4TH MALAYSIAN ROAD CONFERENCE – TOWARDS BETTER HIGHWAY ENVIRONMENT
30 – 31 OCTOBER, 2000, RENAISSANCE KUALA LUMPUR

INNOVATIVE GEOTECHNICAL INPUT FOR APPROACHES TO BRIDGES AND CULVERTS OVER COMPRESSIBLE SOILS

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ABSTRACT

This paper describes some of the innovative geotechnical input that have been used to solve the traditional problems of differential settlement along roads and highways particularly at approaches to structures such as bridges and culverts over marine and river alluvium deposits.

INTRODUCTION

Plate 1: Hump over culvert

Plate 2: Hump at Bridge Approach

The differential settlements as shown in Plates 1 & 2 are still common along our highways. These problems are now better appreciated by road engineers who would seek input from engineers, especially geotechnical engineers who are better trained and experienced in the field of geotechnical engineering to eliminate or mitigate the problem and to provide smoother riding comfort and extra safety to road users.

This paper examines the two common areas where differential settlement exists and describes some of the innovative ways of elimination and mitigation.

Approaches to Bridges

The most common old practice of the bridge approach design is shown in Fig. 1 Bridge abutments over soft deposits are normally supported by piles. The piles for the abutments are usually driven to set at a firmer layer below. The long term settlement of the abutments is hence negligible. The embankment adjacent to the abutments would settle due to the consolidation settlement of the subsoil under the embankment load. The time and magnitude of the consolidation settlement depend on the thickness and the consolidation properties of the compressible deposits and the height of embankment.

