CASE HISTORY: USE OF TENAX AND TENSAR GEOGRIDS FOR BASE COURSE STABILIZATION

LAKESHORE DRIVE IMPROVEMENTS PROJECT (MANDEVILLE)
FEDERAL AID PROJECT NO. STP-9998(002)
STATE PROJECT NO. 742-07-0095
ST. TAMMANY PARISH

Technical Assistance Report No. 18

by

Mark Morvant, P.E.
Geophysical Research Engineer

Rick Holm, P.E.
District 62 Construction Engineer

Louisiana Transportation Research Center
Louisiana Department of Transportation and Development
4101 Gourrier Avenue
Baton Rouge, LA 70808
Tel: (225)767-9108

January 1999

Table of Contents

List of Tables

List of Figures

PROJECT DESCRIPTION

Lakeshore Drive Improvements project, located on the north shore of Lake Pontchatrain in Mandeville, Louisiana was constructed in the summer of 1996 by T. L. James & Company with a geogrid reinforced base course. The majority of the work for the project consists of one and one-half miles of grading, drainage structures, base course and Portland cement concrete pavement. The original plans required the existing asphalt pavement surface and stabilized base course to be removed and replaced with eight inches of class II base course and eight inches of Portland cement concrete. A twelve inch subgrade layer would be required in soft areas as directed by the project engineer. The typical pavement sections are shown in appendix A. The geogrid reinforcement layer was added to the project by a plan change at the request of the contractor to replace the twelve inch subgrade layer.

SUBGRADE CONDITION

The geotechnical investigation performed by Eustis Engineering on February 18,1992 indicates approximately six inches of asphalt pavement constructed over one to three feet of clayey sands, silty sands, and sands with gravel and shells of medium dense to dense consistency. Below three feet, the soils varied with areas of very soft clays, stiff brown clays, sandy clays, silty clays, and loose to medium dense sandy silts. The ground water table was located between two and four feet below the existing ground surface at the time the borings were taken. The water table elevation is influenced by the tidal fluctuations of Lake Pontchatrain, located within 50 to 100 feet of Lakeshore Drive (figure 1). The boring logs and layout are presented in appendix B.

