Choo, S., Koh, S., Lee, J., Park, K., Suh, Y., Jue, K., Lee. D., A study for design method minimizing wetland's influence by tunnel excavation.
International Symposium on the Fusion Technology of Geosystem Engineering, Rock Engineering and Geophysical Exploration
Seoul, Korea, Nov. 18-19, 2003

A study for design method minimizing wetland's influence by tunnel excavation

Seokyean Choo[1], Sungyil Koh[1], Jongho Lee[1], Kyungho Park[2],
Youngho Suh[2], Kwangsue Jue[2], Duhwa Lee[3]
[1] Division of Geotechnical Engineering, Sambo Enginnering Co., Ltd, [2] Hyundai E&C Co., Ltd
[3] CEO, Sambo Enginnering Co., Ltd

Abstract: In recent, as Republic of Korea has been interested in environmental problem increasingly and became a member of many organizations or institutions related to environmental preservation such as a Ramsar convention, fundamental and completed methods to prevent ground water's drying up and leakage in tunnel excavation are requested. In this paper, we have studied the anticipated problems by tunnel excavation under the wetland and described the effective designed method to maintain the wetland's ecosystem environment. To accomplish this purpose, firstly, we investigated the wetland's ecosystem, ground's hydraulic properties and analysed the foreign similar case for tunnel excavation near the wetland. And by numerical analysis, we analyzed the runoff and infiltration quantity of water and hydraulic behaviour properties by saturation and unsaturation concept in rock mass and wetland. Finally, we established the effective countermeasure to minimize the ecosystem's bad influence by tunnel excavation.

1. Introduction

This paper describe a anticipated problem when tunnel is excavated under the ecosystem and wetland preservation areas. And to maintain these area effectively during tunnel construction and working, we study the proper design method.

As a major flow of this paper, firstly, we investigate the ecosystem and geological properties precisely and study the similar construction example in domestic or abroad to propose the proper design direction. Secondly, through the numerical analysis and so forth, we evaluate the influencing possibility as a tunnel is excavated. Finally, we establish the tunnel inner and outer countermeasure methods to minimize the ecosystem's destruction by tunnel.

2. Wetland's condition and investigation of the ecosystem

2.1 Definition of the wetland

Wetlands are among the most productive ecosystems, that is biological supermarkets, in the world. An immense variety of species of microbes, plants, insects, amphibians, reptiles, bird, fish, and mammals can be part of a wetland ecosystem.

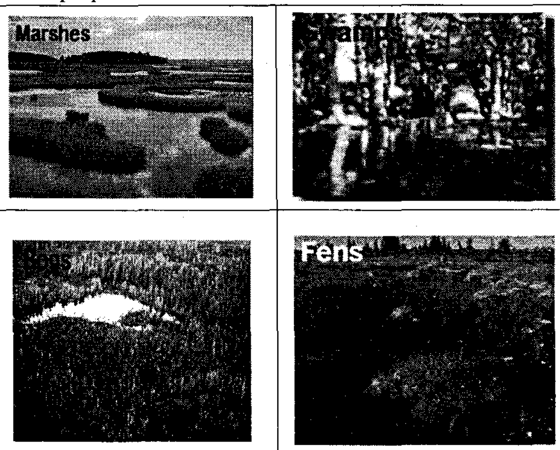
As the wetland preservation's regulation in 1999, wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. And wetland classify the coastal and inland wetlands.

2.2 The kind of wetland

According to the U.S EPA, the wetland is divided by four general categories; Marsh, Swamps, Bogs, Fens and major properties of the each wetland is below.

Table 2.1 Wetland's type and properties.

Type of Wetlands	Properties
Marshes	• Frequency or continually inundated with water, characterized by emergent soft stemmed vegetation adapted to saturated soil condition
Swamps	• Wetland dominated by woody-plants
Bogs	• Characterized by spongy peat deposits, acidic waters, and a floor covered by a thick carpet of sphagnum moss
Fens	• Peat-forming wetlands that receive nutrient from sources other than precipitation



2.3 Wetland in Korea

In Republic of Korea, wetland's developing is insignificant because there are tiny earthquake or volcanic activity, and there is no glacial area. But the crater lake on Mt. Paektu, the mouth of a Nakdong river and so forth are famous large scale wetland and the other large wetlands are distributed all over the Korea sporadically.

