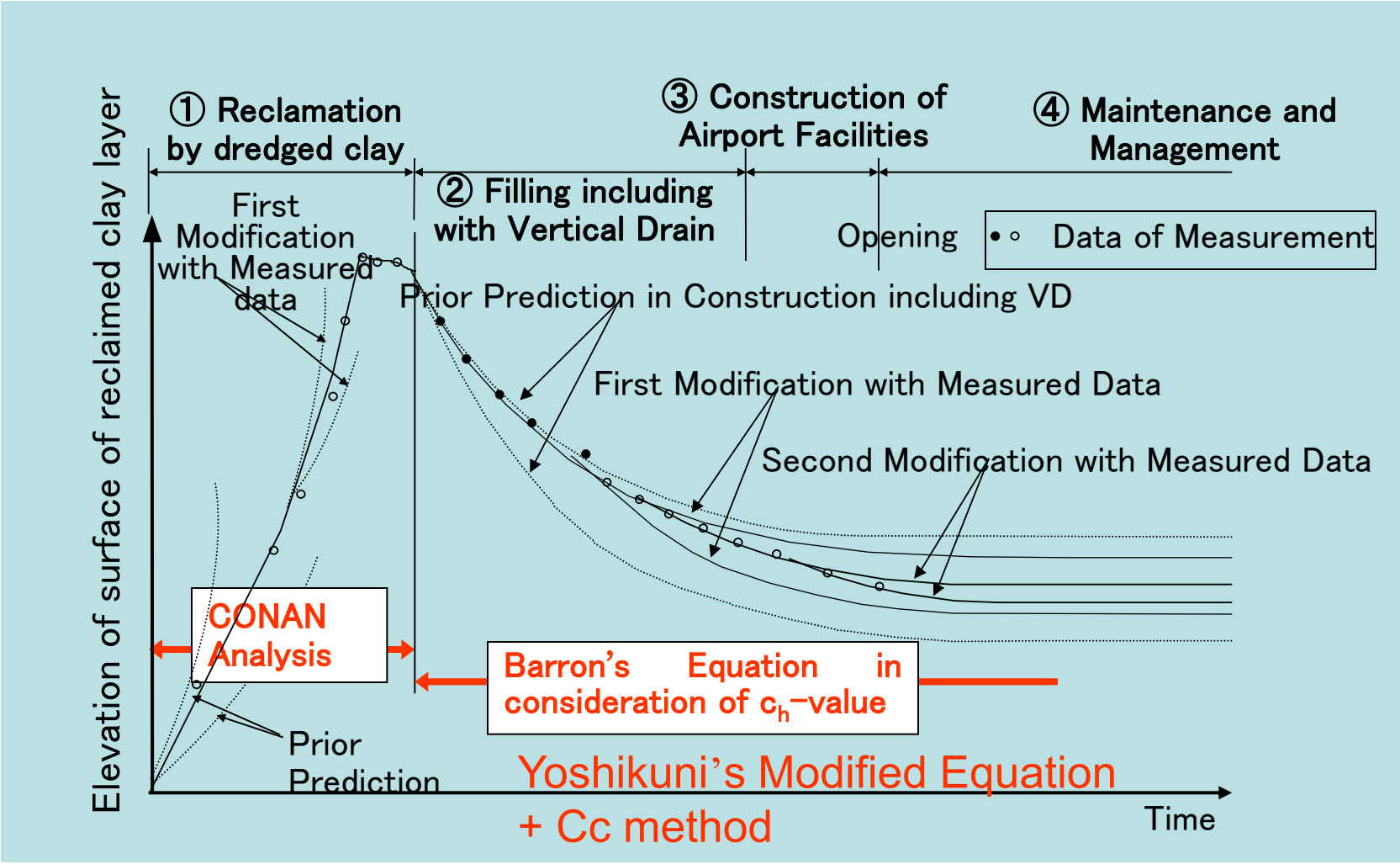
Key issue in the reclamation phase

Total and uneven settlements should be tamed to the allowable level for airport facilities.
Due to a limited construction term, the design of ground improvement had to be performed during reclamation with dredged clay.

