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Advanced Geosynthetics in Flexible Pavement: A Full-Scale Test and Numerical Study

T. Imjai[1], M. Guadagnini[2], K. Pilakoutas[2]

[1] *Department of Civil Engineering, Rajamangala University of Technology Tawan-Ok, Bangkok, Thailand*

[2] *Department of Civil and Structural Engineering, The University of Sheffield, S1 3JD UK*

Abstract

Asphalt pavement rutting is one of the most commonly observed forms of pavement distresses and is a major safety concern to transportation agencies in Thailand. Research into improvements of conventional hot-mix asphalt materials, mix designs and methods of reinforced pavement structural layers, can provide extended pavement life and significant cost savings in pavement maintenance and repair. This paper reports the full-scale testing programme that was carried out at Highway No.11, (Uttaradit Province, Thailand) to evaluate the performance of Geosynthetic-reinforced materials in a conventional flexible pavement. Three test sections consisting of Geosynthetic-reinforced pavements and one unreinforced control test section were constructed in this project. The test sections were subjected to the static load test under truck weights of 20, 30, and 40 tons. Permanent surface deformations and pavement vertical stress had been continuously measured under a pre-specified test truck at 3, 6, 12, 24, 36 months after the construction. Field test data was used to validate a numerical model developed at the University of Sheffield. It is found that numerical results show a good agreement with the field data. The result of the present study also reveals that the Geosynthetic-reinforced pavement significantly improved the performance relative to the unreinforced control pavements. The result of this research is a practical framework for developing extensive full-scale testing data which can be used to validate numerical modeling and develops a design recommendation for the use of advanced Geosynthetics for flexible pavements.

Keywords Geosynthetic, Geotextile, Geogrid, Rutting, Flexible pavement, Paved Road.

1. Introduction

Pavements represent the largest component of government investment in public transport. In Thailand, the pavement portion of highways and streets has a current asset value of more than $50 billion [1]. These pavements deteriorate with time due to traffic loading and environmental exposure. Asphalt pavement rutting is one of the most commonly observed pavement distresses and is a major safety concern to transportation agencies as it affects up to 65 percent of all pavements in Thailand. Millions of dollars are spent annually to repair rutted asphalt pavements. As traffic loading increases significantly and Thailand experiences more frequent periods of hot weather due to global warming, the problem of pavement rutting is anticipated to escalate.

In the Asia-Pacific climate, such as the one encountered in Highways in Thailand, flexible pavement structures are relatively thin with strong base courses provided to ensure good behavior when exposed to high temperature environment. As a result, most of the flexible pavement structures is composed of granular materials with relatively high stiffness. The inclusion of Geosynthetics in flexible pavement structures for base reinforcement has long been accepted as a means of reducing overall costs and/or extending pavement service life. As new products have recently emerged in the road construction market, pavement engineers are forced to speculate concerning the performance benefits of these products when specifying them. Many research efforts have documented and attempted to quantify the performance benefit of geosynthetic materials [2-4]. Most researchers have reported that the use of geogrid (polyester woven) can result in reduced surface rutting of flexible pavement and aggregate base thickness requirements or extended service live of the pavement [2, 3]. However, very little research has been completed regarding the full-scale testing of geosynthetic-reinforced flexible pavements [3, 4]. Research work by Berg et al. [4] have reported that the use of reinforcement material in pavement structure can increase the California Bearing Ratio (CBR) value at the interface boundary of base and sub-base layers. Perkins et al. [2] also concluded that the initial cost of construction for using the reinforcement is higher than the conventional method but the improvement due to long-term behavior is much better than the unreinforced pavement. Barksdale et al, [5] investigated the behavior of geosynthetic materials to use as reinforcement in the under layer of asphalt concrete of flexible pavement by means of a numerical study.

The objectives of this research were to investigate the behaviors of reinforced flexible pavement and reinforced overlay flexible pavement and examine the performance of geosynthetics for structural reinforcement in rut resistant flexible pavement.

2. Full-scale testing programme

The test sections (4 sections with 50 m length) were constructed in February 2012 on Highway Number 11, between km.102+700 to km.102+900, in Uttaradit province located in Northern part of Thailand [6]. This highway section had the relatively high traffic volume of 8,271 vehicles per day, of which 26.5% were trucks. This section was also on the approach of signalized intersection, in which all vehicles are forced to decelerate and stop. Therefore, there were many distresses occurring in this section, especially ruts. The rut depth measurements in this section yielded an average rut depth of 30 millimeters, which is considered as a severe rutting failure [2]. The construction of the test sections is shown in Fig. 1 and Table 1.

Figure 1. Photograph showing an installation of geotextile in a test section.

Table 1. Instrumentation and locations for the test sections.

Test section	**Reinforcing material and location**	Pressure Cell	Strain sensor
P1	No reinforced material	1 at depth 200 mm 1 at depth 400 mm	-
P2	Geotextile at asphalt course-bound base	1 at depth 200 mm 1 at depth 400 mm	4 at 100 mm on geotextile
P3	Paving Fabrics at bound base-base	1 at depth 200 mm 1 at depth 400 mm	4 at 200 mm on geotextile
P4	Paving Fabrics at bound base-base interface and, Geogrid at base-sub-base	1 at depth 200 mm 1 at depth 400 mm	4 at 200 mm on geotextile 4 at 400 mm on geogrid

3. FIELD MEASUREMENT VS NUMERICAL RESULT

Comparison of rut depth measured from reference points installed in asphaltic concrete layer (on the top surface of the pavement) is shown in Fig. 2. The rut depth measurement was conducted after three years of service. As the result, the maximum settlement of pavement section P1, P2, P3, and P4 were 17, 17, 18, and 11 mm, respectively. This indicates that the test section P4 shows good rut resistance compared to other reinforced sections (P2 and P3) and the geosynthetics used in section P4 can reduce rutting distress significantly as also shown by numerical predictions developed at the University of Sheffield (Fig. 2). This illustrates that geogrid reinforcement at bound base-subbase interface could increase the rutting resistance of the flexible pavement.

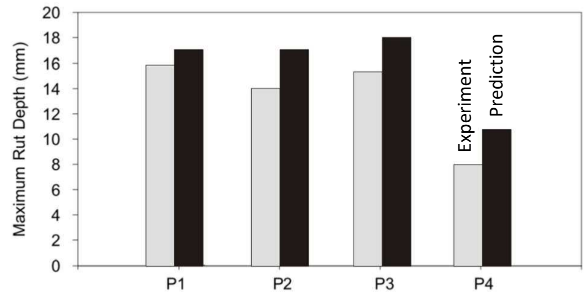

Figure 2. Comparison between rut depths measured at 36 months and numerical predictions.

4. CONCLUSIONS

From the findings of the recent study, it is concluded that the use of geosynthetic-reinforced pavement sections significantly improved the resistance to rutting compared to the unreinforced section. From the full-scale test result, it is found that geogrid reinforcement at bound base-sub-base interface (test section P4) could increase the rutting resistance of the flexible pavement as agreed by the numerical simulation developed at the University of Sheffield.

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