To protect and maintain of the wetland efficiently, Korea had joined the RAMSAR convention, which is the convention on wetlands of international importance especially as waterfowl habitat in 1997, and legislated for the wetland preservation's regulation in 1999.

The ministry of environment name six wetland area including Whaum wetland, which is a kind of fens in yangsan, for wetland preservation area.

Additionally some wetlands including Milbat are continued by environmental group's campaign continuously to assign for preservation area.

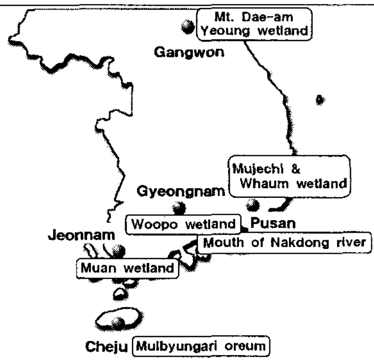


Fig. 2.1 The situation of the wetland distribution.

2.4 Situation of the wetland in design area

Under the two wetlands, #1, #2, tunnel will be constructed. In the case of wetland #2, it is assigned as a wetland preservation area by the law of wetland preservation and wetland #1 is going on environmental group's campaign continuously to assign for preservation area.

Because the wetland #1 is located in the 440m top area of the tunnel, we expect that wetland #1 is influenced by tunnel excavation. But in the case of Wetland #2, it is not influence by tunnel excavation because the wetland #2 is 2,600m away from the tunnel line.

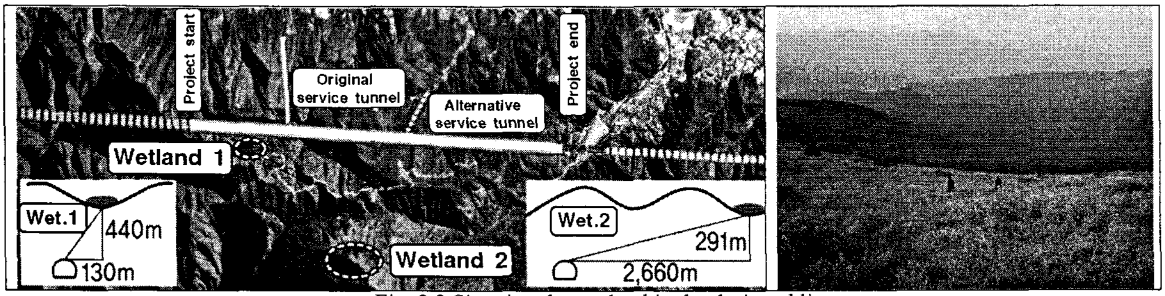


Fig. 2.2 Situation the wetland in the designed line.

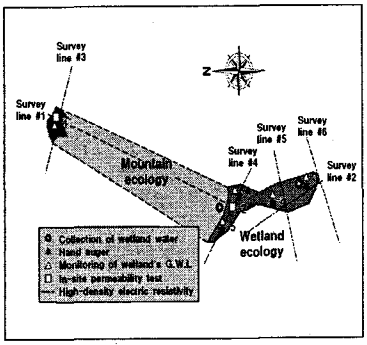
3. Situation of the ground investigation

3.1 The major investigation items

To evaluate the wetland's influence range by tunnel excavation, we are carried out various laboratory and in-situ tests as table 3.1.

Table 3.1 Investigation items.

Item		Purpose
Hand Auger	5ea	Distribution of the peat layer
Analysis of the water's age	1ea	Analysis the wetland's mechanism
Monitoring of the G.W.L	5ea	Evaluate the control guide limits of the ground water
Analysis of the water quality	3ea	
Permeability test in the wetland and LAB	3ea	Analysis the peat layer and Rock mass's permeability parameter
Rock Permeability test in the LAB.	1ea	
High-density electricity resistivity	0.84km	Distribution of the peat layer