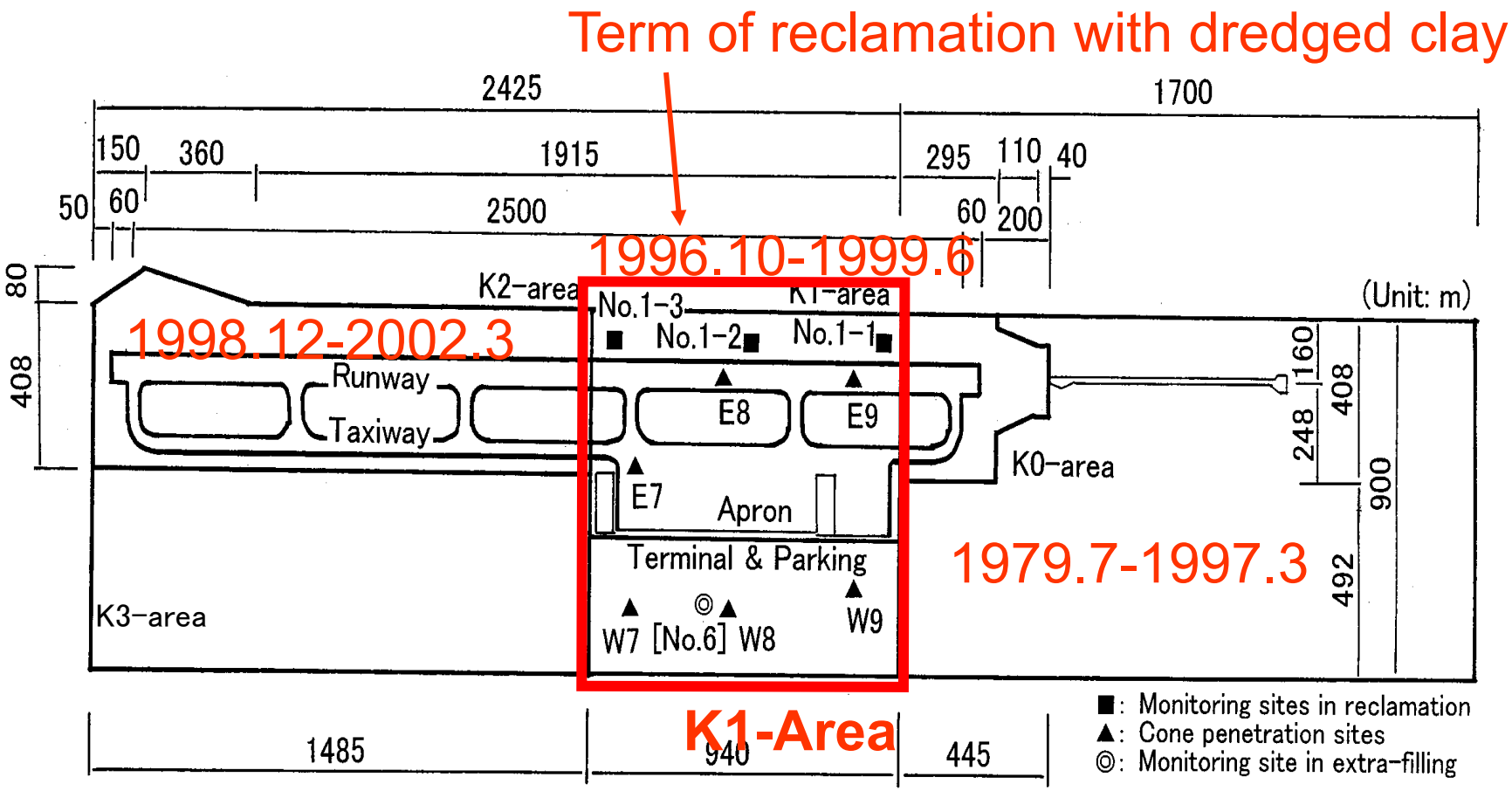
i) the accurate assumption of ground model, and
ii) determination of consolidation parameters
became the important issue.

⇨ Observational method combining Reclamation analysis and careful monitoring of reclamation process provided the reliable ground model and parameters.

