Purdue Geotechnical Society

The Role of Geotechnics in supplying future energy needs.

The Use of Geo-synthetics to increase life and performance of roadways

- Haul Roads at power production plant – Base Reinforcement/subgrade improvement

- Heavy Duty Roads at Ethanol Plants – Base Reinforcement

DESIGN MEMORANDUM NO. 17-04

TO: Chief District Engineers
Design Engineers
Active Consultants

FROM: Gary W. Sharpe, P.E.
Director
Division of Highway Design

DATE: December 14, 2004

SUBJECT: Design Procedures for
Roadbed Stabilization with Geogrids

Geogrids are a category of geosynthetics that have gained increasing acceptance in road construction. The use of geogrids has demonstrated the potential to reduce the required thickness of aggregates for some situations. Geogrid products are categorized in the manner by which they are formed: extruded, woven, or welded. Extruded geogrids are formed using a polymer sheet that is punched and drawn in either one or two directions for improvement of engineering properties. Extruded geogrids that are pre-tensioned in

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pavement, and to reduce the structural cross section required for a pavement section for a specific service life.

Three mechanisms of reinforcement have been associated with the use of geogrids. These are lateral restraint, improved bearing capacity, and a tensioned membrane effect. Lateral restraint has been identified as the primary reinforcement mechanism of geogrids. Geogrids have been used for three different types of reinforcement applications: mechanical subgrade stabilization, reinforcement of aggregate bases, and reinforcement of asphalt pavements. Of these, this design memorandum addresses design considerations for use of geogrids as reinforcement in aggregate base applications.

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Design ... ved Roads.

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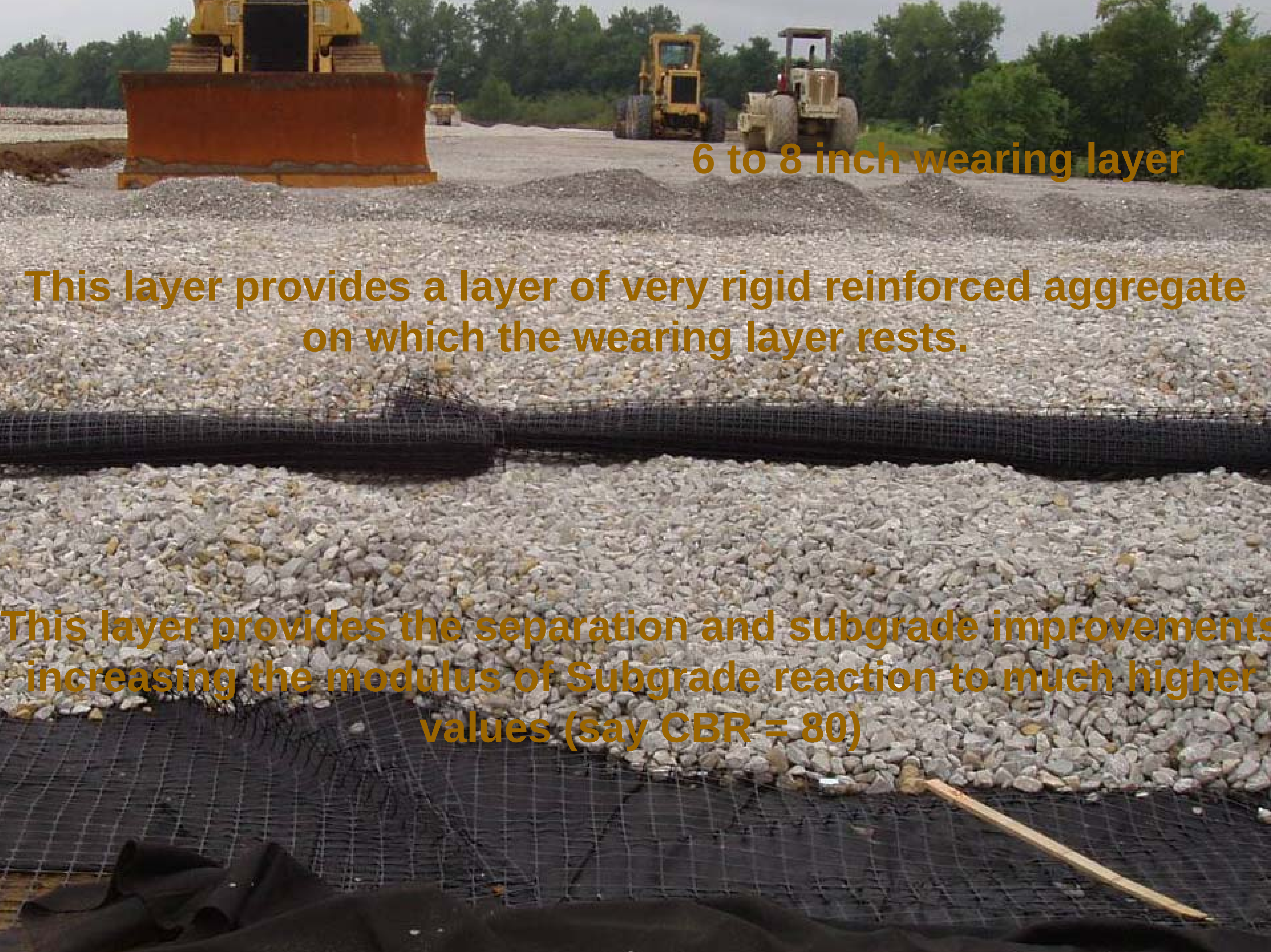
CE Database subj ... Road design; Bearing capacity;
Reinforcement; Cali

