Transportation Geotechnics 9 (2016) 161–174

Contents lists available at ScienceDirect

Transportation Geotechnics

journal homepage: www.elsevier.com/locate/trgeo

The performance of a trial gravel road under accelerated pavement testing

Dina Kuttah

VTI, the Swedish National Road and Transport Research Institute, Linköping, Sweden

ARTICLE INFO

Article history:
Received 23 June 2016
Revised 2 September 2016
Accepted 8 September 2016
Available online 19 September 2016

Keywords:
Dynamic strain
Gravel road
Heavy Vehicle Simulator test
Rut depth
Vertical
Surface deformations

ABSTRACT

This study presents the performance of a trial gravel road subjected to HVS (Heavy Vehicle Simulator) trafficking in a compressed time period. The road structure was constructed with 150 mm-thick aggregate base course, and 125 mm-thick sub-base course. The test road responses, such as surface deformation and rutting were recorded using laser profile measurement instrument while the unbound layers' dynamic deflections and strains data were periodically recorded at different depths during the execution of the test by means of an array of micro strain gauges. The test road was also instrumented with Water Content Reflectometers to record the changes in moisture contents in the road layers caused by the raising of the water table level under HVS trafficking. A total number of 85,000 HVS passes were applied to the trial gravel road structure under near-optimum as well as partially submerged subgrade moisture conditions. The test results emphasize the fact that the partial soaking of the subgrade soil by raising the groundwater table level caused a serious damage to the tested gravel road, as further detailed in this paper.

© 2016 Elsevier Ltd. All rights reserved.

Introduction

Variations in moisture content significantly alter the geotechnical characteristics of the unbound materials, including resilient response (Lekarp et al., 2000; Razouki and Kuttah, 2004; Erlingsson, 2007; Zaman and Khoury, 2007; Salour et al., 2014; Nguyen and Mohajerani, 2016), shear strength (Cokca et al., 2004; Zhang et al., 2014), CBR (Turnbull and Foster, 1956; Sivakumar et al., 2002; Sanchez-Leal, 2002; Razouki and Kuttah, 2006; Ampadu, 2007; Purwana et al., 2012) permeability and volumetric deformation (Vanapalli et al., 1996; Fredlund et al., 2012; Khoury et al., 2012). In addition to the moisture influence, other factors also play an important role on the performance of roads unbounds layers such as the mineralogical characteristics of the materials (Korkiala-Tanttu et al., 2003), the particle size distribution of the materials (Ekblad and Isacsson, 2006), external stress state (Cary and Zapata, 2011), and the degree of compaction (Van Niekerk et al., 2000; Razouki et al., 2011, 2012). Unpredicted variations of soil parameters can shorten the service life of infrastructures and induce major distresses on soil supported structures, including low volume roads (Hedayati and Hossain, 2015). Since pavements are designed to distribute stresses imposed by traffic to the subgrade, the subgrade conditions have a significant influence on the choice of thickness of pavement structure and the way it is design (Jones et al., 2010; Papanicolaou et al., 2015). Moreover, the amount of wear depends on the weight and number of vehicles using the pavement over a given period of time (Gibbons, 1999). In principle, the heavier and more numerous the vehicles using the road, the thicker the pavement needed to support them. In general, the influence of subgrade moisture conditions on the performance of roads becomes more pronounced in unpaved roads (Mishra and Tutumluer, 2012).

E-mail address: dina.kuttah@vti.se

http://dx.doi.org/10.1016/j.trgeo.2016.09.001
2214-3912/© 2016 Elsevier Ltd. All rights reserved.

Nomenclature

WCR	Water Content Reflectometers
APT	accelerated pavement testing
εMU	Strain Measurement Unit (micro strain gauges)
Ev_1	initial modulus, obtained from the first loading loop in the static plate load test
Ev_2	reload modulus, obtained from the second loading loop in the static plate load test
HVS	Heavy Vehicle Simulator
MVSD	the maximum vertical surface deformations, mm
TRV	Trafikverket (in Swedish), the Swedish Transport Administration

The unit costs for unpaved roads construction and maintenance are low compared to those for higher level roads, therefore, in some nations, the road network is generally consisting of gravel roads. Many gravel roads serve rural residents and in some countries gravel roads are the only type that can be provided (Skorseth and Selim, 2000). In Sweden about 20,000 km of road length consists of gravel roads, about 21% of the public roads overall length in Sweden (Trafikverket, 2015).

