An Analysis of the Results of Regular Road Tunnel Inspections

(Research period: FY2021-)

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1. Introduction

In order to respond to issues with road structures, such as aging, statutory inspections have been carried out once every five years since FY2014 on tunnels and other road structures with the aim of preventative maintenance.

This paper presents the state of occurrence of deformation and trends therein as obtained from the results of the first (five years) and second (three years from FY2019 to FY2021) rounds of regular inspections of nationally administered road tunnels.

2. Summary of results of first round of regular inspections

Of the 1,553 national administered road tunnels that were inspected in the first round (FY2014-2018), the diagnostic results of the health of 1,421 tunnels constructed by mountain construction methods (sheet piling, mountain tunnel method) found approximately 3% in assessment class I (healthy), approximately 63% in class II (preventative maintenance stage), approximately 34% in class III (early measures stage), and approximately 0.2% in class IV (urgent measures stage), with the majority of tunnels requiring some sort of measures. Reorganizing this by span (where one span is approx. 10 m), the proportion in class I (healthy) is approximately 46% and the proportion in classes III and IV is approximately 5% (fig. 1). This difference is due to diagnoses of tunnel health being represented by the class of the least healthy span.

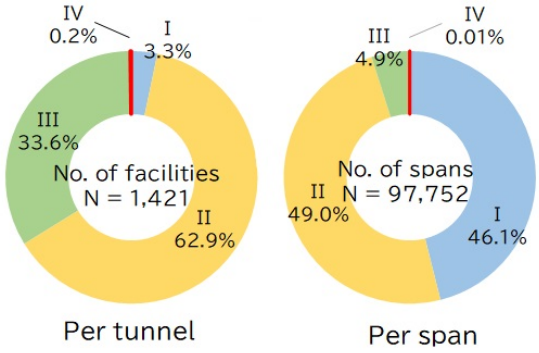

Fig. 1. Proportions of health assessment classes

Looking at the 1,421 facilities by deformation class, approximately 30% of deformations due to material deterioration fall into class III or IV, which tends to be greater than deformations due to external forces or leaking water (fig. 2).

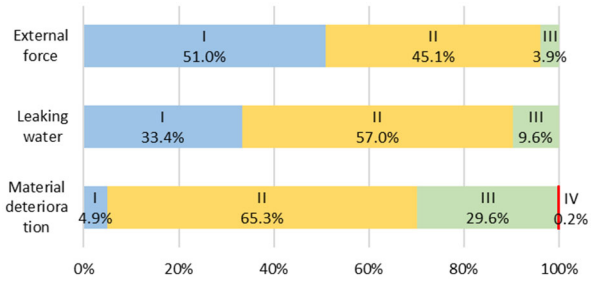

Fig. 2. Proportions of deformation classes

In addition, figure 3 shows the proportions organized by deformation class for the 503 tunnels that were diagnosed with class III or IV health, among the 1,421 facilities. The proportion where external forces were a factor is comparatively small at approximately 11%, while the proportion where material deterioration alone or both material deformation and leaking water were a factor is larger at approximately 78%.

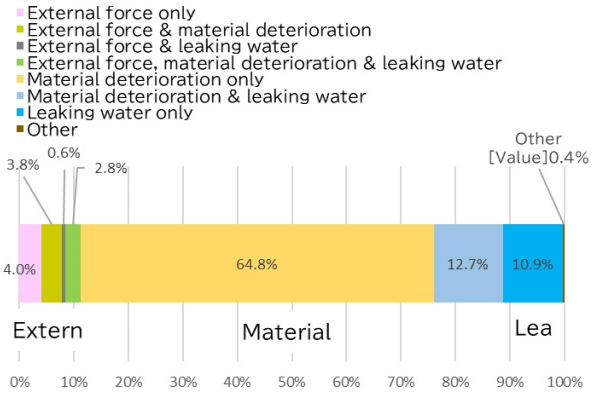

Fig. 3. Breakdown by deformation class in tunnels with class III or IV health

Among the deformation classes, looking at the locations of lining deformation that were assessed as measure class III or IV with “material deterioration” (5,460 locations) by the type of deformation, “bubbling and peeling,” which is a factor in flaking that leads to user harm, accounts for the majority at 92%, and bubbling and peeling that was not completely removed by beating at inspection is a major issue in the preservation of tunnels.

