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AN ANALYSIS ON GEOGRID TECHNIQUE IN ROAD CONSTRUCTION

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Abstract:
In a developing country, there are a lot of road constructions involved especially in rural areas and are still applying conventional techniques in the pavement. Poor roadway geometry can lead to soil settlement caused by heavy load vehicles. Currently, there are many innovations introduced to the construction industry, one of them is geogrid. Geogrids have been used in pavement design for the past 25 years. Geogrid reinforcement is used in permanent paved roadways in two major application areas – base reinforcement and subgrade stabilization. The geogrids are used to build a construction platform over weak subgrades to carry equipment and facilitate the construction of the pavement system without excessive deformations of the subgrade. The aim of the study is to investigate geogrid functions in road stabilization applications and cost-benefit of using geogrids in road construction. The research methodology used in this research is a qualitative method which consists of a case study approach. In conclusion, by using a geogrid technique for road construction, it is cost saving as it is able to reduce the maintenance cost.

Keywords: Pavement; Road Construction; Geogrid; Geosynthetic; Qualitative Method

1.0 INTRODUCTION

Road construction sector is the most important part of infrastructure of a country and it plays a significant role. Also, it consumes a huge amount of money for this contruction. Besides that,the function of road is to connect people from one place to other places. The government has been allocating a huge amount of money for road constructions in yearly Malaysian Budget especially to those connecting to rural places. For example, in The 2018 Budget , West Coast Highway from Banting, Selangor to Taiping, Perak is still under construction with an estimated cost of RM5 billion. Road development programmes will be continued with special emphasis on quality and safety. New road constructions will focus on opening up corridors for development as well as improving accessibility to rural places. Road construction through privatisation and deferred payment method will be continued on a selective basis, thereby sustaining the road project implementation. All plans by the Government is to focus on increasing efficiency, productivity, quality and reliability of infrastructure facilities and services to enhance linkages and improve transportation to support the nation's competitiveness.

The Sungei Way trial during 1984 was conducted to assess the performance of geogrid in road pavement field trial conditions (Ooi et al., 2004). The results of the Sungei Way trial were verified by the more rigorous Transport Research Laboratory (TRL) full scale laboratory trials. Based on the results of the full scale trials, it was concluded that punched and stretched biaxial geogrids for example stiff biaxial geogrids in granular base or subbase is effective in achieving
the following results (Ooi et al., 2004): -

a) Interaction by interlocking between the geogrid and the granular material is mobilised with minimal deformation of the geogrid;

b) Tensile strains and deformations in subgrade are minimised;

c) Interlock provided by the geogrids a reconfined to the granular materials and minimises their lateral displacement; and

d) Reduction in rut depth for similar pavement life.

The subgrade soil layer is an important part in transmitting and distributing the vehicle's load from the asphalt layer to subgrade layer at acceptable stress level. Moreover, conventional road pavement is necessary to maintain frequently however, this can lead to the increase in cost for the public fund. Moayedi et al. (2009) mentioned that without routine maintenance, most types of asphalt would provide approximately 90 percent of their original level of structural integrity after ten years. Once 20 years have passed, the asphalt will only have 55 percent of its initial durability indirectly affect the maintenance cost for this road pavement. Thus, in this study, the potential ability of geogrid in reducing settlement is investigated. Therefore, there is a huge impact on cost comparison between conventional method and geogrid reinforced technique applied in road construction.Hence, the objectives of the research are, i) to investigate geogrid's functions in road construction, ii) to study the cost-benefit of using geogrids in roadway sections, and iii) to make cost comparison between conventional method and geogrid reinforced technique applied in road construction.

2.0 LITERATURE REVIEW

2.1 Flexible pavement

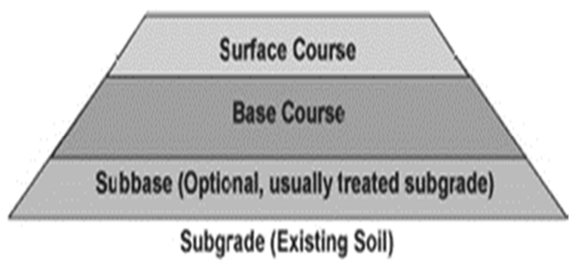

Figure 1: Flexible pavement crossection

Based on Figure 1, flexible pavement is defined as composed of a bituminous material surface course and underlying base and subbase courses (Jamal, 2017). The bituminous material is more often asphalt in which its viscous nature allows significant plastic deformation. Most asphalt surfaces are built on a gravel base, although some 'full depth' asphalt surfaces are built directly on the subgrade. Depending on the temperature at which it is applied, asphalt is categorised as hot mix asphalt (HMA), warm mix asphalt, or cold mix asphalt. Flexible Pavement is so named as the pavement surface reflects the total deflection of all subsequent layers due to the traffic load acting upon it. The flexible pavement design is based on the load distributing characteristics of a layered system. It transmits load to the subgrade through a combination of layers. Flexible pavement distributes load over a relatively smaller area of the subgrade beneath. The initial installation cost of a flexible pavement is quite low which is why this type of pavement is more commonly seen universally. However, the flexible pavement requires maintenance and routine repairs every few years. In addition flexible pavement deteriorates rapidly; cracks and potholes are likely to appear due to poor drainage and heavy vehicular traffic. A valuable advantage of flexible pavement is that it can be opened for traffic within 24 hours after completion. Also the repair and maintenance of flexible pavement is easy and cost effective.

