

Case Study: Punched & Drawn Geogrid Incorporated beneath Asphalt Treated Base Course for Subgrade Improvement

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ABSTRACT

For the past several years private developers along with the City of San Antonio have been using Tensar Biaxial Geogrids to help reinforce pavement sections. The unique ability of punched and drawn biaxial geogrids to improve the performance and serviceability of flexible pavement has proven to be a cost effective construction practice.

Currently, the primary use of this material has been subgrade improvement for traditional pavement sections that consist of a moisture conditioned subgrade, crushed limestone base material and hot mix asphalt concrete (HMAC). The biaxial geogrid is routinely placed at the subgrade and base interface to help reduce the adverse effects of a high plasticity subgrade, as an alternative to traditional methods such as chemical stabilization and undercut and replace.

Recently, the City of San Antonio and the local engineering community has expressed a need to try and apply this construction method to pavement sections consisting of an asphalt treated base material (ATB) placed directly on the subgrade. The goal is to use the geogrid to help minimize premature longitudinal cracking and extend the life of the pavement. This method of construction, utilizing black base, is used primarily in existing developments and street reconstruction where there is a need to keep the street open to traffic during construction.

In-ground testing was conducted to test the critical aspects of placing a geogrid made of high density polypropylene on top of the subgrade directly beneath ATB, which is laid at a minimum temperature of 270 degrees F. Test data was collected from in-field monitoring as well as empirical data gathered from geogrid removed from the test section after construction. This data indicated that the biaxial geogrid was unaffected by the high ambient temperature environment. The results show promise for the utilization of punched and drawn polypropylene geogrids beneath ATB applications for the purpose of mitigating the effects of high plasticity pavement subgrades.

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Abstract

For the past several years private developers along with the City of San Antonio have been using Tensor Biaxial Geogrids to help reinforce pavement sections. The unique ability of punched and drawn biaxial geogrids to improve the performance and serviceability of flexible pavement has proven to be a cost effective construction practice.

Currently, the primary use of this material has been subgrade improvement for traditional pavement sections that consist of a moisture conditioned subgrade, crushed limestone base material and hot mix asphalt concrete (HMAC). The biaxial geogrid is routinely placed at the subgrade and base interface to help reduce the adverse effects of a high plasticity subgrade, as an alternative to traditional methods such as chemical stabilization and undercut and replace.

The City of San Antonio regularly uses hot-laid asphalt treated base material in their street sections. Placed directly on the subgrade, the asphalt treated base helps to keep the streets open to users even under inclement weather conditions. Historically, geogrid has not be used in this application due to concerns about changes in the material properties of the grid from exposure to the elevated temperatures of the asphalt treated base. If weakened during this process, the performance of the grid and pavement section may not be as expected.

A test section was constructed and monitored to further investigate this concern. Tensor BX 1100 geogrid was laid on a clay subgrade and then covered with hot laid asphalt treated base. Temperature measurements of the subgrade, base material and ambient air were recorded. A section of the grid was later removed from the pavement section. Test results indicate no significant change in the grid properties as a result of being exposed to the higher temperature. The pavement section continues to perform well.

Introduction

The utilization of geosynthetic products for the stabilization of an aggregate component of a asphalt-aggregate-subgrade pavement system has greatly increased in the past 10 years in the state of Texas. The placement of such products, to include both geogrid reinforcement and geotextile, is typically located at the aggregate base-subgrade interface. Empirical and

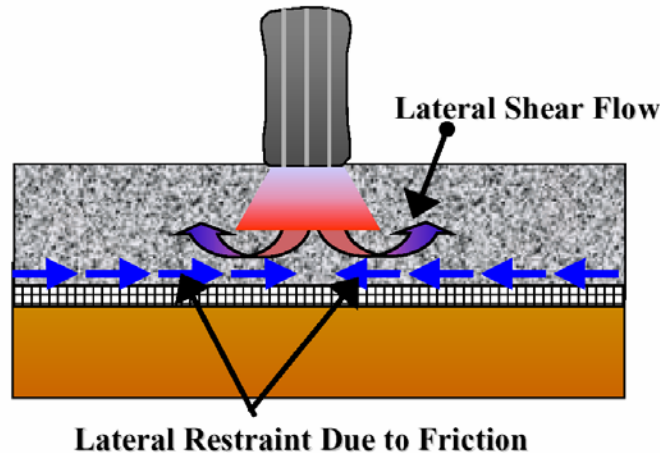
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laboratory evidence indicates that these products can greatly increase the bearing capacity of the pavement subgrade and improve the service life.

