Use of geogrid-stabilized aggregate layers in roadway application projects, Honduras case studies

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Abstract. This document shows at least three roadway application projects that show the benefit of using geogrid-stabilized aggregate layers to build safe roads while reducing the carbon footprint construction and engineering. Most of these projects are located in conditions of narrow streets conditions where construction procedures tend to be more critical because alternative routes during construction are limited and traffic is high. Thus, where traditionally chemical stabilization or soil substitution has been used, mechanically stabilizaded layers with geogrids have been gaining importance, increasing their use because more previsibility, good performance, quick installation, carbon footprint reduction and others. These experiences could be helpful to planners and the engineering community for the implementation of more sustainable pavement projects.

1 Introduction

Relevant Honduras local experience and application of mechanically stabilized aggregate base course layer has been documented and published at Vennapusa et al. (2018) [2]. Road Route-39 El Carbón-Bonito Oriental Project, which consist in a two-lane roadway with 45.6 Km with a double chip seal showed through at least 21 automated plate load testing (APLT) tests that the pavement performance was substantially improved. For it well backed calibration proofs, its good success and impact, the project itself in 2018 was selected between 83 projects from Latin America and Caribbean within the 5 finalists of the *Superheroes of Development Award* [1] a recognition from the Inter-American Development Bank (IDB). However, even with this great double engineering milestone (considering also that was the first APLT testing in America outside Canada and US) it seems that there is still some local resistance to recognize the important of the scientific proved benefits that a well calibrated mechanically stabilized layer (MSL) can provide to the road's performance on time, in their life extension and contribution to C02 reduction because reduction of thickness of aggregate. Nevertheless, there is a city which has been changing the approach. Through good known municipally experiences, Central District Municipality (M.D.C., because its acronym in Spanish) conformed of two twin cities Tegucigalpa and Comayagüela, in recent

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years it has starting to switching from traditional untreated soil or cement treated subbase layers to mechanically stabilized layers (MSLs).

This paper will focus its attention to some of the projects implemented in M.D.C., describing their main characteristics, the year of implementation and their current status. In Table 1, a resume of the road projects can be seen. One of the mains shared aspect of this projects is that all consist of hydraulic concrete pavements 20 cm thick with a subbase layer underneath, which are directly constructed and supported by the subgrade. Because the local geology, the soils near to the surface typically consist in Clays (CL or CH sometimes) or Sanded Clays (SC). In some of these cases the CBRs of the subgrade indicated conditions of soft subgrade (CBR less than 3) but in others not.

Table 1. Case studies of road pavements in Honduras with geogrid-stabilized aggregate layer

Case	Project name	Subgrade CBR	Subbase layer Thickness (cm)	Year
1	La Reforma Underpass	2.4 %	17	2020
2	Boulevard Juan Bosco Underpass	1.6 %	30	2019
3	Juan Pablo II Boulevard Underpass	4%	20	2016
4	21 de Octubre Underpass	4% to 7%	17	2018

2 Background

2.1 Location and background

The projects presented here are located in different streets of M.D.C. in Francisco Morazán, Department, Honduras and were constructed as part of the improvement of road circulation planned by the Mayor's Office in a city with very narrow streets where in recent years the traffic volume has become a big problem. Because traffic is every year higher, in these projects, the authorities need quick action, then, one of the benefits of mechanically stabilized layers that have come to be appreciate it is their rapid construction because they do not need too many controls and waiting time as cemented treated material does to continue the road construction, being the last a common practice that they have used from the past. Because they have proved successfully the application of mechanically stabilized subbase layer, it is being applying in new streets rehabilitation of different points of the city.

2.2 Pavement materials

As previously mentioned, all the projects consist of hydraulic concrete pavements 20 cm thick with a mechanically stabilized subbase layer underneath. For the mechanical subbase stabilization, a multi-axial geogrid was used. The properties of the geogrid are presented in Table 2. As for soil properties itself, for these projects normally is recommended a typical AASHTO [9] subbase material, it means among some features liquid limit not greater than 25 and plasticity index not greater than 6.