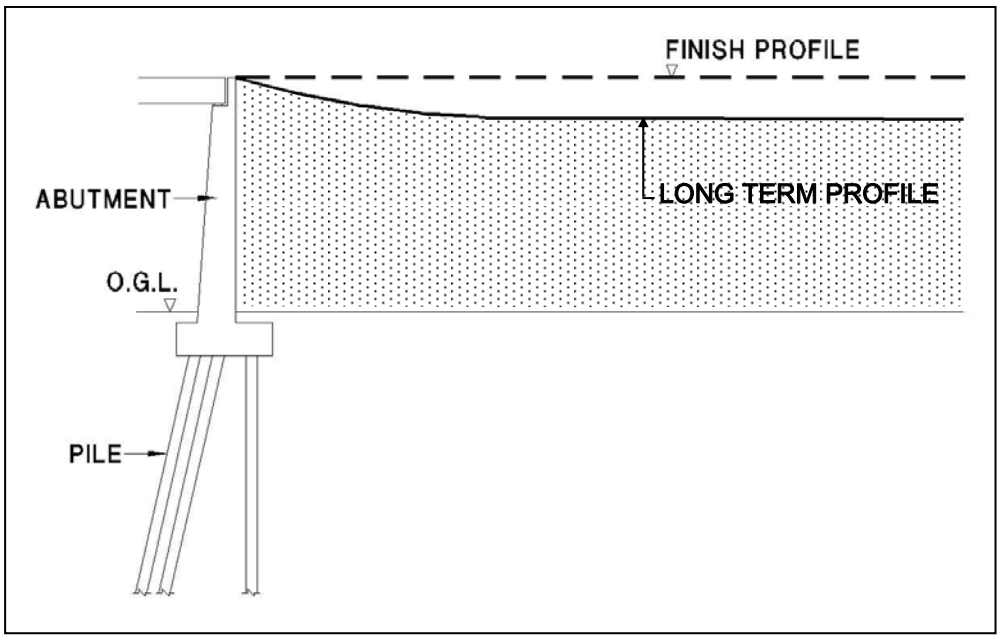

Fig. 1 Settlement Of A Bridge Approach

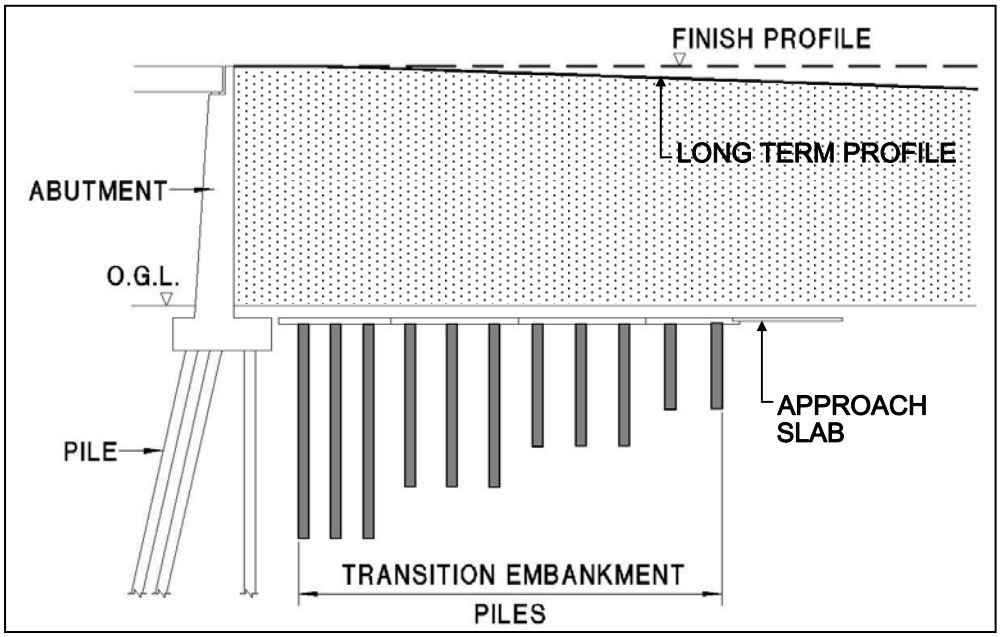

Fig. 2a Transition Embankment Piles

Fig. 2a and 2b show some of the innovative solutions to the problems. Fig. 2a shows the use of transition piles to provide a smooth transition to bridge abutment. The transition piles are designed to settle and the piles close to the unpiled section would have a smaller differential settlement. This area can further be refined with an approach slab as indicated. High quality of field tests, sampling and laboratory tests are needed to obtain reliable soil parameters for analysis and prediction of the settlement.

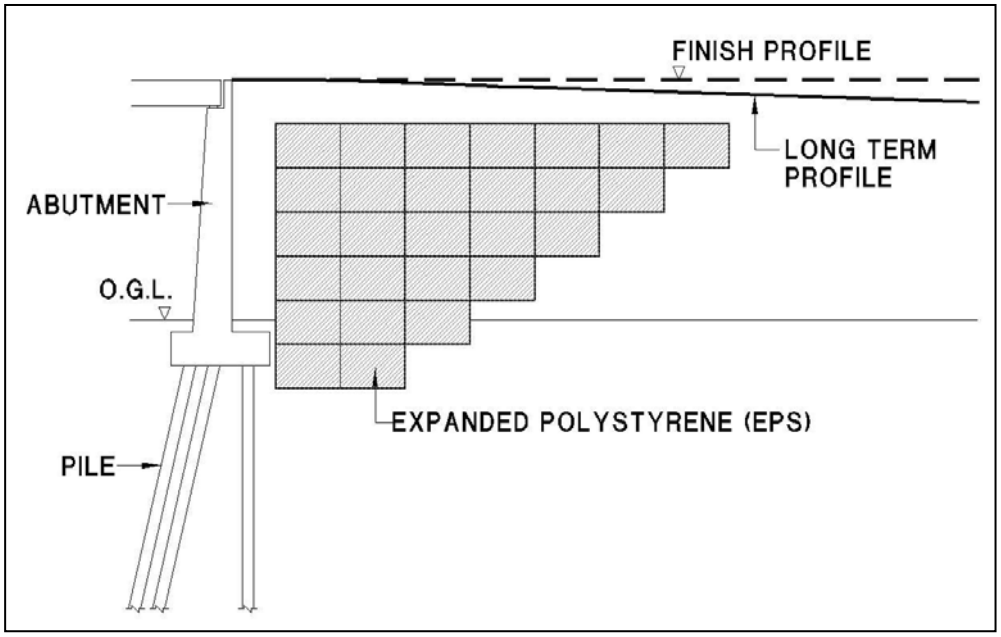

Fig. 2b Expanded Polystyrene (EPS)

Fig. 2b shows the use of Expanded Polystyrene (EPS) to reduce the weight of the embankment particularly near the bridge abutment. However, this technique is very sensitive to the high water table and the design is usually controlled by the floatation [Ref: NRRL (1992)]

The other methods are surcharging with or without vertical drains and stone columns to smoothen the transition. As the transition is a short section of the alignment, the first two methods illustrated are generally more economical, particularly the use of transitional embankment piles as this technique does not need another set of plant and equipment, thereby saving on the extra mobilization cost.