2.2 Geogrid reinforced

Naue (2012) defines geogrids are polymeric products formed by joining intersecting ribs. They have large open spaces also known as "apertures". The directions of the ribs are referred to as machine direction (md), orientated in the direction of the manufacturing process or cross machine direction (cmd) perpendicular to the machine direction ribs. Geogrids are mainly made from polymeric materials, typically polypropylene (PP), high density polyethylene (HDPE) and polyester (PET). Geogrids are manufactured as either biaxial or uni axial. Biaxial geogrids are those that exhibit the same strength in both machines and cross machine directions while uniaxial geogrids exhibit the primary strength in the machine direction with minimal strength, just enough to maintain the aperture structure, in the cross machine direction. Figure 2 shows a geogrid element.

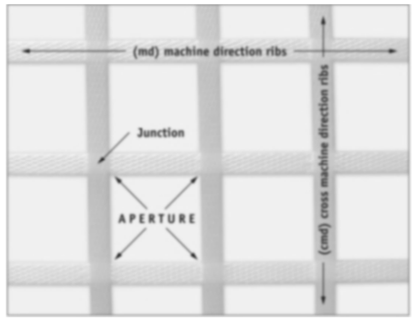

Figure 2: Geogrid (Naue, 2018)

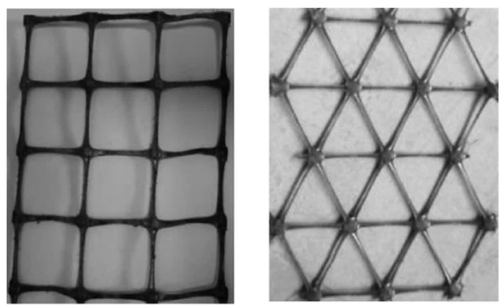

Figure 3: Biaxial and triaxial geogrid. (Chen et al. 2013)

Referring to Figure 3, geogrids are polymer grid structures used in soil reinforcement. Some construction professionals compare them to rebar in concrete, since they provide interior strength. They are manufactured to provide either uniaxial or biaxial reinforcement, meaning they are designed to accept and distribute strain in one or two directions (referred to as longitudinal and tranverse). When soil reinforcement is needed to support strain in one direction, such as behind a retaining wall, uniaxial geogrids are often applied. For roads, the strain is more diffuse, so biaxial geogrids are generally applicable (Naue, 2012)

Figure 4 shows that geogrid reinforced put within an aggregate layer, the grid gives a surface against which the aggregate grabs while helping distribute the load from the above. This interaction will greatly reduce migration within the aggregate layer; migration is a major cause of road settlements. When coarse aggregates mix with fine aggregates, small voids and weak spots develop beneath the road, which in turn causes cracking, rutting, and pot holes. Geogrids minimise the risk of intermixing, improve the strength of the base aggregate layer, and minimise the amount of aggregate needed. A better alternative is using geogrids for both paved and unpaved roads, which reduces the need for base course aggregate—a major cost, even in aggregate mining regions. And geogrids are playing structural role within the aggregate layer reduces the wear and tear on the overall road system, thus extending its life (Giroud et al., 1985).

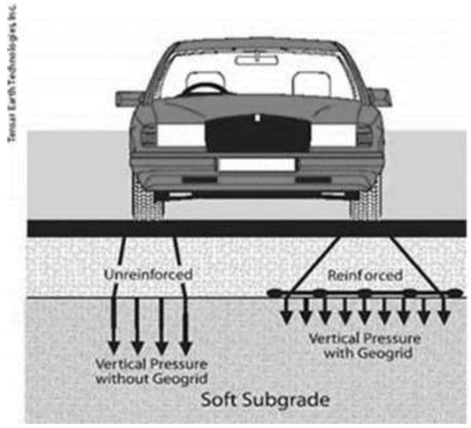

Figure 4: Geogrid reinforced in road pavement
(csengineermag, 2014)

Geosynthetic materials have been successfully used to stabilise subgrade soils in road construction,which leads to improved performance of paved and unpaved roads. Reinforced soils are often treated as acomposite material, in which the reinforcement resists tensile stresses and interacts with soil through friction. Geogrids can improve the performance of the subgrade soil through four mechanisms: prevention of local shearing of the subgrade, improvement of load distribution through the base course, reduction or reorientation of shear stresses on the subgrade, and tensioned membrane effect. Placed between the subgrade and base course, or within the base course, the geosynthetic improves the performance of paved roads. Besides, reinforcement increases the bearing capacity of the subgrade, stiffens the base layer thereby reducing normal stresses and changing the magnitude and orientation of shear stresses on the subgrade in the loaded area, restricts lateral movement of the base course material and the subgrade soil, and can provide tensioned membrane support where deep rutting occurs (Giroud et al., 1985).