Haul Roads
Existing Conditions Design Criteria

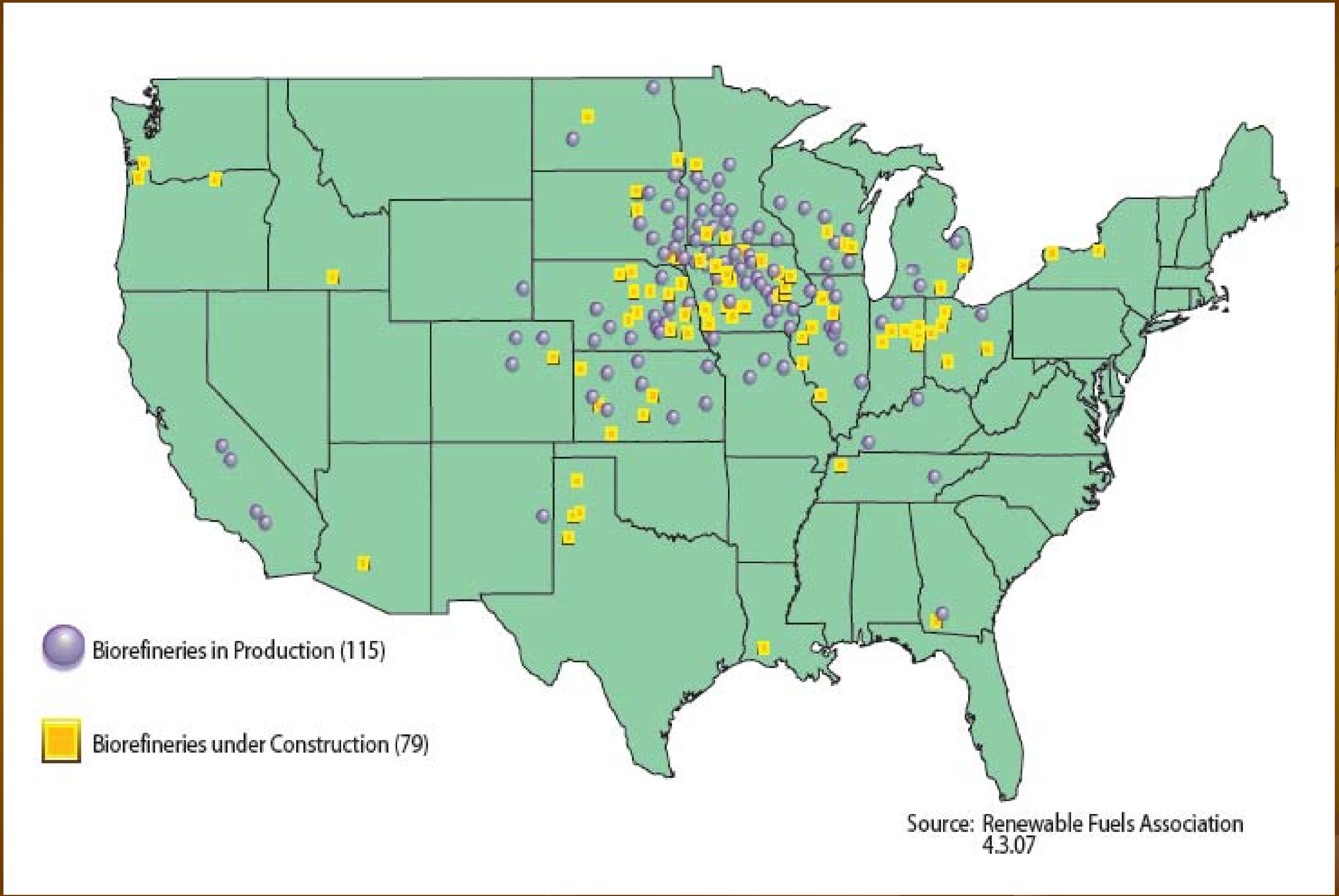
- Rolling wheel loads of 100,000 lbs
- Subgrade CBR value = 3 (Clayey Silt)
- No maintenance requirements over life road
- Approximate length of 1.5 mi. and up to 80 ft. wide