An analysis of the positions where this bubbling and peeling occurs has revealed that most occurs in two locations: joint sections and their surrounds (65%) and locations where deformation has occurred or repairs have been made in the past and their surrounds (34%). Based on these analysis results, the inspections from the second round basically used a proximal visual inspection of the entire lining surface, while performing hammering tests of joint sections and repair locations was reflected in the revision of the regular inspection guidelines (2019), leading to more streamlined and efficient inspections (fig. 4).

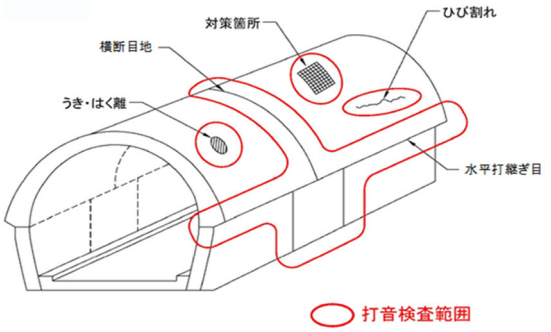

Fig. 4. Image of hammering test scope from second round

3. Comparison of results of first and second rounds of regular inspections

Comparing changes in the number of bubbling and peeling locations due to material deterioration in the 927 tunnels that underwent a regular inspection in the second round (FY2019-2021) and also had data from the first round of inspections did not show a major change in the number of locations of deformation by measure class between the first and second rounds (fig. 3).

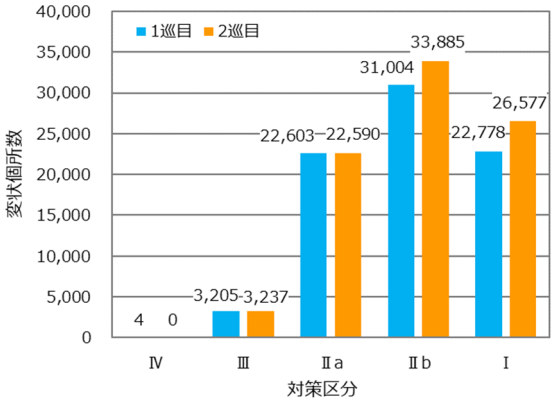

Fig. 5. Changes in the number of bubbling and peeling deformation locations

Figure 6 shows the measure classes for deformations by material deterioration in the second round of inspections (the degree of progress from the first round of inspections). Looking at the number of deformations where repairs or measures were performed after the previous inspection, there were very few deformations in measure class III and most were in measure class I.

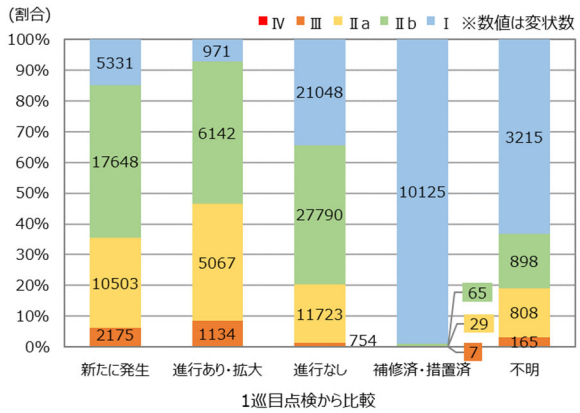

Fig. 6. Proportion of measure classes in second round of inspections (material deterioration)

This shows that the repairs or measures were performed appropriately. Conversely, with regard to deformations by material deterioration that had "newly arisen" or "progressed or expanded" since the previous inspection, the proportion of deformations in measures class IIa or III tended to be higher.

4. Conclusion

Based on the results of regular tunnel inspections to date, we prepared a casebook[2] with brief commentary using photographs and explanations for cases of deformation in repair and reinforcing materials, in addition to deformations in lining concrete like cracking, bubbling and peeling, and published it in 2022.

We intend to continue comparing the results of the first and second rounds of regular inspections, organizing the data from the time of construction, and conduct analyses to find trends in structural conditions, environmental conditions, deformations by part, and the like, which we will connect to proposals for greater streamlining and efficient in inspections, including considering applying new technologies, such as making use of inspection assistance technologies.

☞See here for detailed information

1) Tech. Note of NILIM, No. 1175, "Data Collection of Regular Inspection Results for Road Tunnels (FY2014-2018)"
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1175.htm
2) Tech. Note of NILIM, No. 1206, "Reference to Inspection Manual for Road Tunnels (2021): Casebook of Damage of Road Tunnels"
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1206.htm