第 III 部門　　A Case Study on Field Investigation on Tunnel Safety for an old Korean Railway Tunnel

KISTEC KOREA	Regular Member	○Si-Hyun, PARK
KISTEC KOREA	Non-Member	Sang-Ro, Ahn
KICT KOREA	Non-Member	Gyu-Jin, Bae
KYOTO University	Regular Member	Toshihiro Asakura

1. Introduction

In this study, various kinds of field investigation(Park, 2004) were executed and deformation phase and magnitude were examined in the damaged parts of ASSM railway tunnel. Effects of recorded deformation phase were evaluated through numerical analysis. Possible reinforcing methods were reviewed to obtain the safety of tunnel lining as well. It is estimated that safety of lining can be threatened in the case of defects in tunnel lining as well as cavity existence behind lining.

2. Field Investigation

2.1 Observing inspection

From an observing inspection, it was found that there were a great amount of dust which its thickness is 2~10mm. It is confirmed that cracking, leakage, and segregation were occurred locally. Especially at the research section area, symmetrical longitudinal offset-cracks are distinctively appeared in arch part of the tunnel. These offset-cracks are discontinuous in the site of the construction joints which are due to the construction span by one concrete placement. Following picture is showing the description of lining which are generated longitudinal offset-cracks in tunnel arch.

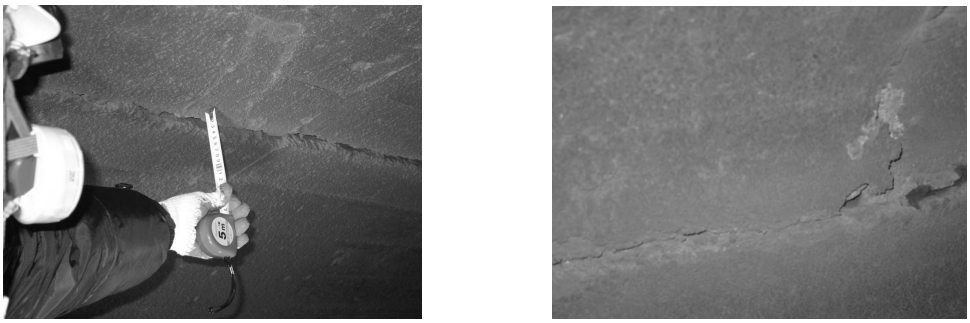
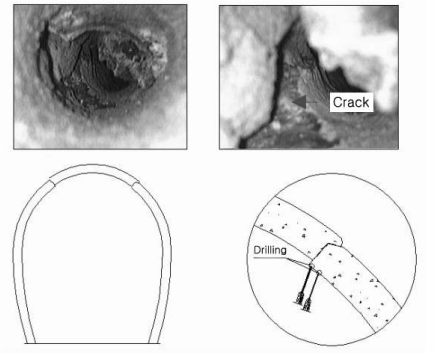


Fig. 1. Longitudinal offset-cracks in the tunnel arch

2.1 Inspection Scope survey

Inspection scope survey was done to see distribution and direction phase of offset-crack at the region of cavity behind lining and arch part. If penetrated offset-cracks of arch section are interlocked and sheared, or crushed, and their direction phase is similar to the Rabcewicz's research(Rabcewicz, 1965), they are evidently structural cracks caused by increasing horizontal pressure of soil/rock mass with time-dependent relationship such as ground loosening. Crack survey was made by boring 2 holes ($\phi 10mm$) below the cracks. Crack conditions are definitely visualized and they are not the sheared shape with interlocking. Also, cracks are separated from each one with the distance of some millimeters, and traces of crushing are not founded. It is estimated that crack conditions were established long time ago. General direction tendency of cracks were investigated by changing the boring locations, respectively. As a result, cracks are normal to the curved surface of lining. With this in mind, cause of offset-cracks in arch are inferred some kind of cold joints induced by discontinuous placement of concrete. For another thing, there are cavities behind the lining in the arch section with cracks. Interface with cavity and ground is located below the cracking point. Lining

thickness is about 22 ~ 25cm and the depth of the cavities is about 60 ~ 80cm.



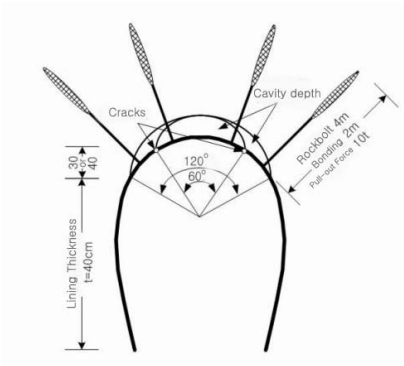


Fig. 2. Inspection scope survey for the offset-crack **Fig. 3. Schematic draw for analysis**

3. Safety Assessment

3.1 Analysis Conditions and Process

Analysis conditions are categorized by the lack of lining thickness, cavity phase, lining cracks, and reinforcing methods.

CASE 1 represents the design thickness of 40cm, and CASE 2 indicates the shortage of thickness, 30cm of arch. For considering cavity behind lining concrete, CASE 3 represents that the cavity distribution is 60 degrees in crown, and CASE 4 is to 120 degrees in crown. CASE 5 is assumed that longitudinal cracks are symmetrical to the center of crown. Lastly, for applying reinforcement, autoclaved lightweight mortar is backfilled in cavity, and 4 rockbolts. Assumptions in each category are the following Fig. 3.

3.2 Analysis result

Section forces for tunnel lining were shown in Fig. 4. According to the analysis result, lining load is lower than design strength in the case of no cavity behind the lining concrete. However, for the case of cavity existence, lining loads in crown and arch section are higher than the allowable stress. Therefore, it is estimated that safety of lining can be threatened in case of cavity existence. By applying reinforcement, bending moment and shear stress in arch and crown are definitely reduced.

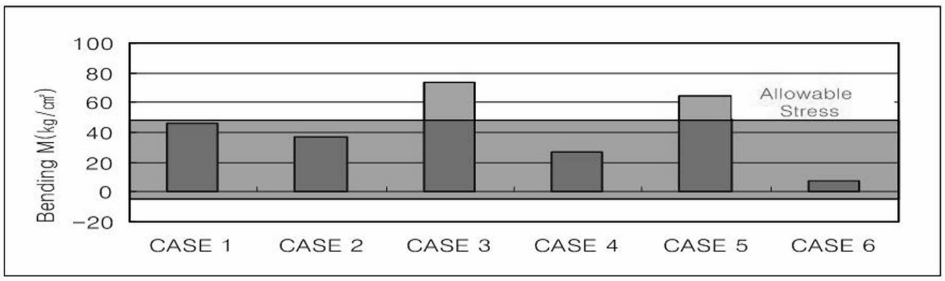


Fig. 4. Bending moment at Crown(Compressive + bending)

4. Conclusion2

It is very important to sustain the designed function of the infrastructure. In this study, safety assessment was carried out for an old Korean railroad service tunnel with defects in and/or behind lining through numerical analysis. More active researches and investigations will be demanded to make certain the proper assessment f the structures with defects.

List of References

Pak, Si-Hyun et al (2004), A study on the evaluation of tunnel safety through a series of field inspection for ASSM tunnel(Korean), Korean Tunnelling Technology, V.6. No.2, 2004, pp.151-160.

Rabcewicz L.V.(1969), Stability of tunnels under rock load, Water Power, June/July/August.