Tensar

Tensar's SpectraPave™ Software – Always Advancing

Executive Summary

Tensar's SpectraPave™ software continues to lead the market as a research-based design tool for applying geogrids in roadway applications. This includes stabilizing soft subgrade soils and improving performance of unpaved and paved roadways. As products testing and validation technologies improve, our design tools are attuned to make sure they produce appropriate engineering guidance in-line with those setting the standards of practice. ***Older versions of SpectraPave software are outdated and should not be used.*** Outdated versions include SpectraPave4-Pro™ Version 4.6.1 or lower released prior to February 2019.

Overview of Tensar's SpectraPave Software

Subgrade Stabilization

The quantification of the geogrid's performance benefit is relatively straightforward – a geogrid/aggregate composite is used to more effectively distribute loads over an unsuitable subgrade to provide for improved compaction and stability. This is quickly measured through density testing and/or proof rolling. Tensar's rollout of SpectraPave2™ included an approach that utilized Boussinesq equations to estimate the maximum stress applied to the subgrade directly beneath the loaded area. The unstabilized and stabilized fill requirements were then developed by adjusting the bearing capacity factor, and re-working the Boussinesq equations, in order to account for the added shearing resistance of the geogrid.

In 2004, Dr. J. P. Giroud and Dr. Jie Han developed the Giroud-Han method, which was published in the ASCE Journal of Geotechnical and Geoenvironmental Engineering (Giroud and Han 2004a; Giroud and Han 2004b) . This method addressed many other factors not considered by previous methods including distribution stresses, strength of the base material, traffic volume, wheel loads, the influence of the geosynthetic product being used on the failure mode, and rut depth. This methodology was adopted by Tensar in SpectraPave3™ software and quickly became the standard of practice in the industry – being incorporated into the FHWA NHI-07-092 manual (FHWA 2008). This method is generic. However, it requires product specific calibration be performed to properly apply the benefits of that product in design. Tensar has continued to use this methodology within our SpectraPave software as it is still the standard of practice. (More information can be found at https://www.tensarsolutions.com/subgrade-stabilization-research/)

Tensar has gone through the proper calibration of this method for our BX1100 and BX1200 geogrids as well as our TriAx® line of products.

Pavement Optimization (Flexible Pavement Design)

Early testing on flexible pavements incorporating Tensar BX biaxial geogrids to stabilize the aggregate base layer indicated significant improvements in pavement life. However, the number of data points was limited and the configurations used for this testing were also limited. As Tensar developed and introduced methods for pavement optimization (then referred to as "base reinforcement") using biaxial geogrids, the data available from both Tensar's testing and that performed by independent entities were synthesized to arrive at the best possible estimate of traffic benefit ratios (TBR's) for Tensar BX geogrids. These TBR's would be valid only over the relatively narrow range of pavement configurations that had been tested.

In SpectraPave2 software (released in 2004), a default TBR value of 3 was assigned to BX1100 geogrid, and a default TBR value of 6 was assigned to BX1200 geogrid. These values were user-controlled, and were to be adjusted by the designer based on the specific configuration and conditions under consideration. In addition, the user guidance stated that the TBR's used should be based on full-scale tests conducted under identical or very similar conditions.

Following the release of SpectraPave2 software, extensive empirical research was conducted by other agencies to refine the TBR values for Tensar BX geogrids:

- At the University of Alaska, full scale tests were conducted to address optimum depth and levels of benefit

- The US Army Corps of Engineers, using 30-kip wheel loads, developed and tested different sections. Significant improvement was found for base and ACC combined thickness between 8 inches (200mm) and 16 inches (400mm), but TBR values ranged depending on the section, geogrid type and subgrade conditions (Jersey and Tingle 2010; Jersey et al. 2012).
- The University of Illinois full scale accelerated pavement tests demonstrated that the geogrid positively contributes to the response of the stabilized base layer through the development of residual or locked in lateral stress under traffic loading, and that the geogrid positively influences the rutting damage models for base and subgrade layers (Al-Qadi et al. 2008).

From this work it has become evident that the TBR is not a constant for each geogrid type or grade and the benefit gained from the inclusion of geogrid is significantly influenced by a range of other factors. Conditions affecting each experimental TBR value have been shown to include:

- Aggregate quality and thickness
- Location of geogrid (sub-base or base course layer, and location within the layer)
- Asphalt quality and thickness
- Stiffness of the Mechanically Stabilized Layer (MSL)
- Subgrade strength or resilient modulus
- Effectiveness of the geogrid to provide lateral confinement (function of aperture shape, aperture size relative to aggregate size, rib orientation, and stiffness, manufacturing process,….)