Approaches to a Culvert

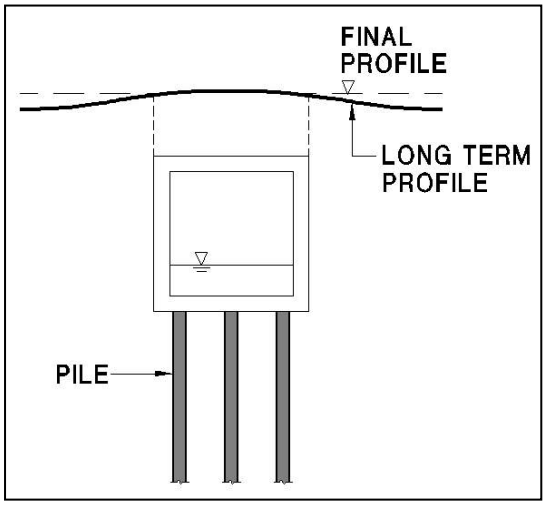

Fig. 3a Piled Culvert

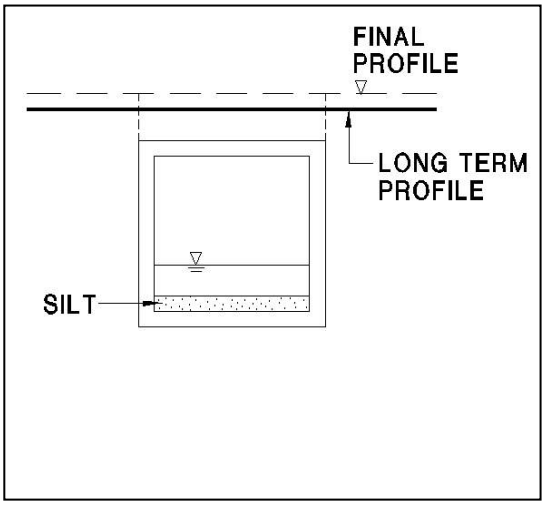

Fig. 3b Oversized Culvert

Very often, culverts are designed and constructed as shown in Fig. 3a to ensure that the area of flow of the drain through the embankment remain unchanged with time. This is achieved by using piles to provide a rigid platform. The consequence of having rigid platform as shown induces differential settlement between the rigid piled culvert and the unpiled embankment. The unpiled embankment over compressible soil will settle time.
The possible solutions to eliminate the differential settlement are:-

1) Provide a larger culvert to allow for long term settlement.
2) Provide a transition piles to the approaches to a culvert.

The first option is shown in Fig. 3b, which allow the culvert to settle together with the embankment. Hence, the size available for flow will reduce with time as the culvert settles and a section of the culvert will be silted up as shown. The net flow area after taking into consideration of settlement and siltation should have a size not smaller than that required for the volume of flow designed just like the piled culvert as shown in Fig. 3a.

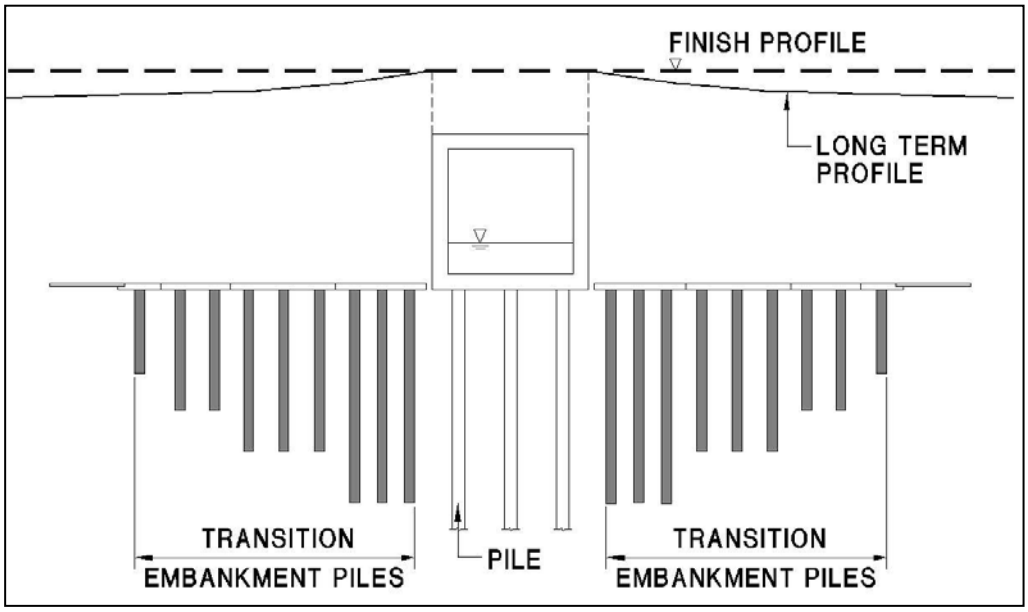

Fig. 4 Transition Embankment Piles for Piled Culvert

The second option as shown in Fig. 4 is similar to the transition piles described earlier.

CONCLUDING REMARKS

The differential settlement at the approaches to bridges over compressible deposits could be eliminated or smoothened by using transition piles. However, differential settlement at approaches to culverts could be solved by using oversized culverts allowing them to settle together with the fill embankment.

REFERENCE

1) Norwegian Road Research Laboratory (1992) “Expanded Polystyrene used in Road Embankmens – Design, Construction and Quality Assurance”, Norwegian Directorate of Public Roads, Oslo/Norway