Review on assessment method for long-term settlements on abutments in design stage

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ABSTRACT: The driving discomfort on the bridge ends have become an important issue for highway users. There are many reasons for the driving discomfort on the bridge ends such as compression of natural soil and embankment, insufficient compaction, loss of embankment soils, soil movement and so on. Among these reasons, the main factor for driving discomfort at the bridge ends can be the compression of natural soil and embankment. However, there is few methods to assess the long-term compression settlements of natural soil and embankment. This paper presents a review current method to assess a long-term settlement of natural soil and embankment at the bridge ends.

Keywords: long-term settlements, driving discomfort, bridge ends

1 INTRODUCTION

A bump at the bridge ends due to differential settlements between the abutment and the embankment including backfills is caused not only the driving discomfort but also the driving safety. In the United States, the bump at the bridge ends has become a social issue since the late 1980s, and related research and studies have been carried out mainly in transportation bureaus (Korea Highway Corporation, 2012). There are many reasons for the driving discomfort on the bridge ends such as compression of natural soil and embankment, insufficient compaction, loss of embankment soils, soil movement and so on. Among these reasons, Korea Expressway Corporation (2012) defines that the main factor for driving discomfort at the bridge ends can be the compression of natural soil and embankment. The occurrence of the embankment settlement can be classified into a long-term settlement in service and a settlement due to insufficient compaction during construction. The settlement due to insufficient compaction during construction can be overcome by strict construction quality control. However, the unexpected long-term settlement in service are difficult to manage during construction and maintenance phases. Hence, an assessment on the long-term settlement in the design stage was reviewed to minimize long-term settlements in service.

2 MAIN REASON OF BUMP AT BRIDGE ENDS

As mentioned before, Korea Expressway Corporation (2012) defines that the main factor for driving discomfort at the bridge ends can be the compression of natural soil and embankment. It is reported that long-term compressive settlement of 0.2 ~ 0.5% of the height of the embankment occurs over a long period even if the embankment is sufficiently compacted. These long-term settlements are not considered at all in the design and construction stages. Conversely, the foundation of the abutment is supported on hard strata over weathered rock, and the allowable settlement of the foundation is strictly controlled within 25 mm in within the design and construction phases. As a result, the differential settlement between the abutment and the embankment can inevitably occur.

For example, the differential settlement at the bridge ends that installed in a 20 m high embankment can be calculated as follows.

- Embankment settlement (S_c): 100 mm (applying a long-term settlement rate of 0.5%)
- Abutment settlement(S_a): 25 mm (applying an allowable settlement of abutment as 25 mm)
- Differential settlement (δ_d): S_c - S_a = **75 mm**

Even if the proper design and construction are performed, the bump at the bridge ends is inevitably occur and this situation is shown in Figure 1. Therefore, it is necessary to consider the long-term settlement that can occur in the bridge ends in the design stage and to secure the driving comfort in the bridge ends.