Consolidation Analyses employed

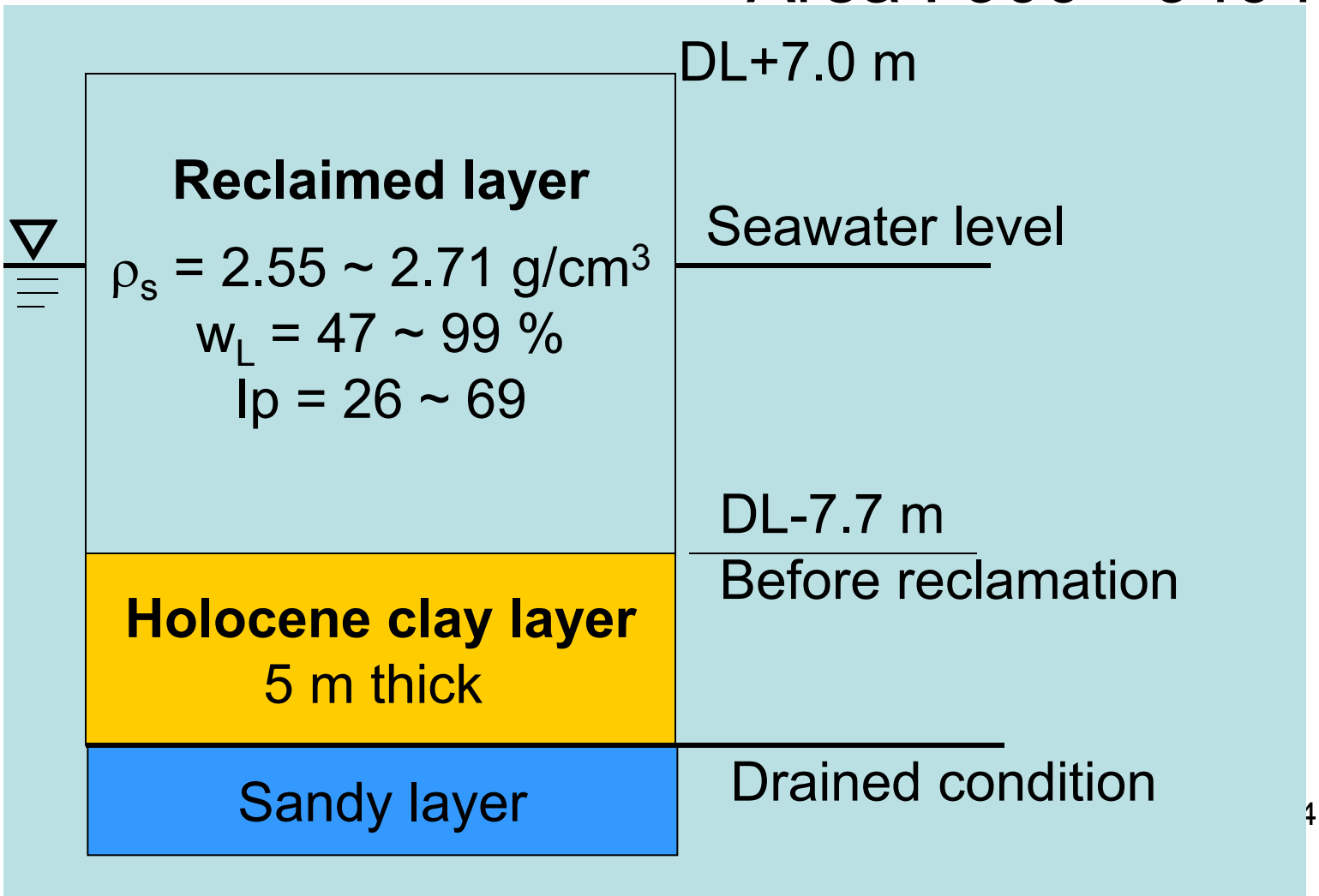


Example of analyses at K1 Area



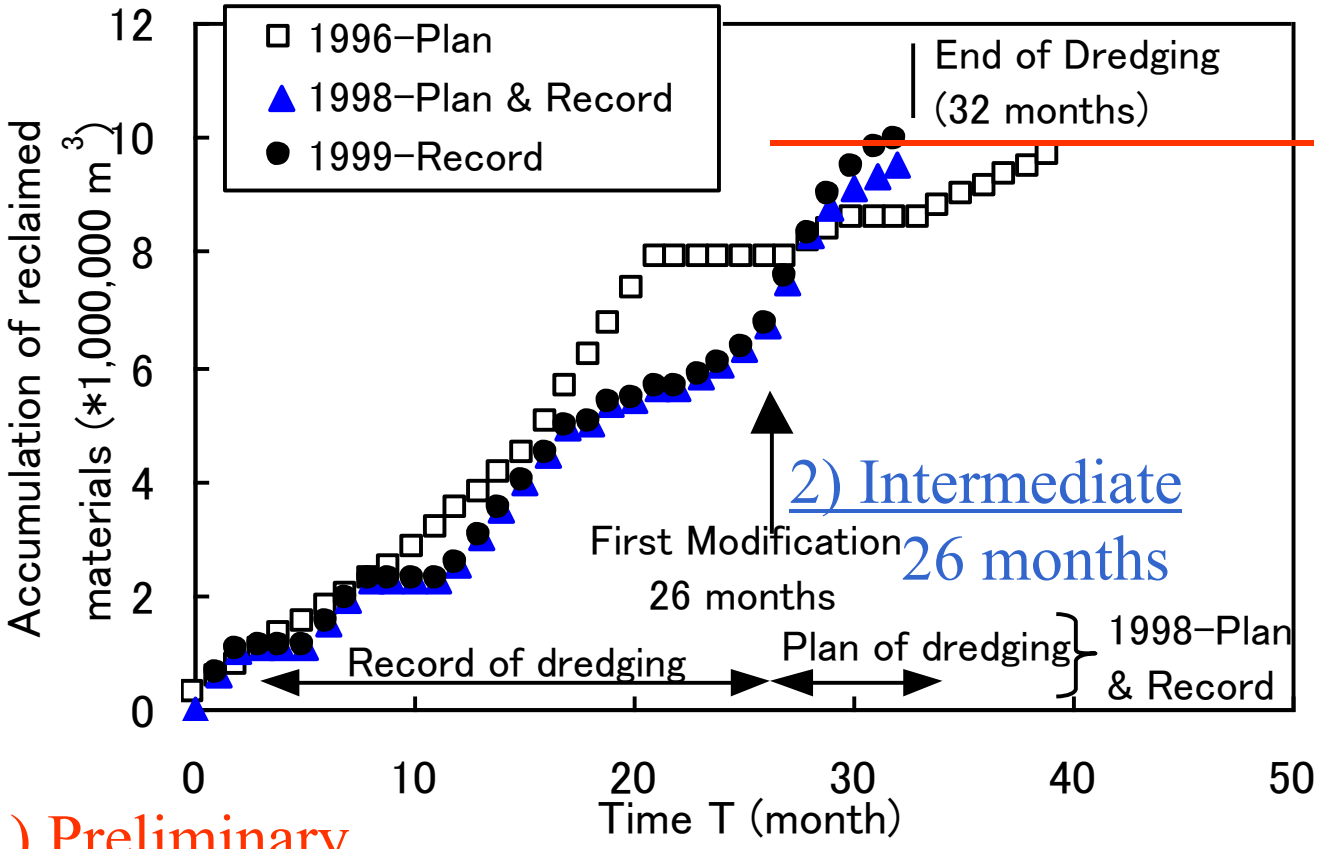
Conditions of K1-area

Area : 900 * 940 m



Time rate of discharge into K1-area

3) Back analysis conducted after reclamation