2.3 Comparison between conventional and geogrid reinforced technique

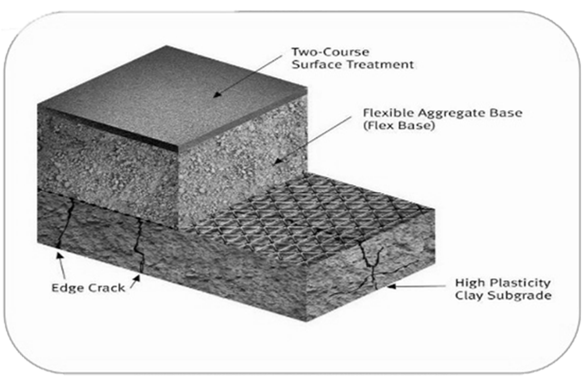

Figure 5: Geogrid reinforced road on high PI clay
(Tensar, 2013)

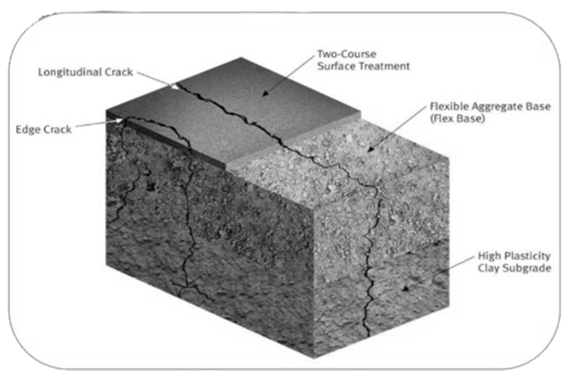

Figure 6: Conventional road on high PI clay
(Tensar, 2013)

Based on Figure 5 and Figure 6, there are huge comparisons between those techniques. Figure 4 shows that the settlement of subgrade does not affect other road components because geogrid joining prevent the cracking of other road components from occuring. While figure 5 shows that the subgrade settlement occurs in the road pavement, affecting the above of the road components which include aggregate layer and surface layer. As a result, there are a lot major failures in Figure 5 that need to be considered such as maintenance cost as it requires a long period of time to repair the failures compared to Figure 4 that which is unnecessary to repair the failure unless it is harmful.

3.0 METHODOLOGY

The research methodology adopted for the research is a qualitative method which consists of a documental analysis and case study approach.

4.0 ANALYSIS AND FINDINGS

Life Cycle Costs							
		Unreinforced			Tensar TriAx Geogrid Reinforced		
Year	Discount Factor	Initial Cost	Maintenance	Rehabilitation	Initial Cost	Maintenance	Rehabilitation
0	1.0000	$533,000			$597,000		
3	0.8890		$ 102,234.58				
6	0.7903		$ 90,886.17	$ 122,498.75			
9	0.7026		$ 80,797.47			$ 80,797.47	
12	0.6246		$ 71,828.66	$ 96,812.54			
15	0.5553		$ 63,855.42				
18	0.4936		$ 56,767.23	$ 76,512.36		$ 56,767.23	$ 76,512.36
	Sub-Totals	**$533,000**	**$466,369.54**	**$ 295,823.65**	**$597,000**	**$137,564.71**	**$ 76,512.36**
	PWOC Total			**$1,295,193.19**			**$811,077.07**

Additional Cost	**12%**
LCC Saving	**37%**

Table 1: Comparison between conventional and geogrid reinforced in USA (Tensar, 2011)

Based on the Table 1, the implication of geogrid in road construction is that it can reduce the initial cost in the pavement component which is the reduction of asphalt layer in range 15-30% and the reduction of aggregate layer in range 25-50%. Besides that, it can also reduce its Life Cycle Cost (LCC). Through the unique properties of geogrid, it offers engineers, contractors and owners a solution that extends the service life of a pavement structure. This feature offers reduced maintenance and extends rehabilitation intervals which yields significant life cycle cost savings over conventional solutions (Tensar, 2011).

5.0 CONCLUSION

As a result, by applying this new innovation in road construction, the overall cost of construction can be reduced. In addition, indirectly, National Economy is minimised because road construction is one of the Government's projects and welfare to the citizen. Besides that, by using this new innovation technique, the lifespan of the road will be more durable compared to the traditional method and it reduces the maintenance work which related to the maintenance cost.

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