Findings of this research were incorporated into the Advanced Base Course Reinforcement Module of SpectraPave3 software. SpectraPave3 software included two base course reinforcement design modules; Standard Method or the Advanced Method. In the Standard Method, default TBR values of 2 for BX1100 and 4 for BX1200 were used to develop geogrid-reinforced designs.

In the Advanced Method, a TBR was used in combination with a set of enhanced layer coefficients to explain aggregate stiffness enhancement in the zone above the geogrid. An effective improvement in the response of the overlying granular layer was represented by an increase in the overlying layer coefficient and the accumulated damage was represented by a TBR. Under this approach, default base TBR values of 1.5 and 2.5 were used for BX1100 and BX1200, respectively. However, the effective TBRs after incorporating the increased layer coefficients were actually greater than those values. At that time, the SpectraPave3 design methodology was the most advanced algorithm available for the use of Tensar BX geogrids in flexible pavement optimization. However, it did not accommodate the changes needed with TBR based on changing subgrade conditions, differences in aggregate, or thicknesses in the pavement layers.

Later, SpectraPave3 was superseded by SpectraPave4-PRO™. SpectraPave4-Pro is based on extensive performance testing of Tensar TriAx geogrids, including several recent full-scale accelerated pavement testing (APT) programs, over 100 Automated Plate Load Tests (APLT) on different materials and subgrades across the United States, Canada and Latin America, and continuing pavement condition surveys. This work is in-line with validation efforts now being conducted by many agencies and pavement experts. Additionally, SpectraPave4-PRO's TriAx design module has gone through an independent 3rd-party review and validation with Applied Research Associates (ARA) and Ryan R. Berg & Associates in 2013 and then again with ARA in 2017 (ARA 2017; ARA and RRBA 2013). These reviews by industry experts were never completed with prior versions. These independent expert reviews examined the documented research to make sure that the results and calculations from Tensar's SpectraPave4-Pro software are conservative as well as consistent and in accordance with AASHTO 1993 design (AASHTO 1993) and in-line with AASHTO's R50-09 practice for incorporating geosynthetics into flexible pavement design (AASHTO 2009). (For more information please reference https://www.tensarsolutions.com/pavement-optimization-research/)

In the 2017 3rd-Party review by ARA, which also included the review of the 2017 APT results by the Corps of Engineers, the following quotes were made:

> *"The SpectraPave4-Pro flexible pavement design module follows the empirically based 1993 AASHTO Guide for Design of Pavement Structures. The design approach uses enhanced layer coefficients to account for the benefits of the geogrid…The coefficients are specific to the Tensar TriAx geogrids and are a function of the technical specifications of the geogrid, thickness of the asphalt layer, thickness of the aggregate base course, and subgrade strength."*

"After more than 6 years of research and development, Tensar introduced TriAx geogrid into North America in 2009. Tensar has since demonstrated, through a series of rigorous comparative laboratory and field tests, that TriAx functionally outperforms the old generation biaxial geogrids."

"The SpectraPave4-Pro design procedure takes material properties for MSLs using only Tensar TriAx geogrid materials and increases the layer coefficients for those layers based on the anticipated increase in strength and durability for the MSL. ***At this time, increasing the layer coefficient is a technique that should only be applied when using Tensar TriAx, as no other products have had this technique validated through accelerated pavement testing."***

Previous versions of Tensar SpectraPave software provided a non-peer-reviewed design element that allowed for the user to design with biaxial geogrids using enhanced layer coefficients. However, it is clear from the 3rd-party review that this enhanced layer coefficient approach with biaxial geogrids does not have the appropriate testing to justify its use. To accommodate biaxial geogrids into the current version of SpectraPave software, additional design tools were researched with a focus on adopting a current standard of practice for incorporating biaxial geogrids into flexible pavement design. One of the most referenced design approaches was developed and published by California Department of Transportation (Caltrans 2012). The concepts within this method have now been adopted for use, within the latest version of SpectraPave, for biaxial geogrid stabilized flexible pavement design. This method is generic and applies to many of the biaxial geogrids encountered in the market today. One adjustment to the concepts within the CALTRANS method was the addition of a BX1100 geogrid within the software. (It should be noted that the CALTRANS method has also not gone through the same level of testing, validating and 3rd party peer review as the TriAx Pavement Optimization Design Module.)

Summary and Conclusions

Tensar has spent significant resources over the past 35+ years to better understand how geogrids contribute to the performance of paved and unpaved roadways. Our goal is to provide owners and designers the best design tools, support and products on the market. SpectraPave is a tool that will continue to provide current designs in accordance with those setting the standard of practice. As testing and performance requirements and metrics continue to change, it is imperative that designers work from the latest release of the software when completing a design or considering alternative biaxial geogrid designs.

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