Total amount of dredged clay : 10 million m^3

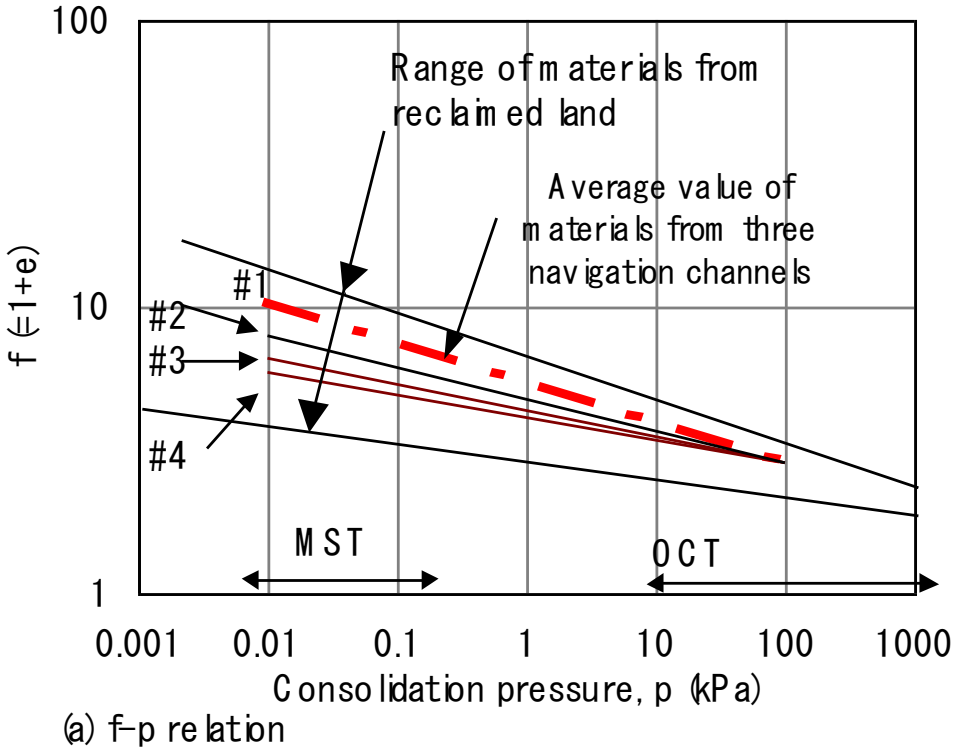
2) Intermediate 26 months

Determination of ground model
Design of ground improvement

1) Preliminary before reclamation

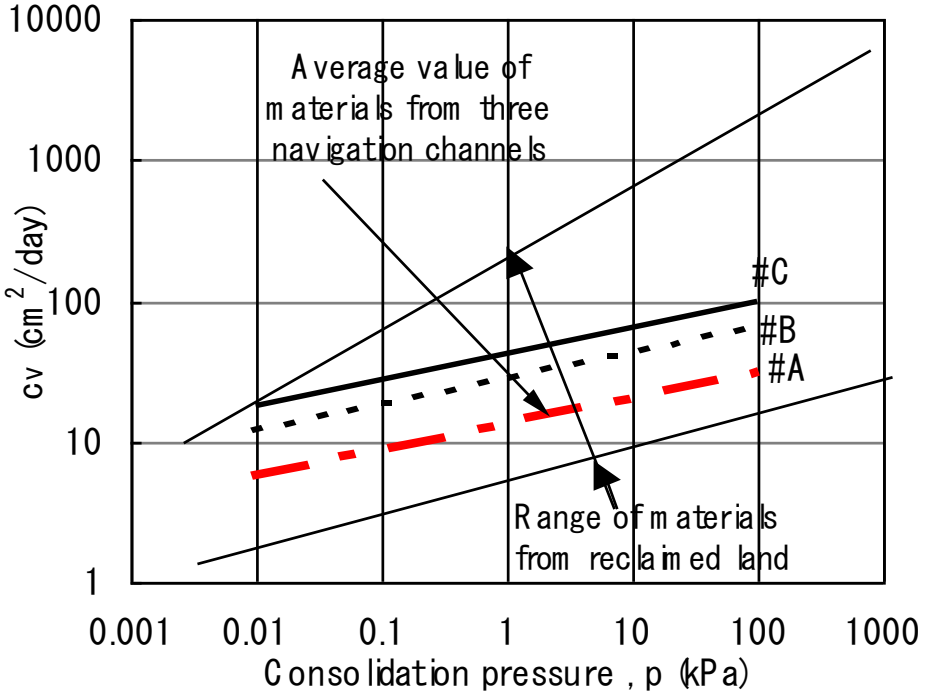