3.2 The Conclusion of the investigation

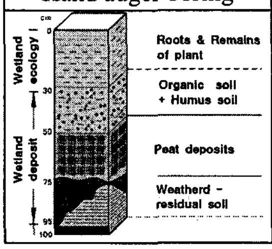
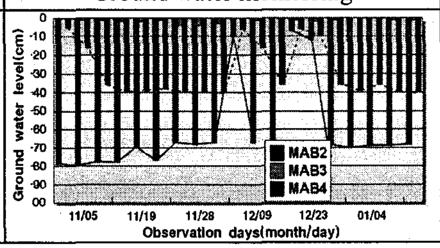
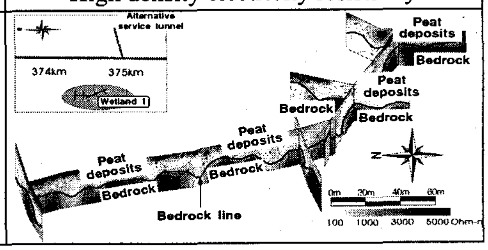
a) The vertical distribution properties of the wetland's peat layer :
- G.L-0 ~ G.L-0.3m
- G.L-0.3 ~ G.L-2.0m

b) The water level of the wetland
- Minimum water level : G.L-0.8m (in dry season)

c) The permeability properties of the peat layer(k) : 1.3×10^{-6}cm/sec

d) The depth of the rock mass by the high density electricity resistivity investigation : G.L-15 ~ 20m

Table 3.2 Investigation result in wetland area.

Hand auger boring	Ground water monitoring	High density electricity resistivity
		

3.3 Analysis of the geological properties

The design line is located to between Yangsan fault and Dongrae fault that is famous for its large scale fault in Korea. Major distributed rock mass in concerned area are biotitic granite, granitic andesite as a bulguk granite and andesite, rhyolite tuff, andestic tuff as a volcanic rock. Because of the large scale fault, that is Yangsan and Dongrae fault, the concerned area have a lot of minor lineament as a Fig 3.1.

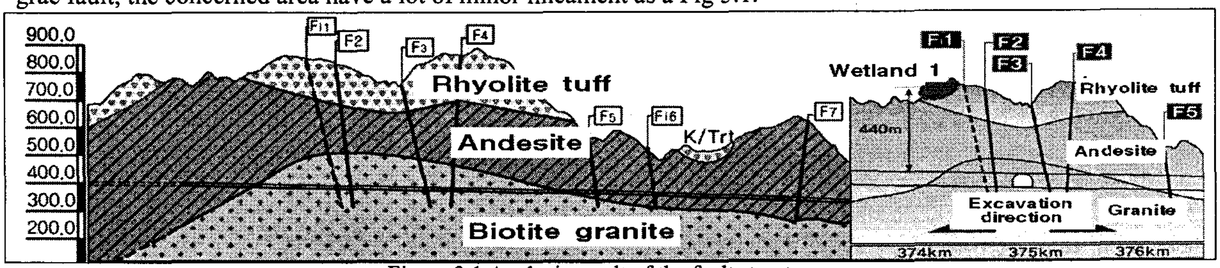


Figure 3.1 Analysis result of the fault structure.

4. Analysis of the similar construction and design case

4.1 The construction case in Korea

As a figure 4.1, The similar tunnel construction case in Korea neighboring wetland is an oil stockpiling base in Mt. Jaesuk. To prevent leakage of the oil gas, the tunnel have a water curtain on the tunnel upper part. Until now, the wetland that located to tunnel upper area had no effect on the wetland's ecosystem in spite of ground water's drop about 10m.

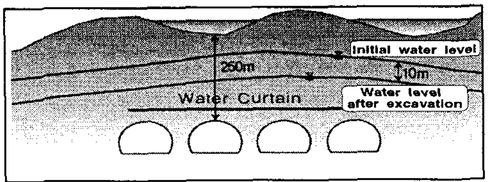


Fig. 4.1 Oil stockpiling base in Mt. Jaesuk.

4.2 The construction case in foreign

4.2.1 Yokomichi Tunnel in Hukusima Japan

Yokomichi Tunnel is located to neighboring Daen wetland, 750m^2 area, in Joil national park in Hukusima Japan. Although the wetland's ground water drop range is very small as the tunnel excavated, unexpected a large of leakage of water happened when tunnel penetrated a fault connected with the wetland.

