Study on design methods to meet performance requirements of underground structures

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1. Overview

The Ministry of Land, Infrastructure, Transport and Tourism is progressing with the formulation of design criteria that meet the performance requirements of roads. Technical criteria for road earthworks were introduced in FY2014, and clarified the performance requirements for road earthworks. At the NILIM, we are maintaining the technical conditions that meet the performance requirements for road earthworks. This research will examine the design conditions and methods required for designs that meet the performance requirements for underground structures (culverts, retaining walls, sheds, etc.).

2. Examination contents

(1) Examination of design method for box culverts

A box culvert placed in an embankment (we call it a culvert in the following) is designed using a conventional design method for a relatively small culvert according to a guideline[1]. In this design method, the verification of the effect of seismic motion can be omitted based on past accumulated experience. On the other hand, the structural damage conditions to satisfy the performance requirements for the underground structures were diverse, ranging from minor damage that is not a hindrance to traffic (performance level 1) to a condition where damage makes it necessary to close the road, but the hindrance is not critical (performance lever 3), as shown in Figure 1.

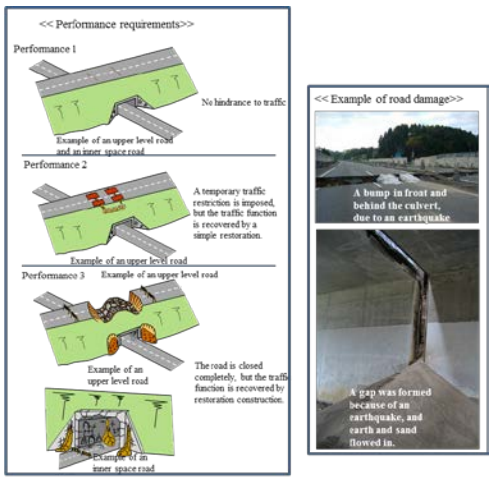

Figure 1 Relationship between performance requirements for culvert and damage

Therefore, it was necessary to clarify the design conditions and methods that can meet such performance requirements for underground structures.

In this study, we assumed that seismic motion (Level2 class) affects a culvert placed in an embankment. Then, to clarify by obtain an applicable range for the safety allowance and a design condition for the culvert itself, we evaluated the seismic response deformation of the embankment, and the propagation of strain in the culvert and soil around ….. , earthquake resisting for along with the interaction between them (Figure 2).

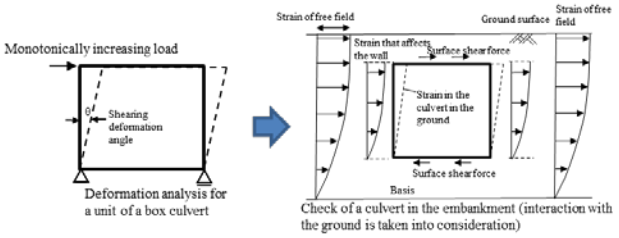

Figure 2 Schematic of deformation caused by interaction between culvert and embankment

Additionally, we examined the influences of various characteristics of box culverts (size, form, overburden, etc.) on the shearing deformation by seismic motion (Figure 3).

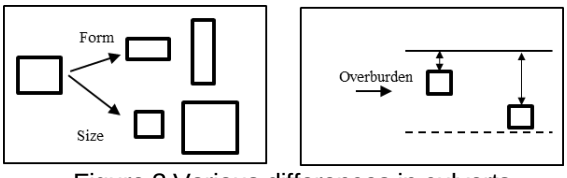

Figure 3 Various differences in culverts

(2) Examination of design methods for retaining walls and sheds

Similarly, to examine the design conditions while considering the performance requirements against seismic motion for a retaining wall, which is a structure that bears the earth pressure on its back under normal conditions, and a shed placed on the road along the slope that has a high risk of falling rocks, we are now

examining the influences on the stability of structures and the safety of components against an external force based on various regulations such as the Guideline of road civil engineering and construction of retaining walls, Specifications for highway bridges, and Handbook of measures for falling rocks.

3. Future plans

We plan to examine the design conditions during an earthquake that meet the performance requirements of civil engineering structures within the applicable range of the present guideline. In addition, we plan to examine the design conditions for earthquake cases and summarize examination results that can be useful for the design conditions of new types of underground structures that are outside of the applicable ranges of the guidelines, which are expected to increase in number in the future.

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1) Guideline of road civil engineering and construction of culverts (March 2010, Japan Road Association) (in Japanese)