Table 2. Summary of properties of the implemented geogrid in the case studies

Parameter	Description
Geogrid	TX5 Multi-axial geogrid
Rib shape	Rectangular
Aperture shape	Triangular
Rib pitch longitudinal	40 mm
Rib pitch diagonal	40 mm

According to Dong et al. 2011 [8], through comparison of numerical evaluations, they concluded that under tensile loading the triangular apertures of a multi-axial geogrid have far more uniform stress and strain distributions than geogrids with rectangular apertures. Moreover, Peng and Zornberg (2017) [5] using transparent soil evaluated the soil-geogrid interaction behaviour of geogrid specimen with different aperture shapes and based on results that geogrid with triangular aperture showed fewer displacements at three different junction locations along the specimens (both, the one with triangular apertures and the other with rectangular apertures) and demonstrated that in general that geogrid with triangular aperture showed better confined stiffness behaviour. Moreover, Wayne et al. (2019), basing on Automated Plate Load Testing (APLT) testing results on Interstate 5, Santa Clarita, California, demonstrated that using MSL (stiff mechanically stabilized layer with multi-axial geogrid) within a concrete pavement foundation reduces deformation as compared to thicker aggregate base sections. So, thicker sections do not imply a better performance a traditional approach that author has observed is still used in local practice. Also, Wayne et al. (2019) concluded that stiff mechanically stabilized layer with multi-axial geogrid within a concrete pavement foundation provides more uniform support improving rigid pavement performance, improves the performance of the aggregate base through confinement and less subgrade soil contamination. [7]

2.3 Pavement IRI measurement on urban collectors

Using IRI Thresholds according to Arhin et. al. 2015 [4], it would be possible to evaluate the smoothness of the road projects presented in this document. See Table 3. These values are more related to IRI at urban roads and closer to motorist's perception of ride quality in dense urban environments. For example, according to Arhin et. al. 2015 [4], on the average, motorists in Washington DC considered a IRI value of about 285.5 in/mi as fair for Collector Road type. Considering what has been observed locally, it could be of application on M.D.C. too. Regarding Table 3 criteria, all the case studies presented here are considered as Collectors.

Table 3. IRI Thresholds for DC (From Arhin et al. 2015)

	IRI Thresholds in/mi (m/km) depending on the road classification		
	Freeways	**Arterials**	**Collectors**
Good	≤ 124 (1.96)	≤ 182 (2.87)	≤ 188 (2.97)
Acceptable	124 (1.96) – 218 (3.44)	182 (2.87) – 281 (4.43)	188 (2.97) – 318 (5.02)

2.4 Measurements of pavement condition

Using smartphone technology, in August 2023 it was possible to measure the pavement condition of each road segment with a fully automated IRI measurement, with the TotalPave app. C. Cameron (2014) explains in detail how the TotalPave system works.

3 Projects case studies

3.1 Project 1 La Reforma Underpass

3.1.1 Description and pavement section

In this project, a mechanically stabilized subbase layer with a thickness of 17 cm was implemented. See Table 1 and Table 2. This project was developed in a street just in front of the US American Embassy. According IRI data collection, the observed road ride quality in August 2023 is between Good and Acceptable as shown on the right of Fig.2 and in Fig. 3. From right to left on Fig.3, segments of geogrid-stabilized of 100 m each, show the next IRI values, 2.62 m/km the first, 4.48 m/km the second and 2.92 m/km the third.

Fig. 2. Project 1 La Reforma at M.D.C., Honduras. Before (2020) and after (August, 2023)

Fig. 3. IRI measurement at Project 1 La Reforma at M.D.C., Honduras. (August, 2023)

3.2 Project 2 Boulevard Juan Bosco Underpass

3.2.1 Description and pavement section

In Juan Bosco Underpass, a mechanically stabilized subbase layer with a thickness of 30 cm was implemented. See Table 1 and Table 2. This project was developed in 2019 in one of the busiest streets in the city because it connects different neighbourhoods with the main shopping mall of the city and the Presidential house. The observed road ride quality in August 2023 is Acceptable as shown on the right of Fig.4 and in Fig. 5. From right to left on Fig.5, segments of geogrid-stabilized of 100 m each, show the next IRI values, 3.72 the first segment and 3.1 m/km the second. Regarding the pavements segments (also 100 m each) before and after the geogrid-stabilized segment, these sections without geogrid stabilization have values of 4.53 m/km and 4.61 m/km, respectively.