Because of this leakage, the ground water level in rock mass and wetland dropped down 20m and 25cm separately.

As a countermeasure methos about this leakage, this construction site applied to cement milk grouting.

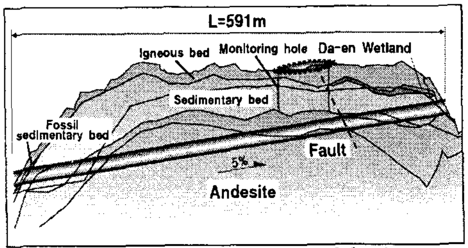


Fig. 4.2 Yokomichi tunnel in Hukusima.

4.2.2 Seto Tunnel in Nagoya Japan

Seto Tunnel is located to neighboring Damp wetland, 30,000m^2 area, in Nagoya Japan. To minimize the influence by tunnel excavation, the designer have evaluated the ground water's drop range and ecosystem's influence by tunnel excavation.

As a basic mechanism in analysing of the ground water behaviour properties, the ground water level and wetland's water level are changed separately when the tunnel excavated (saturation and un-saturation concept).

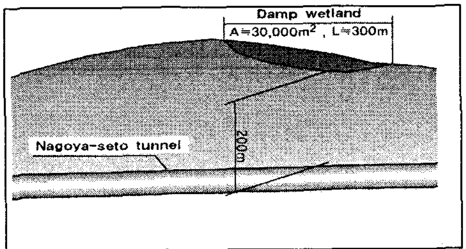


Fig. 4.3 Seto tunnel in Nagoya.

5. The mechanism wetland's generation and maintenance

Through analysis of the construction case and investigation of the wetland area, we studied the wetland generation and maintain mechanism. A thousand years ago, the moisture area was formed by FÖhn phenomenon, and a peat layer were accumulated(Stage Ⅰ).

As the stage Ⅱ, the wetland was produced as the basin was enhanced and then the ground water was formed to the wetland's upper layer due to the rain continuance.

As the stage Ⅲ, Although the condition of the wetland layer is changed in the saturated condition to the unsaturated condition in dry season, The wetland maintain the its dampness because of peat layer's low permeability.

As the stage Ⅳ, The peat layer changes to the saturated situation because the wetland's water level rises until G.L-0 in rainy season. Through the repeating of the rotation continuously in dry and rainy season, wetland's ecosystem maintains until now.

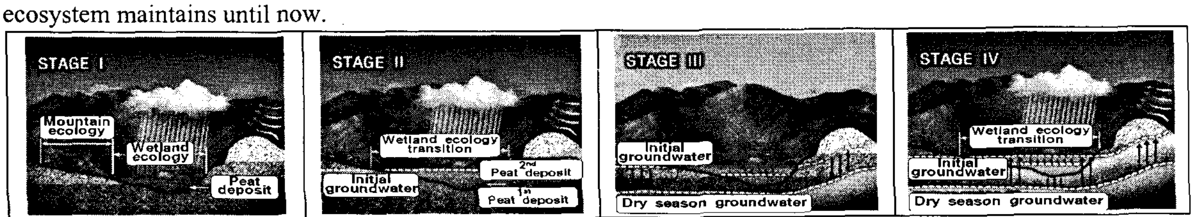


Fig. 5.1 Mechanism wetland's generation and maintenance.

6. Analysis of the wetland influence by tunnel excavation

According to the various hydraulic and geological investigation, we could decide the reasonable hydraulic parameters that anisotropic permeability using rock mass's joint orientation. And we made efforts for evaluating the actual hydraulic behaviour that wetland's peat layer is changed the saturated-unsaturated condition periodically.

6.1 Conclusion of the numerical analysis

In the case of wetland #2, its distance between tunnel and wetland #2 is 2,600m. Because of this long distance, we can presume that the wetland's influence is not happened.

