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Modelling a Highway Embankment on Peat Foundations Using Transparent Soil

Earl Marvin De Guzman and Marolo Alfaro
The University of Manitoba, Winnipeg, Manitoba, Canada
earl.deguzman@umanitoba.ca, marolo.alfaro@umanitoba.ca

Abstract
Laboratory-scale physical modelling was conducted to understand the behaviour of highway embankments constructed on peat foundations. Artificial transparent soil was used to simulate the deformation properties of the peat foundation. The use of a transparent soil allows the determination of spatial deformations underneath the modelled embankment using Particle Image Velocimetry (PIV). The load-settlement behaviour in the field is reasonably simulated in the laboratory-scale physical model. This paper presents the results of a modelled embankment with a geotextile fabric across its base.

Keywords: peat foundations, embankments, transparent soil, particle image velocimetry, physical modelling

1 Introduction

In Northern Manitoba, hundreds of kilometers of roads are built over peat terrain. Peat is a highly compressible material with very low shear strength, very high moisture content, and very high organic content. Past methods of highway embankment construction over peat deposits included excavation or displacement of peat that resulted in large fill quantities. In many cases fill materials are obtained from bedrock quarries at great distances from work area.

A research partnership was established to improve the understanding of the performance of road embankments on peat terrain in Northern Manitoba. The partners are Manitoba Infrastructure and Transportation (MIT), AECOM Ltd., and the University of Manitoba. The research involved design, construction, and monitoring of a 2 km stretch of new road along the Provincial Road (PR) 373, 200 km southeast of Thompson, Manitoba. The emphasis on embankment construction for this project is the displacement method or without removal of peat. This can result to large settlements, which is a concern for both design and long term maintenance operations.

A test section was instrumented for this study to improve embankment performance on peat deposits. The test section has geotextile wrap-around reinforcement placed at the base of the embankment (Figure 1). The test section was constructed when the ground was still frozen for ease of

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construction and to minimize the negative impact to the environment. The geotextile layer was placed on the surface of the peat before the embankment fill was placed. This provided a separation layer between the fill materials and the underlying peat, preventing sharp corners of the rock to punch (shear) the ground. The peat foundation is 4 m thick, with the first 2 m classified as fibrous peat and the next 2 m as amorphous peat, and is underlain by a stiff clay layer. This paper is a continuation of the results presented by De Guzman & Alfaro (2013a, 2013b) and will focus on the physical modelling of the test section using Particle Image Velocimetry (PIV).

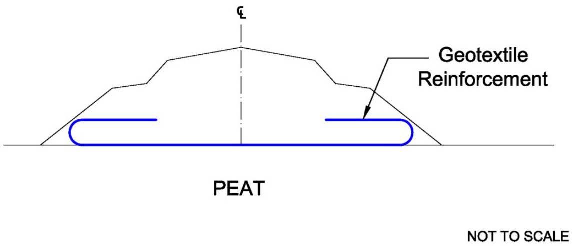

Figure 1. Schematic diagram of embankment with geotextile wrap-around reinforcement

2 Field Performance

A complete account of the field performance of the highway embankment is presented in De Guzman & Alfaro (2013b). Monitored settlements are briefly discussed for the test section. The test section was constructed on April 2011. The road embankment has a base width of 28 m, crest width of 14 m, and height of 3.7 m. About 0.5 m of the ground was still frozen at the time of construction as verified by field technicians using steel bars punched into the ground and using ground temperature readings from thermistors.

The test section is an embankment reinforced with wrap-around geotextile as illustrated in Figure 1. The geotextile layer was placed on the surface of the peat before the road was constructed. This was envisaged to provide platform for the road and to act as separation layer between the fill materials and the underlying peat.

The test section has recorded settlements (as of July 25, 2012) ranging from 1.8 to 2 m. There was almost 1 to 1.4 m settlement observed for the first month after the start of embankment construction on April 4, 2011. This is nearly 70% of the total settlements. Settlement is gradual for the period of four months after construction until the latest reading. Figure 2 shows the settlement with time at different offsets to the right of the embankment centerline. No readings were made between the period of September 13, 2011 and April 17, 2012. It is noted that the settlement readings after April 2012 started to become constant.

3 Physical Modelling

In order to understand the operating mechanisms of the embankment in the field, laboratory-scale physical modelling was conducted. The use of laboratory-scale physical model tests is relatively cheaper compared to constructing full-scale field embankments, though full-scale tests offer better understanding of the actual behaviour of the foundation soil in the field. The laboratory-scale physical model tests can still provide 'idealized' behaviour of the same embankment as cost-effective alternative. The development of an artificial transparent soil as well as the use Particle Image Velocimetry (PIV) to determine deformation is discussed.