6 to 8 inch wearing layer
This layer provides a layer of very rigid reinforced aggregate on which the wearing layer rests.
This layer provides the separation and subgrade improvements increasing the modulus of Subgrade reaction to much higher values (say CBR = 80)

Normal Design Parameters

- Graphical solutions and history only available for design.
- Could have required as much as 7 feet of stone vs. the 4 ft. used
- Saved time and significant $ due to the savings of imported stone

Ethanol Plants


Biorefineries in Production (115)
Biorefineries under Construction (79)
Source: Renewable Fuels Association
4.3.07

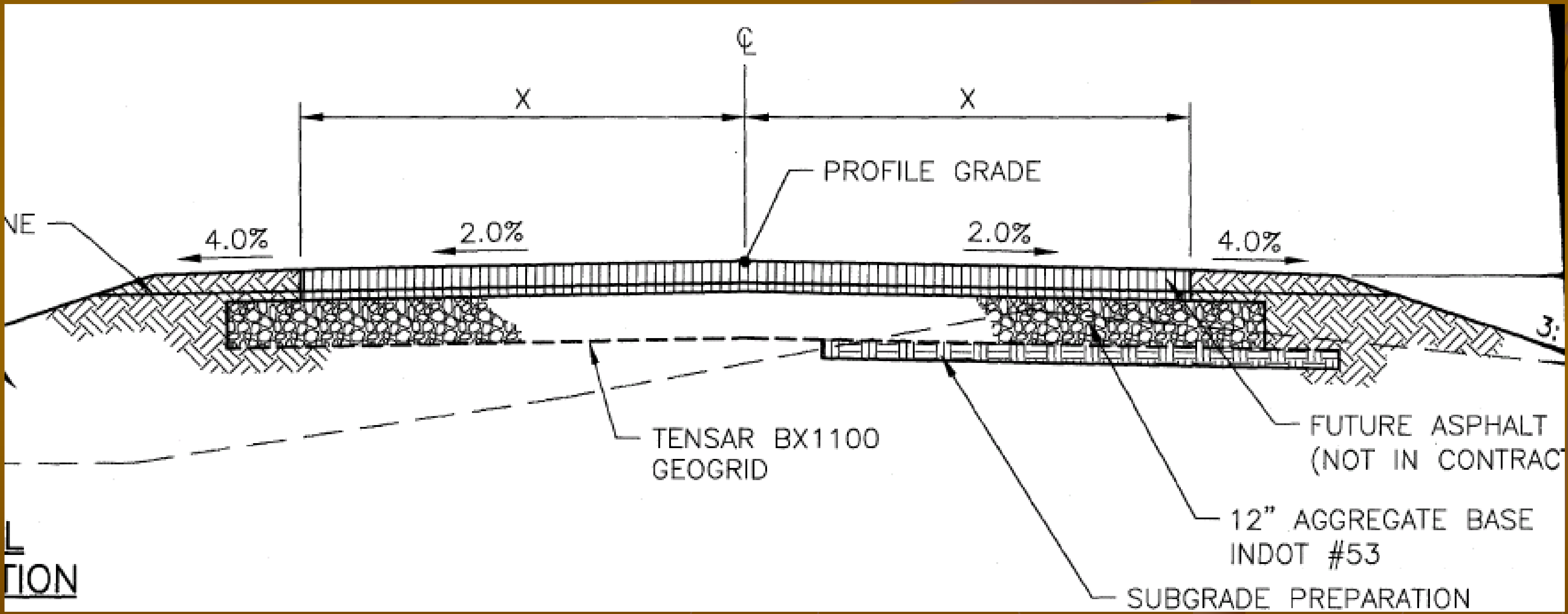
Some perceptions cited in local papers

- "I don't know if you realize," said another resident. "That's 12,000 train cars feeding it, 36,000 semis feeding it, a hundred semis a day."

Not just the facility though!

- 1 bushel of corn will produce @ 2.7 gallons of ethanol.
- 1 bushel of corn weighs 56 lbs.
- 1 gallon of ethanol weighs 8.5 lbs.
- Typical large fuel truck capacity is 9000 gallons.
- Typical fuel truck ESAL count is 2.3.
- Typical corn truck hauls 1200 bushels.
- Typical corn truck ESAL count is 2.3.
- So, a 100 million gallon per year plant creates the following:
- 100 million gallons = 11,111 TLs. x 2.3 ESALS per TL = 25,555 ESALs per year due to Ethanol out.
- 100 million gallons will require 37 million bushels of corn. Roughly 1200 bushels are carried on the biggest grain trucks, requiring 30,833 trucks for the corn, x 2.3 ESALS per TL = 71,000 ESALS for the grain in.