Geogrid reinforcement is designed to confine aggregate material from migrating laterally in opposite direction from an applied wheel load (base reinforcement) and to prevent particles from being punched into the pavement subgrade resulting in excessive strain in the pavement surface:



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Applications for geogrid reinforcement have increased in the state of Texas to the point that many public entities, such as the Texas Department of Transportation and the City of San Antonio, regularly specify and install this product for a variety of reasons:

- Subgrade improvement over soft, compressible soils (i.e. construction platform)
- Mechanical stabilization of sulfate-laden soil where calcium-based stabilizers are not recommended (lime, cement, or fly ash)
- Base aggregate restraint over high plasticity clay subgrade to mitigate edge and longitudinal cracking
- Aggregate base layer reinforcement for extended service life or component thickness savings
- “Factor of safety” measure to insure pavement service design life

Practically every application defined above limits the utilization of the geogrid reinforcement to be used in conjunction with a crushed aggregate base course without the use of any cementitious or bituminous binder. The primary function of the geogrid is to work as a composite system with an unbound aggregate layer to effectively add stiffness to an otherwise relatively weak (in tension) medium. The desired benefit realized by adding portland cement or asphalt cement to the aggregate medium is essentially identical to that of a geogrid reinforced aggregate. A primary limitation to utilizing a punched-and-drawn biaxial geogrid is its susceptibility to strength loss when exposed to extremely high temperatures common to asphalt-treated aggregate. This paper highlights an installation of a polypropylene punched-and-drawn geogrid beneath an asphalt treated base course along a short length of Valley Green Road in San Antonio, TX. Preliminary results reveal no loss in tensile strength of the geogrid reinforcement as the median

⁴ Department of the Army, U.S. Army Corps of Engineers – “USE OF GEOGRID IN PAVEMENT CONSTRUCTION,” ETL 1110-1-189, p. 4

temperature of the asphalt treated base-geogrid-subgrade interface was well below the softening point of the biaxial geogrid.

Asphalt-Treated “Black” Aggregate Base

The City of San Antonio has long advocated the use of bituminous treated crushed aggregate base for the primary purpose of performing partial or full-depth repairs of flexible pavements. Historically, this form of pavement repair (or construction of new pavement) can significantly expedite the time of (re)construction, allow construction in inclement weather conditions and allow partially re-constructed pavements to be opened to traffic even before the permanent asphalt riding surface is paved.

Asphalt treated aggregate base course is processed such that the aggregate particles is completely coated with bitumen. Typically, the material is mixed off-site and delivered to the jobsite via an end-dump or belly-dump type aggregate hauling truck:



Biaxial Geogrid Reinforcement

Geogrid reinforcement has long been utilized for City of San Antonio projects for the primary purpose of providing subgrade improvement over soft, compressible soils (i.e. construction platform). Empirical evidence from city projects dating back to early 1990 indicate that geogrid reinforcement is greatly enhancing the service life of asphalt pavements by mitigating the formation of cracks due to expansive, high plasticity clay during seasonal moisture variations. The City of San Antonio has a number of projects where biaxial geogrid was placed over expansive subgrade conditions in a conventional asphalt-aggregate-subgrade system that yielded impressive performance relative to other pavement systems placed over similar subgrade type(s). The Texas Department of Transportation has since documented the performance of geogrid-reinforced aggregate base in investigating different methods for repairing pavements over expansive soils:

“For full-depth repairs due to longitudinal cracking, methods currently being used in the Bryan District of the Texas Department of Transportation (TxDOT) using geogrid reinforcement to prevent cracks from propagating through the pavement surface show promise... In efforts to minimize the longitudinal cracking from highly plastic subgrades, the Bryan District has been using geogrids beneath a layer of flex base on FM roads to provide a barrier to keep cracks from coming through the surface. Results have been promising... The most effective treatment for dry-land cracking is the full-depth recycling method utilizing geogrid reinforcement (used in the Bryan District).”⁵