Fig. 4. Project 2 Boulevard Juan Bosco at M.D.C., Honduras. Before (2019) and after (August, 2023)

Fig. 5. IRI measurement at Project 2 Boulevard Juan Bosco at M.D.C., Honduras. (August, 2023)

3.3 Project 3 Juan Pablo II Underpass

3.3.1 Description and pavement section

Juan Pablo II Underpass implemented a mechanically stabilized subbase layer with a thickness of 20 cm in the ramps of entrance and exit. See Table 1 and Table 2. This project was developed in 2016 in one of the busiest streets in the city. It connects different principal streets with the Presidential house and the main shopping mall of the city. The observed road ride quality in August 2023 is Acceptable as shown on the right of Fig.6 and in Fig. 7. From right to left on Fig.7, segments of geogrid-stabilized of 100 m each, show the next IRI values, 4.67 m/km the first segment and 3.04 m/km the second. Regarding the pavements segments (also 100 m each) before the entrance and after the exit, these sections without geogrid stabilization have values of 4.79 m/km and 6.09 m/km, respectively.

Fig. 6. Project 3 Juan Pablo II Boulevard Underpass. Before (2016) and after (August, 2023)

Fig. 7. IRI measurement at Project 3 Juan Pablo II Boulevard at M.D.C., Honduras. (August, 2023)

3.4 Project 4 21 de Octubre Underpass

3.4.1 Description and pavement section

In this project, a mechanically stabilized subbase layer with a thickness of 20 cm was implemented. See Table 1 and Table 2. This project was developed in 2018 in one of the busiest streets in the city and the observed road ride quality is between Good and Acceptable as shown on the right of Fig.8 and in Fig. 9. It connects the main peripheral boulevard with Próceres Boulevard where the US American Embassy is located. From right to left on Fig.9, segments of geogrid-stabilized of 100 m each, show the next IRI values, 2.77 m/km the first segment and 3.63 m/km the second. Regarding the pavements segments (also 100 m each) before the entrance and after the exit, these sections with cement treated subbase have values of 4.74 m/km and 4.91 m/km, respectively. This project actually begun with cement treated subbase of 17 cm but in process was changed to geogrid-stabilized layer.

Fig. 8. Project 4 21 de Octubre Underpass. Before (2020) and after (August, 2023)

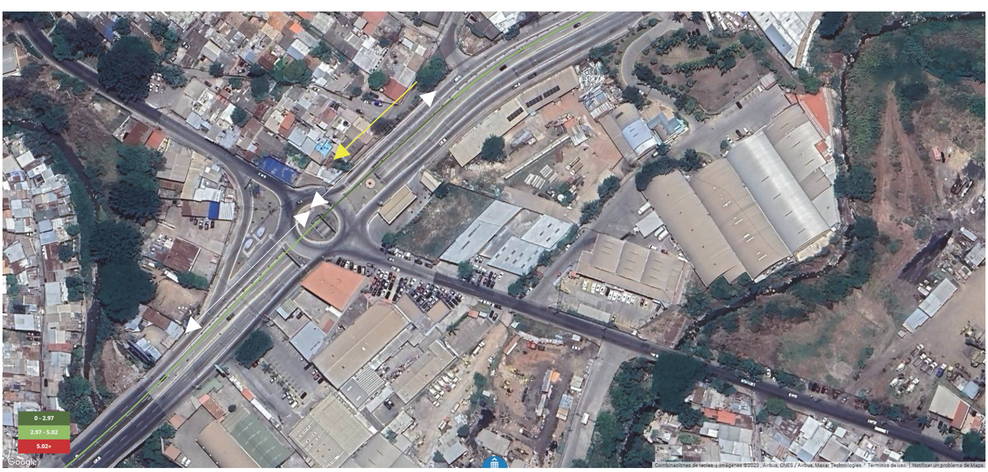

Fig. 9. IRI measurement at Project 4 21 de Octubre at M.D.C., Honduras. (August, 2023)

4 Final Comments

It is important to say that due to the good experiences presented here, the M.D.C. continues with the implementation of layers of aggregates stabilized by multiaxial geogrids with scientific support in its projects. Projects not only continue to apply multiaxial geogrids with triangular aperture but are also taking steps forward in next-generation geogrids (with three aperture geometries) concurrently with road projects in the United States. According to Tamrakar et. al. (2022) [6], this new type of multi-axial geogrid, which consist of continuous and non-continuous ribs forming three aperture geometries (hexagon, trapezoid, and triangle) and an unimpeded suspended hexagon, which test results showed this new multi-axial geogrid performed better than multi-axial geogrid that only have triangular apertures by improving the mechanical properties and resisting permanent deformation. As reported in Tamrakar et. Al. (2022), new full-scale tests on this newly developed multi-axial geogrid were conducted at the U.S. Army Engineer Research and Development Center (ERDC) and the results show that the geogrid stabilized sections experience about 68% to 41% less surface deformation than that of the control section (without geogrid) at the 10,000th load cycle.

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