But in the case of wetland #1, it is so close that we made efforts for evaluating the hydraulic behavior. The major numerical conditions are as follows

- Distance between tunnel and wetland : 454.0m
- Fault properties near by tunnel : width 2.0m, permeability(k) 10^{-5}m/sec
- Rock mass permeability

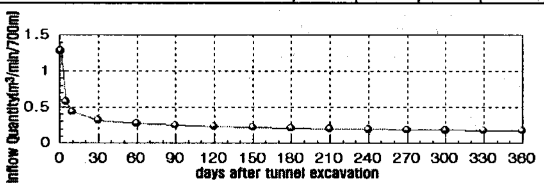
Table 6.1 The anisotropic permeability in rock mass.

Rock kind	Kx(cm/sec)	Ky(cm/sec)	Kz(cm/sec)
Andesite	5.70×10^{-7}	6.18×10^{-7}	2.15×10^{-7}

Influence range by tunnel excavation is that ground water drop to G.L-233m from tunnel. And tunnel inflow quantity is $0.2m^3$/min/700m after 180 days.

Table 6.2 Inflow and G.W.L change range

Day after tunnel excavation	5	30	90	360
Drop range of G.W.L(cm)	0	0	0	0



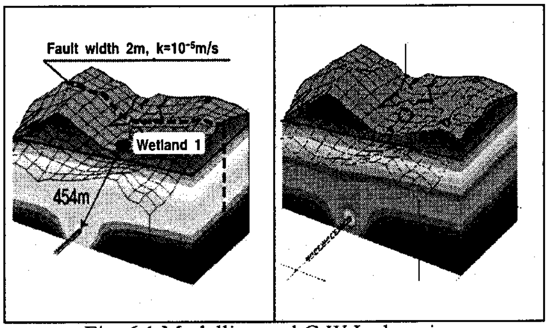


Fig. 6.1 Modelling and G.W.L changing.

6.2 Case study of the worst case considering a fault

To consider the active countermeasure, we assumed the condition of the worst case about the fault and accomplished the numerical analysis. The worst case of the fault's width and permeability as follow table 6.2.

Table 6.3 Analysis condition according to a width and permeability.

Permeability	Fault width 5m	Fault width 10m	Fault width 20m
10^{-4}m/sec	Case 1	Case 4	Case 7
10^{-5}m/sec	Case 2	Case 5	Case 8
10^{-6}m/sec	Case 3	Case 6	Case 9

Among the case of the table 6.3, the case 7, that is fault width 20m, permeability 10^{-4}m/sec, is the worst case. About the case 7, ground water level and wetland's water level dropped 65m and 10cm separately.

The wetland's water level did not changed during 20days after tunnel excavation. In this reason, If we planed the grouting construction method for countermeasure, we must finish the grouting within 20days.

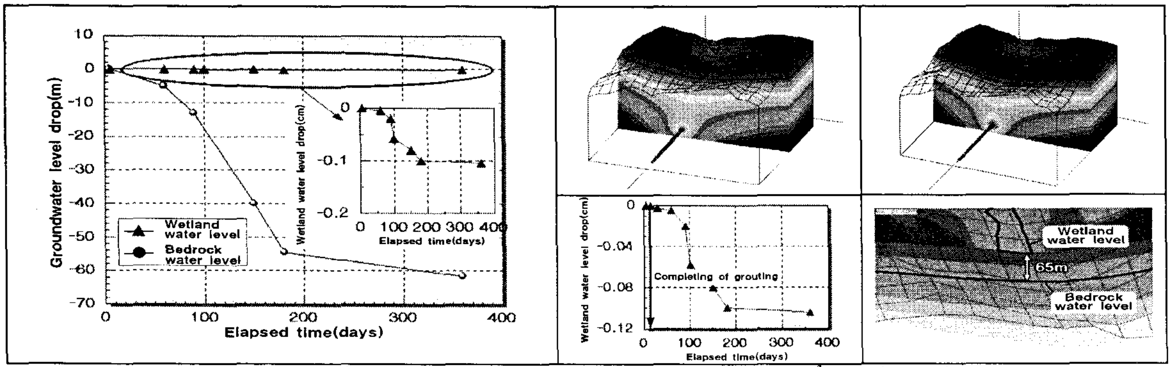


Fig. 6.2 Analysis result about fault width 20m, permeability 10^{-4}m/sec(Case 7).

7. The countermeasure in tunnel about water level drop

Through analysis of the similar construction site, we decide the countermeasure about water level drop using the pilot tunnel.