- So, the plant grounds will see 25,555 + 71,000 = 96,555 ESALS per year due to loaded corn trucks coming in and loaded fuel trucks leaving. But empty corn trucks will leave and empty fuel trucks will arrive. At .6 ESALS per TL, this adds another 57,933 ESALS. So, **per year ESALS will be @ 155,000**. This assumes no trucks for other supplies, maintenance, etc. With 5" asphalt and 12" base agg, this pavement fails after 3 years. This assumes a Mr of 5000. (Mr = 1500 x CBR), so if the subgrade CBR is a bit low the life of the pavement will be even less.
- Also, terminal serviceability may be bumped up. Standard ride indeces can be too low for very low speeds, especially with grain trucks which can be damaged by uneven pavement (ruts can be less severe at higher speeds). So, 5 on 12 lasts less than 3 years for a terminal serviceability of 2.5.
- And what about the municipal roads around the plant? They're likely designed for standard traffic loading. How about "Mr. Township Engineer, what concerns might you have about the service life of your roads around the new plant?". (it can be very difficult to provide a thicker pavement section to an existing road because you would have to raise the FG, causing all sorts of problems, or go deeper which in flat areas means you might hit crowns of culverts, disrupt waterlines, etc.)

Typical Cross Section of Plant Pavement



So What?

- In this case, the use of BX1100 as part of the pavement system has taken place of almost 5 inches of crushed stone.
- The use of some geogrids (as described by KYDOH, Han, et. Al., USCOE, FHWA, and the FAA) help increase the rigidity of the stone layer, in lieu of the extra stone.

THE END