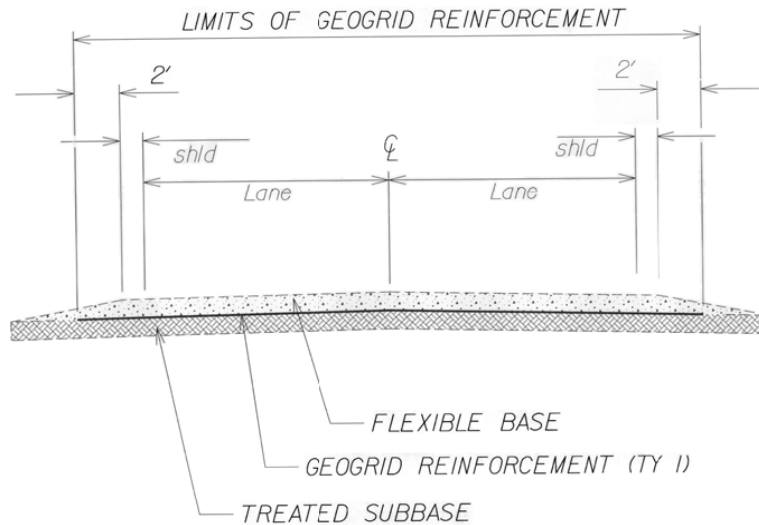


Figure 18. Geogrid Reinforcement on Expansive Soils.

*Schematic courtesy of Darlene Goehl, P.E.*⁶

Such beneficial performance is likely the same benefit recognized by the City of San Antonio for well over 10 years in utilizing the biaxial geogrid for subgrade improvement purposes initially. Given the performance of these projects, engineers at the City of San Antonio desired to evaluate the performance of a geogrid-reinforced pavement where asphalt-treated base course was utilized in lieu of an untreated crushed aggregate. The biaxial geogrid chosen by the City of San Antonio was Tensar BX1100, which meets the requirements of TxDOT Department Material Specification, DMS 6240 – Geogrid for Base/Embankment Reinforcement, Type 1.

Pavement Test Section

⁵ Texas Department of Transportation (sponsor), Texas Transportation Institute (author organization), “INVESTIGATION OF MAINTENANCE BASE REPAIRS OVER EXPANSIVE SOILS: YEAR 1 REPORT” Abstract, pp. 1, 7, 19

⁶ Texas Department of Transportation (sponsor), Texas Transportation Institute (author organization), “INVESTIGATION OF MAINTENANCE BASE REPAIRS OVER EXPANSIVE SOILS: YEAR 1 REPORT” p. 33 – Figure 18

On October 7, 2005, a test section was installed along Valley Green Road near the intersection of Huebner Road and Babcock Road in northwest San Antonio. The objective of performing the test was:

1. Monitor the temperature of the asphalt-treated base course at the surface and mid-point of the placement thickness.
2. Monitor the temperature of the pavement subgrade just below the geogrid layer.
3. Test the difference in tensile strength of the biaxial geogrid before and after the placement asphalt treated base course to determine strength loss (if any) due to high temperature
4. Monitor visually the performance of the test section over time in relation to the control section without geogrid reinforcement

The geogrid item was added by the City of San Antonio to evaluate the performance of an asphalt-asphalt treated base-subgrade system. Given the promising performance of previous geogrid installations over expansive subgrades, the City wished to evaluate whether or not the biaxial geogrid could potentially offer similar benefit in this application.



Geogrid Placement (10-07-2005)

Geogrid Sampled on Test Date

A test section measuring approximately 30 feet wide by 250 feet long was selected and cut to subgrade elevation. The biaxial geogrid was placed on top of a compacted, untreated subgrade in preparation for the delivery and placement of the asphalt treated base course. Prior to delivery of the treated aggregate base, a sample of the geogrid was taken for testing in a controlled laboratory environment. The product was tested for the following index properties:

- Aperture size
- Rib Width
- Rib Thickness
- Node (Junction) Thickness
- Tensile Strength @ 2% Strain
- Tensile Strength @ 5% Strain
- Ultimate Tensile Strength

To monitor the effect of the asphalt-treated base course upon being placed on top of the geogrid, the engineers involved in the test section decided to place electronic thermocouples at the midpoint of the base and on top of the subgrade. Expectations were that the subgrade temperature would potentially cool the asphalt treated base near the geogrid such that the geogrid layer would not be affected adversely by the high heat.