Since gravel roads in many regions in Sweden subjected to relatively low traffic, it has become interested to test the effect of traffic on the performance of relatively thin gravel road under different subgrade moisture conditions.

It is worth mentioning that the subgrade moisture conditions are not only important for roads and highways construction, but railways can also be exposed to high water levels, for example due to intense rainfall, which may decrease their performance and jeopardize the safety of running trains (Jiang et al., 2015, 2016; Bian et al., 2016).

With respect to this study, a trial gravel road of 275 mm thickness was constructed and loaded using the VTI's Heavy Vehicle Simulator (HVS). The road was instrumented by means of εMU coils (εMU Users Manual, 1994) to measure the vertical dynamic deformations and strains at various depths along the road structure. Moreover, the surface deformations and the corresponding rutting were recorded using laser profile measurement instrument. The first 35,000 HVS passes were applied under near optimum subgrade moisture condition. Afterward, the groundwater table level was raised up to reach 30 cm below the subgrade soil surface. After reaching a constant groundwater table level, the trial road was further loaded by HVS to failure. A total number of 85,000 HVS passes were applied to the road structure throughout the test. The test results showed that the water table raising has an important effect on the performance of the gravel road studied, as further detailed in this paper.

The trial road construction and instrumentation

The construction materials used

Two types of sandy soils were used as subgrade soils to construct the gravel road. The deepest 2 m of the subgrade layer consisted of the main sandy soil (already available at the VTI's accelerated pavement testing facility) and referred to as sand A in Fig. 1. The remaining subgrade layer thickness, which was about 0.6 m, was complemented by a mix of sand A and sand B. The particle size distribution of the two types of sands used is illustrated in Fig. 1. It is clear from Fig. 1, that the maximum particle size of the two types of sands is less than 4 mm. Sand A has a uniformity coefficient of approximately 3 while sand B has a uniformity coefficient of approximately 4.5. Therefore, sand A can be considered poorly or uniformly graded while sand B is well graded.

The solid curve in Fig. 2 represents the particle size distribution of the sub-base material used in this study. This material fitted perfectly the requirements on sub-base materials gradation used to construct gravel roads in Sweden according to TRVKB 10 (2011) limits, referred to as TRV limits in Fig. 2.

It is clear from Fig. 2, that 90% of the sub-base material particles have a maximum particle size of less than 45 mm and about 3% particles finer than 0.063 mm. The uniformity coefficient is approximately 36 and therefore well graded.

The gradation of the crushed stone used as base material is given in Fig. 3. The base material used was within the TRVKB 10 (2011) limits on particle size distribution of base material used in constructing the gravel roads in Sweden. It is clear from Fig. 3 that only 2% of the base material used have a maximum particle size greater than 32 mm and about 3% particles finer than 0.063 mm.

A uniformity coefficient of approximately 24 has been reported for the base material, and therefore well graded.

The trial road construction

The test road was 4 m-long (along the wheel travel direction) and consisted of three different installed layers (base, sub-base and subgrade). The base layer and the surface layer of the gravel road were merged to form 150 mm and referred to as base layer in Fig. 4.

Furthermore, the road structure was constructed with 125 mm-thick sub-base course and the sandy subgrade soil was about 2600 mm in depth, as shown in Fig. 4.

Note that a thin layer of local available geotextile was placed in the interface between the subgrade layer and the sub-base layer in order to avoid contamination of subgrade sand with the sub-base material. The thin geotextile layer has been used only for soil separation purposes and hence a possible reuse of the sandy soil for future projects.

With respect to the subgrade soil construction, the sandy subgrade soil was tilled up to 1 m depth and

Download English Version:

https://daneshyari.com/en/article/6779601

Download Persian Version:

https://daneshyari.com/article/6779601

Daneshyari.com