Consolidation Parameters

Compressibility



(a) f-p relation

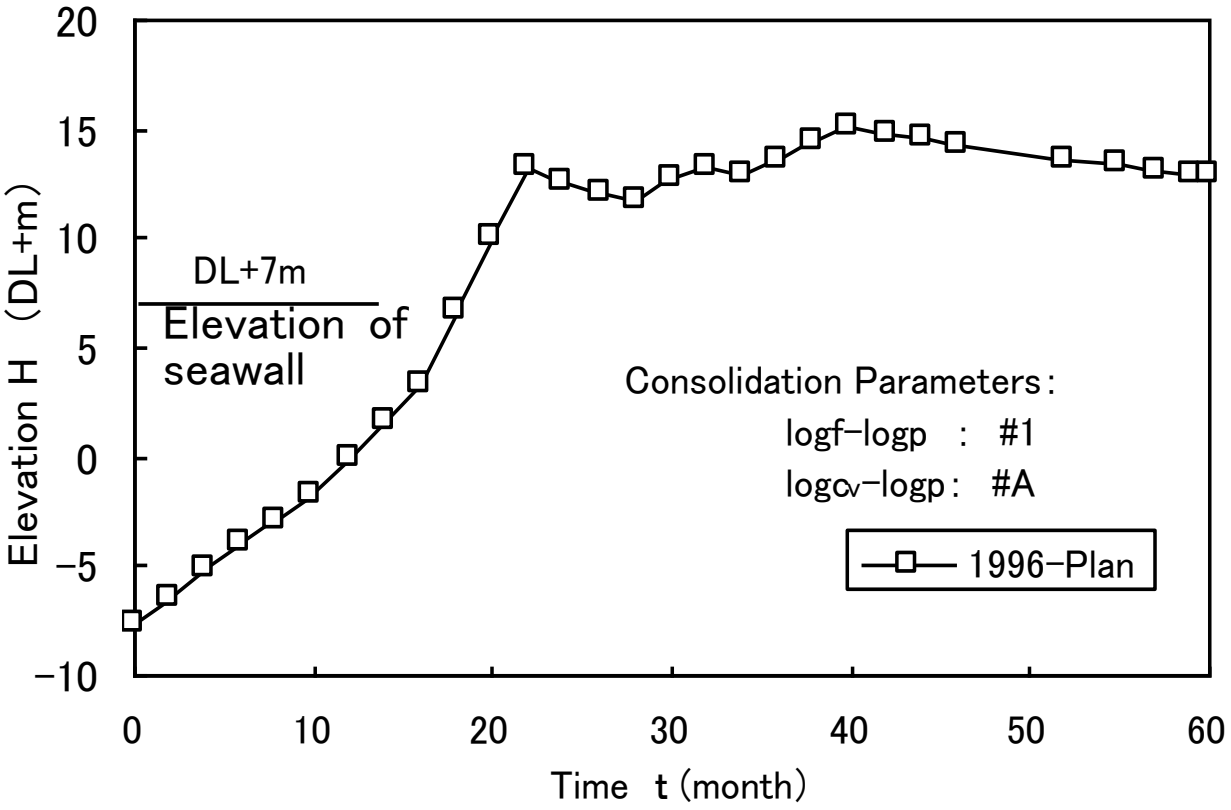
Rate of consolidation



(b) c_v – p relation

Evaluation of CONAN analysis

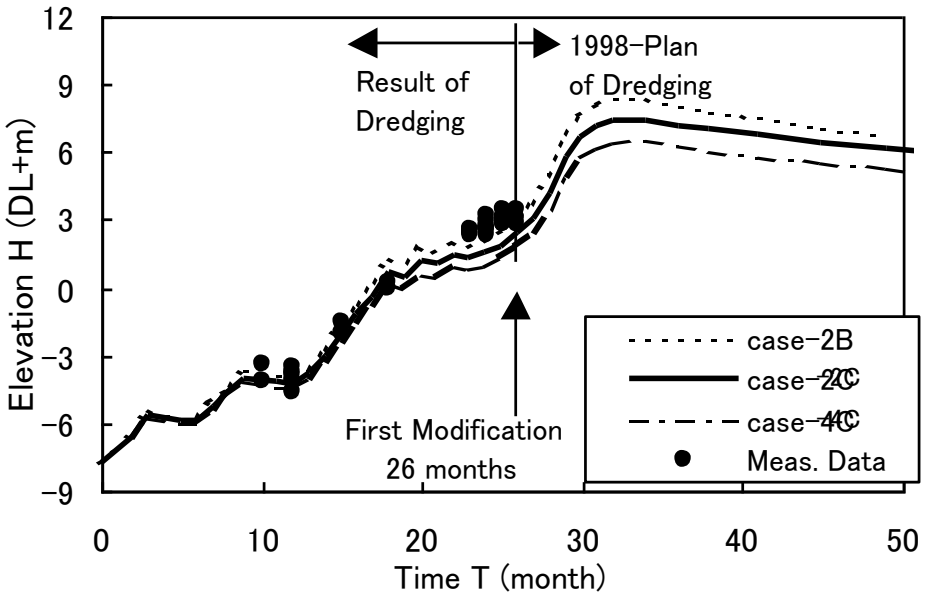
Preliminary prediction (Before reclamation)