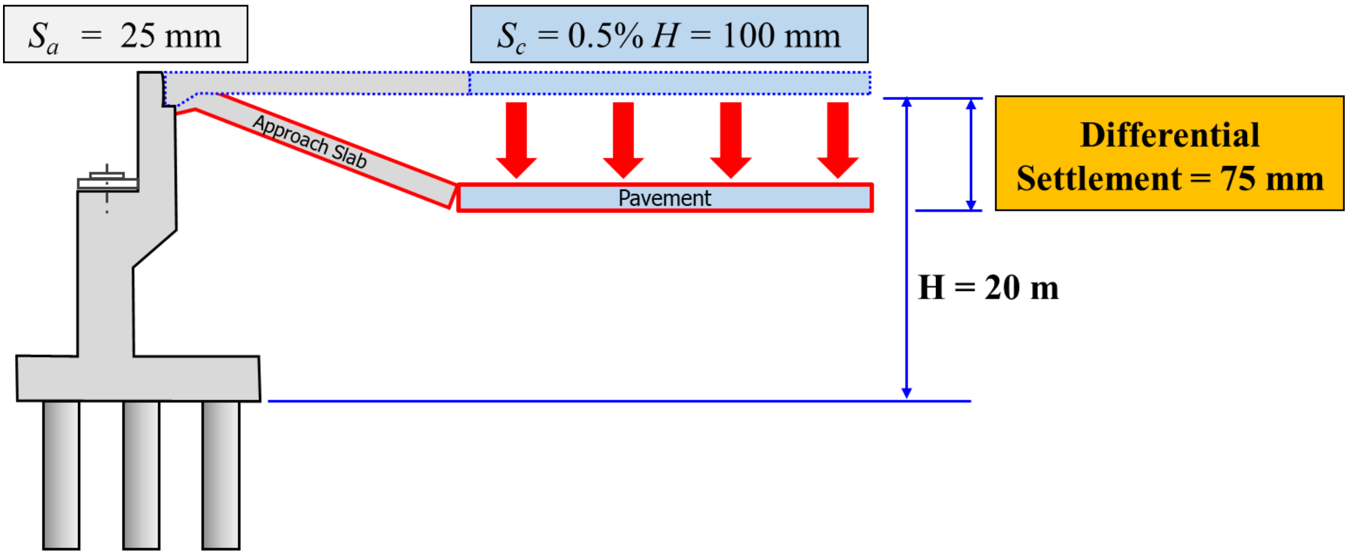

Figure 1. Example of differential settlements at the bridge end

3 REVIEW OF DIFFERENTIAL SETTLEMENTS AT BRIDGE ENDS IN DESIGN STAGE

In order to review the differential settlements at the bridge ends in the design stage, it is necessary to set the allowable differential settlements (δ_a). In this study, 1/200 of the length of the approach slab(L_a), which is the allowable differential settlements at the bridge ends in service, was applied (Ministry of Land, Transport and Maritime Affairs, 2011). The differential settlements (δ_d) that can occur at bridge ends can be estimated through careful examination by long-term compression settlement test or experience (0.2 ~ 0.5% of embankment height). Therefore, it is considered that a review of the differential settlements of the bridge ends that can occur in service can be examined using the following equation (1) or Figure 2 in the design stage. Here, soft ground is excluded.

$$\delta_d \le \delta_a = (1/200)\ L_a \qquad (1)$$

4 CONCLUSIONS

In this study, a method to secure the driving comfort at the bridge ends in the design stage by considering differential settlements which can occur in service. In order to examine more closely and to improve the driving comfort, further study on the characteristics of long-term compressive settlement for embankment soils and original grounds will be needed.

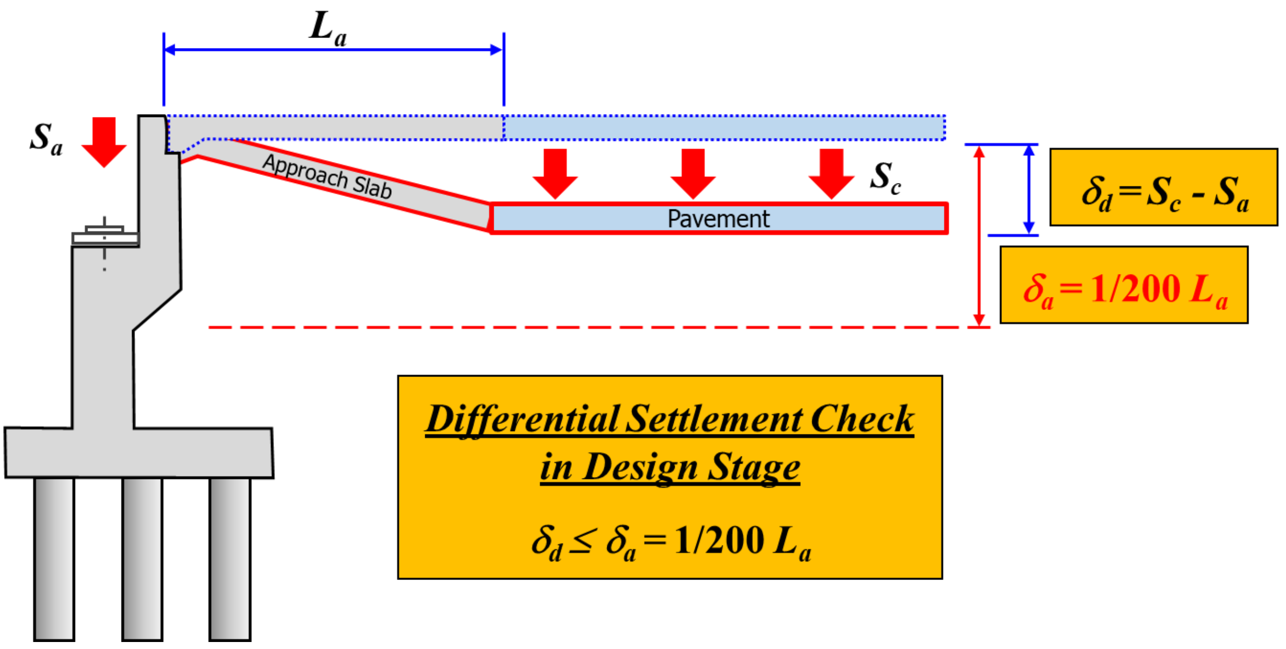

Figure 2. Schematic of review the differential settlements at the bridge ends in the design stage

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