7.1 The review of the pilot tunnel plan

Through the pilot tunnel construction before major tunnel excavation, we can check the geological condition and ground water condition of the tunnel front area. Additionally, when we need to be grout the tunnel circumference for reinforce or preventing the inflow, the pilot tunnel can be used usefully.

Fig 7.1 is the section of the Yokomichi tunnel in Hukusima Japan. Like the Fig 7.1(c), We determined the pilot tunnel section to be considered the grouting efficiency, the degree of difficult of the grouting and analysis of the foreign construction case and so forths. Additionally, we determined the proper grouting area as a section (c) to prevent the ground water level drop through numerical analysis.

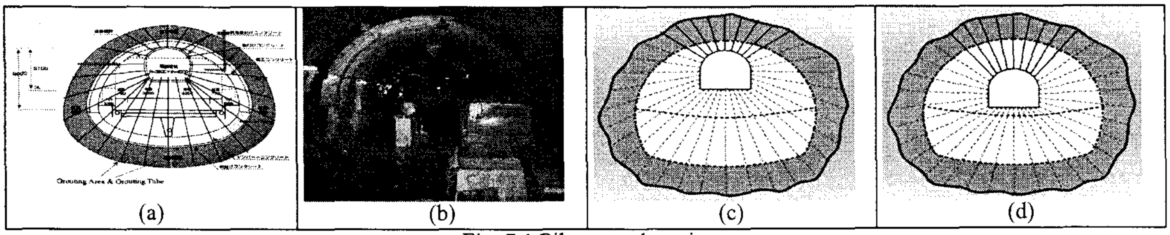


Fig. 7.1 Pilot tunnel section.

7.2 Construction sequence of the pilot tunnel

Like a Fig 7.2, pilot tunnel construction sequence is below

Ⅰ : excavate the pilot tunnel (Stage 1)

Ⅱ : execute the grouting for preventing the inflow (Stage 2)

Ⅲ : finish the pilot tunnel excavation and prepare the major tunnel excavation (Stage 3)

Ⅳ : excavate the major tunnel (Stage 4)

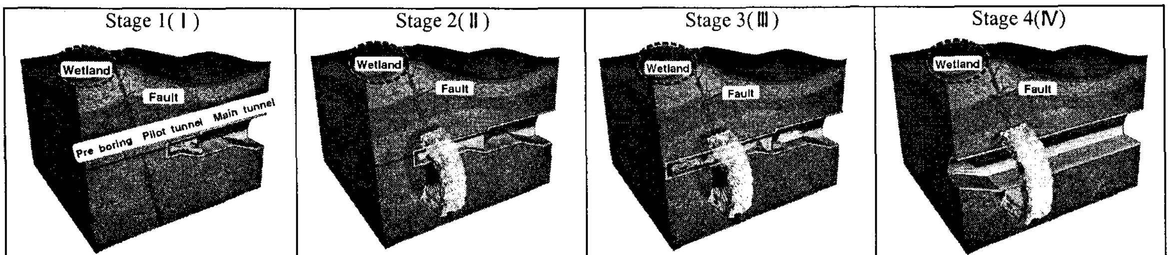


Fig. 7.2 Construction sequence of the pilot tunnel.

8. Conclusions

According to the precise investigation of the wetland's ecosystem, engineering and geological properties,

- We examined the mechanism of the wetland's generation and maintenance
- Through the numerical analysis, we evaluated the wetland's influence by tunnel excavation
- And then through analysis of the similar construction site, we decide the countermeasure about water level drop using the pilot tunnel.
- Finally, during the tunnel excavation period in the future, we study about the hydraulic behaviour properties about the wetland's ground water continuously to evaluate the appropriateness of the countermeasure.

References

1. The law of the preservation, The ministry of environment(1999), pp.1~2.
2. U.S Environmental Protection Agency(2002). Wetlands.
3. Choo, S. Y. et al., 2003, Analysis of Two Dimensional Coefficient of Permeability Using Electrical Logging and AMT Survey, The Korea Society of Rock Mechanics Annual Conference, pp.113~119.
4. Guymon, G, *Unsaturated Zone Hydrology*, P.TR PRENTICE HALL, New Jersey, pp.80~108.