Time-Elevation relation

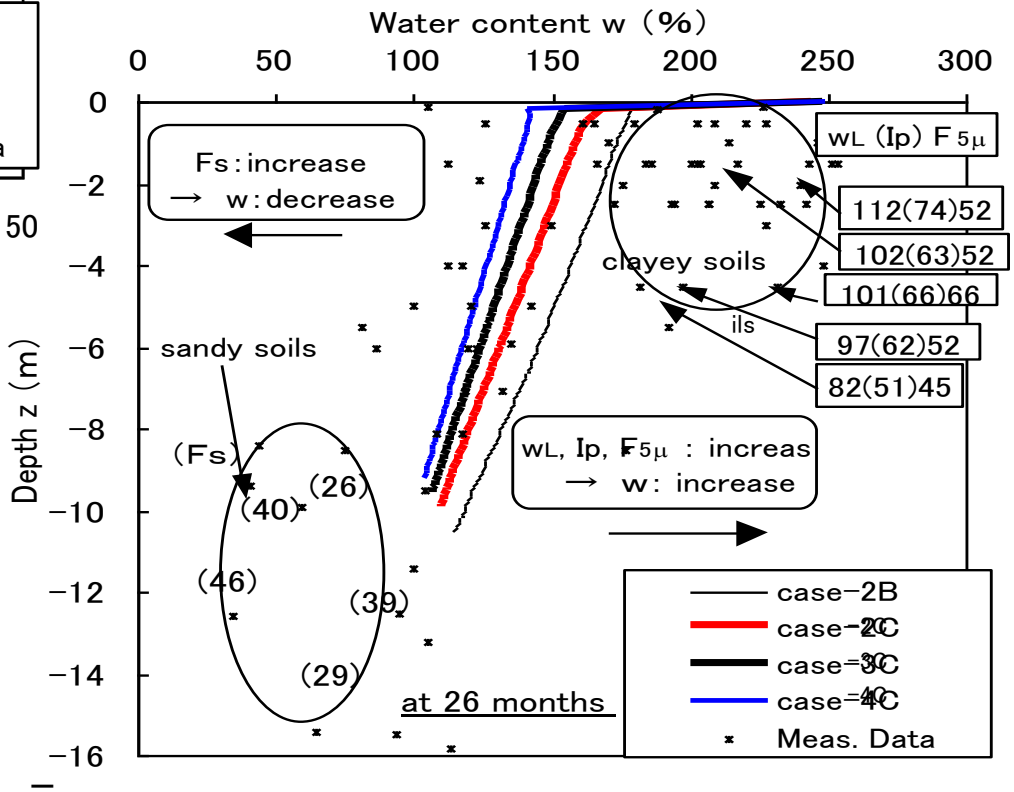
Intermediate prediction

(at 26 months)



Time-Elevation relation

Water content distribution

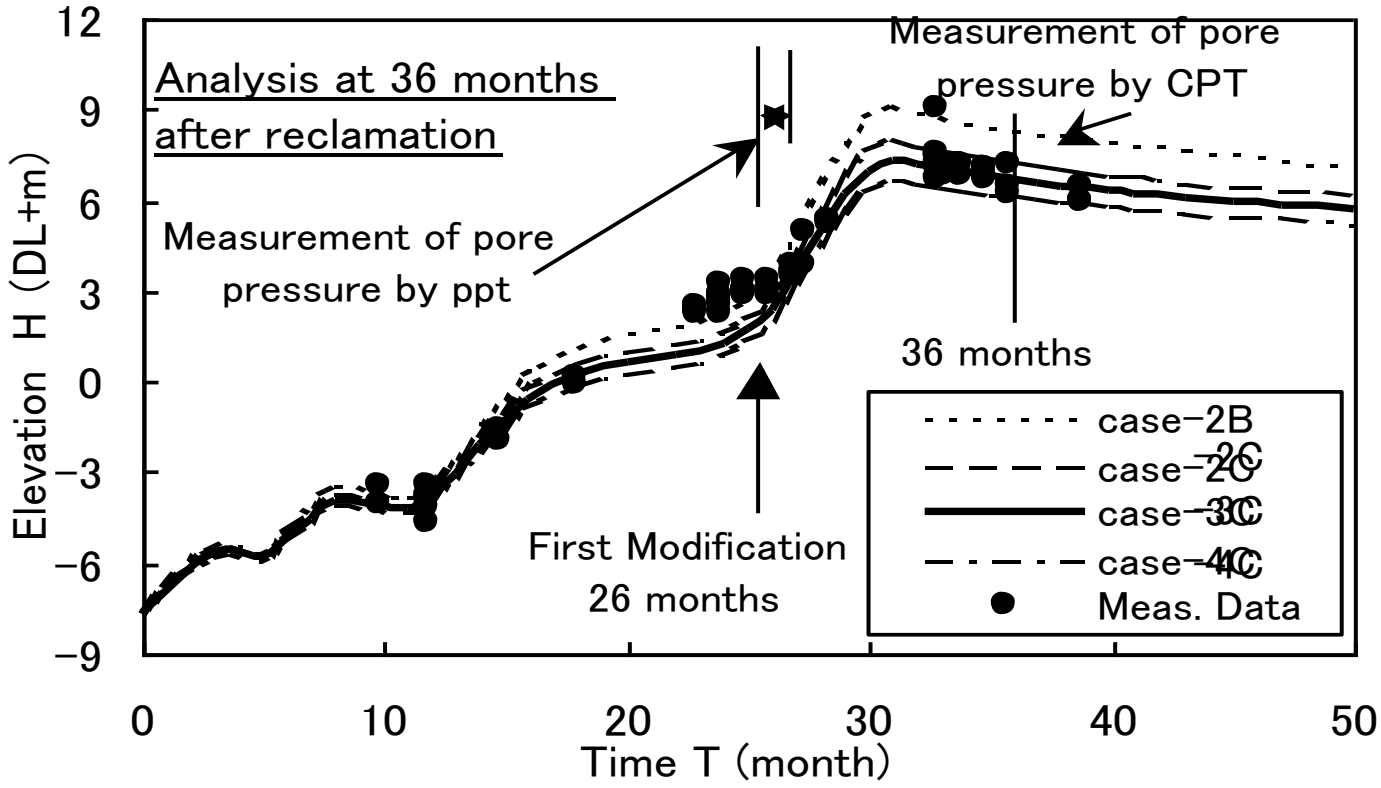


Original material:

Ip = 59 – 69

Fs = 4 – 8 %

Back Analysis



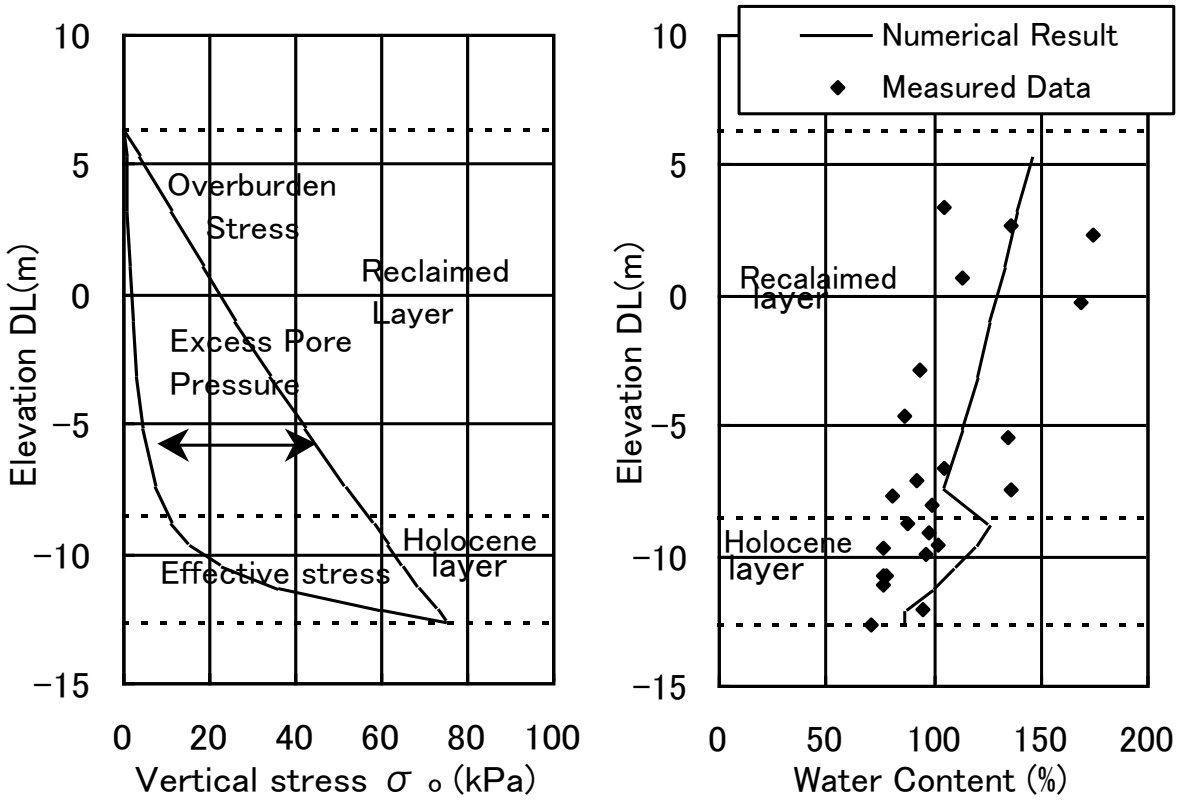
Intermediate prediction using case-2C is slightly larger than back analysis (3C) .

Estimation of soil profile for ground improvement design

At 26 months (during reclamation)

Best-fit combination case – 2C

Initial condition (ground model)



Estimation of consolidation parameters

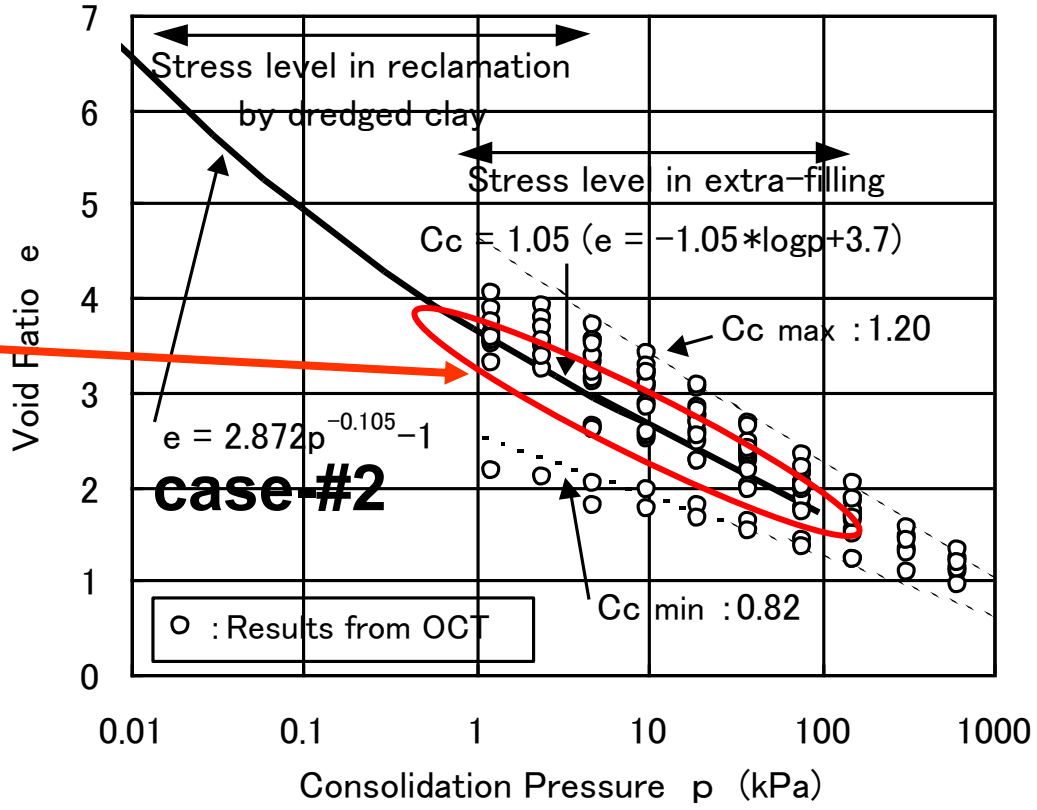
At 26 months (intermediate prediction)