Asphalt-treated base delivery



Asphalt-treated base installation



Thermocouple placement



Temperature reading of subgrade

A laser temperature gage was utilized to take readings of the pavement subgrade prior to installation of the asphalt treated base and to test the surface temperature of the base upon being delivered to the jobsite and after compacted in place. Results of temperature readings are shown in Table 1 below:

TABLE 1 – TEMPERATURE VS. TIME

Date: 10/3/2005
 Time: 3:45 PM
 Ambient Air Temp: 94 F
 Subgrade SurfaceTemp: 105 F
 Subgrade Internal Temp: 98 F
 Black Base Arrival Temp: 268 F
 Black Base Thickness (Uncompacted): 8" - 10"

Time Elapsed After Dumping Asphalt Treated Base onto Subgrade	Top of Subgrade Thermal Coupler Temperature Readings	Midpoint Thermal Coupler Temperature Reading of Asphalt Treated Base	Surface Laser Temperature Reading
Initial	132	245	240
5 min	140	235	230
10 min	140	233	214
15 min	141	230	204
20 min	141	228	191
25 min	143	226	189
30 min	143	224	189
40 min	143	221	174
50 min	143	219	174
60 min	143	219	166
80 min	143	213	*
90 min	143	210	*
10/4/05 - 9:55 AM	91	*	93

* Not Recorded



Surface reading of asphalt-treated base



Temperature reading at mid-point

Results from the temperature readings, particularly at the subgrade elevation, indicate a significant difference between the temperature at midpoint of asphalt treated base and the top of the subgrade. This would indicate that the biaxial geogrid would not be adversely affected due

to the softening point (about 190° F) of the polypropylene material not being reached during placement (and after placement).

Post-Construction Testing

To confirm that the biaxial geogrid was not damaged due to the heated asphalt-treated base, a sample of the biaxial geogrid was exhumed in order to be returned for testing. To ensure the geogrid was not damaged during the exhumation, a section was cut and front-end loader was utilized to lift the asphalt-treated base without cutting the geogrid:



Sawcutting of black base



Exhumation of geogrid sample



Exhumation of geogrid sample



Exhumed geogrid sample

Sampling of the exhumed geogrid was relatively simple as the grid did not adhere to the black base as was anticipated during construction. Upon viewing the asphalt treated base, it was evident that aggregate “strike-through” was indeed achieved during placement and compaction of the base as shown in the above photograph indicated aggregate interlock with the geogrid. Finally, testing of the exhumed sample was necessary to confirm that the geogrid did not lose any strength or shape geometry after being exposed to the high heat environment:

TABLE 2 – GEOGRID INDEX TESTING – CONTROL VS. EXHUMED

Dimensional Properties (average values)			Control	Exhumed Samples
Aperture Size (mm)	MD		27.0	27.0
	TD		36.4	36.2
Rib Width (mm)	MD		3.24	3.27
	TD		3.12	3.03
Rib Thickness (mm)	MD		1.00	1.03
	TD		0.80	0.80
Node Thickness (mm)			2.90	2.88

Tensile Properties (average values)			Control	Exhumed Samples
Load @ 2% Strain (kn/m)	MD		4.64	4.74
	TD		8.02	8.19
Load @ 5% Strain (kn/m)	MD		9.80	9.93
	TD		15.6	16.0
Ultimate Strength (kn/m)	MD		15.2	15.2
	TD		21.4	22.3

Observations and Conclusions

Laboratory testing indicated that the biaxial geogrid maintained its original shape/geometry and tensile properties in spite of being subjected to temperature extremes consistent with asphalt treated aggregate base course. Based upon temperature readings in the field during the base placement, it is evident that the subgrade soil immediately cooled the base material surrounding the geogrid and thus, the geogrid was able to withstand the heat of the “resultant” temperature without losing strength or shape.

Performance of the test section reinforced with the biaxial geogrid will be determined in time as, at the time of this writing, the test section is less than one (1) year old. However, empirical data from previous installations in the City of San Antonio and TxDOT indicate that the inclusion of the geogrid may aid in minimizing the effects of an expansive subgrade soil by mitigating the formation of longitudinal and edge cracking. Previous concern regarding installation damage of the biaxial geogrid when used in conjunction with asphalt treated aggregate base can be allayed from the results of the Valley Green Road test section.