Best-fit combination
: case-2C

$Cc = 1.05$

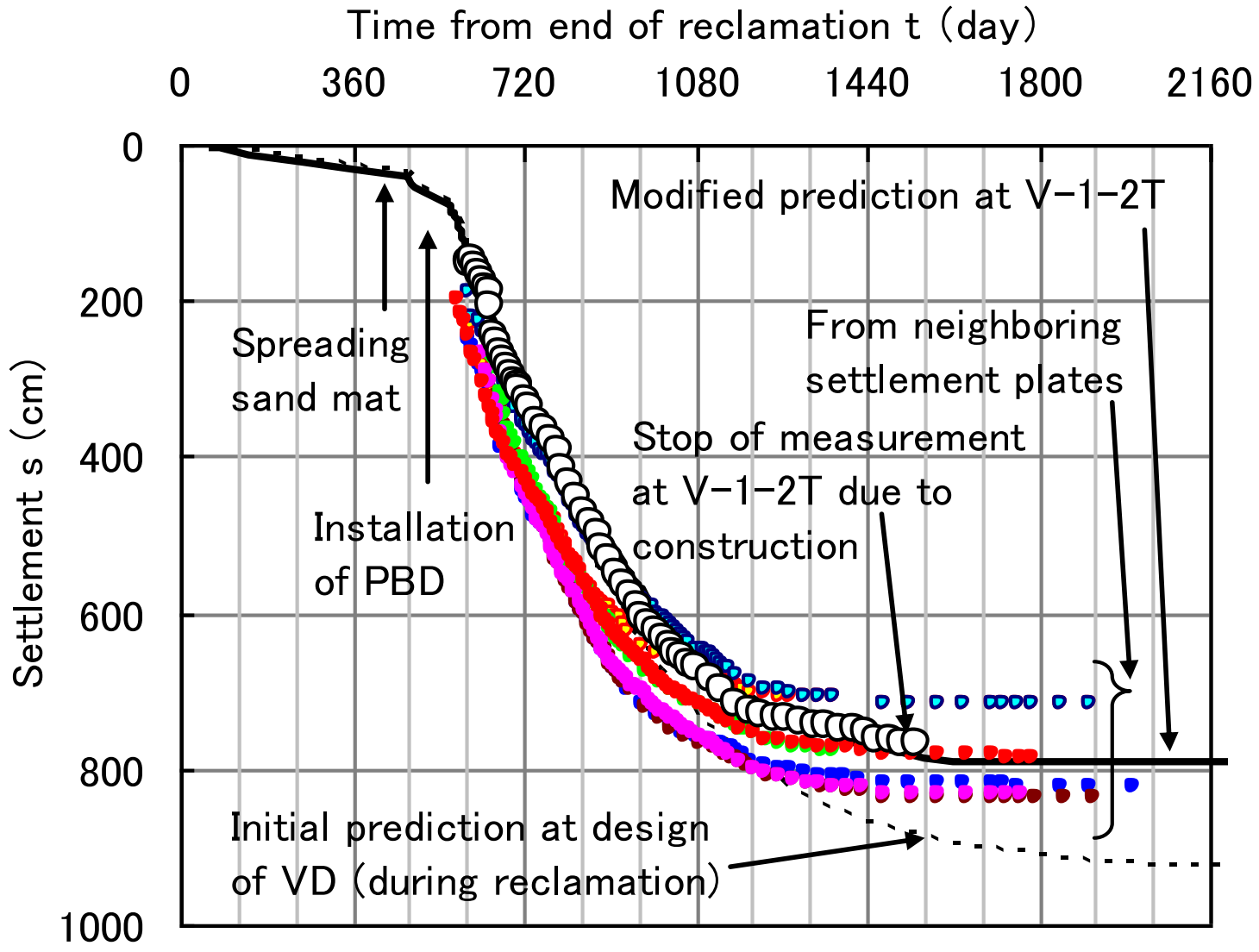
$c_v = 50\ cm^2/day$

Lower value of case-#C
from 1 to 100 kPa



Consolidation Parameters

Evaluation of ground improvement design by monitoring results



Summary of presentation

- Construction of the manmade island for the New Kitakyushu Airport was started in 1970s with the primary purpose of accommodating dredged clay slurry from nearby navigation channel. Seawall construction on soft Holocene clay needed the application of a variety of ground improvement technologies.
- After the Airport construction was decided in the middle of 1990s, total and residual settlement became the major geotechnical issue to be overcome. Prefabricated band shaped drain was extensively employed.
- The accuracy of predicted reclamation behavior is improved by the parameters identified through the detailed soil investigation and monitoring.
- Using the identified parameters, the consolidation behavior of dredged clay layer under fill pressure can be estimated with high accuracy.