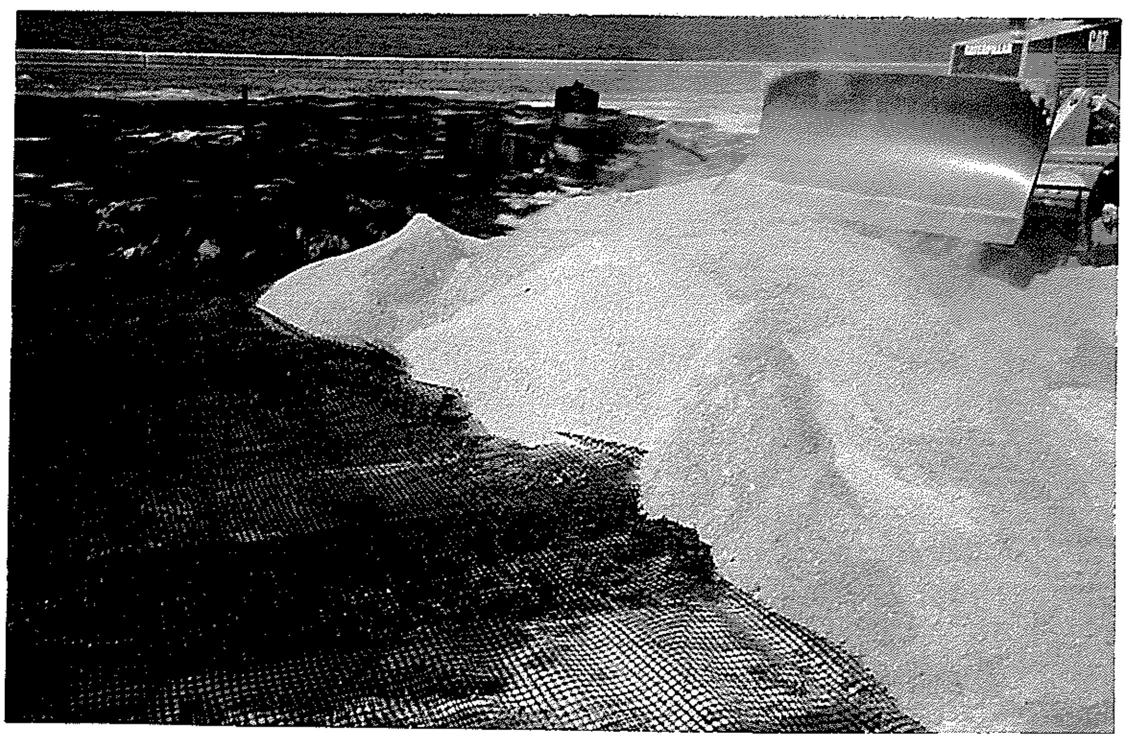


Figure 1
Vicinity of project to Lake Pontchatrain

CONTRACTOR TEST SECTIONS

Prior to beginning construction, the contractor was concerned with his production schedule. Depending on ground conditions, the excavation could be constantly changing from eight inches to twenty inches depending on the necessity of a subgrade layer. At his own expense, the contractor constructed four test sections on the west end of the project. The test sections, 50 feet long, were constructed as indicated in table 1.

Table 1
Contractor Test Sections

Test Section	Thickness (in)	Description
A	8	Base course on natural ground
B	12	Base course on natural ground
C	8	Base course on Terratex geotextile fabric
D	8	Base course on Tensar BX1100 geogrid

Crushed gravel aggregate stabilized with fly ash was used for class II base course. The Terratex fabric conformed to the properties of class S stabilization fabric in the standard specifications. The Tensar geogrid, conforming to the state specification for stabilization geogrid, was manufactured from polypropylene sheets that are punched and stretched to form a grid (figure 2). A loaded haul truck was placed on the test sections to simulate construction traffic. Test sections A, B and C experienced pumping and rutting. Test section D with the geogrid performed satisfactorily. The number of truck passes was not recorded.

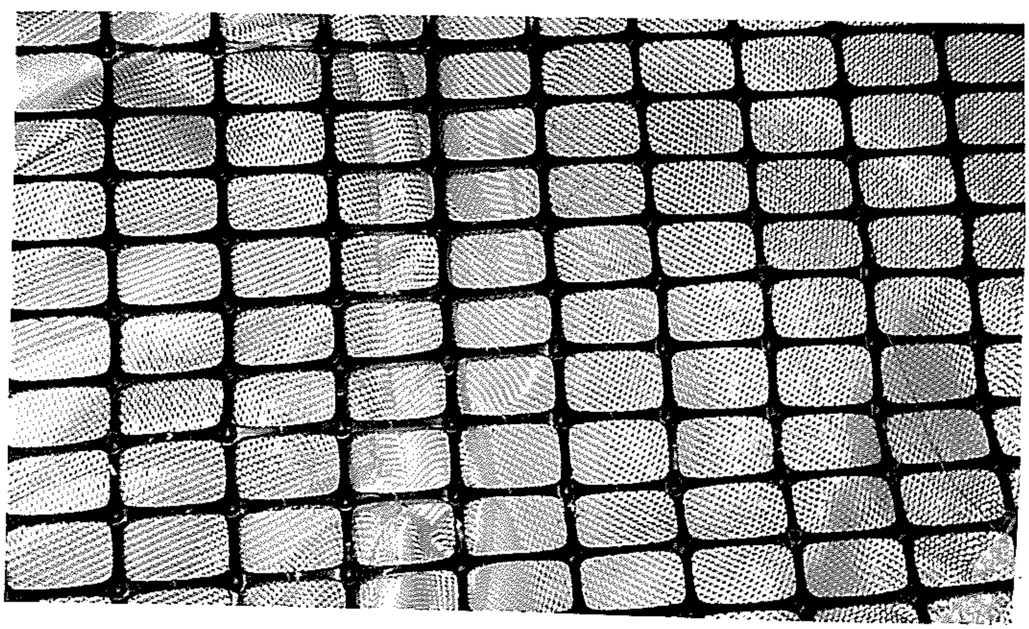


Figure 2
Tensar geogrid

Based on the results of the test sections, a plan change was approved to include a geogrid at the bottom of the base course throughout the project. A generic specification supplied by the DOTD Pavement & Geotechnical Design Section was used in the plan change to incorporate minimum material properties of the geogrid. The geogrid specification is presented in Appendix C. The contractor submitted Tenax MS220 geogrid rather than the Tensar BX1100 used in the test section. The Tenax geogrid was composed of two layers of extruded polypropylene mesh (Figure 3). The geogrid was approved for use based on the manufacture's certificate of compliance submitted in accordance with the specifications.

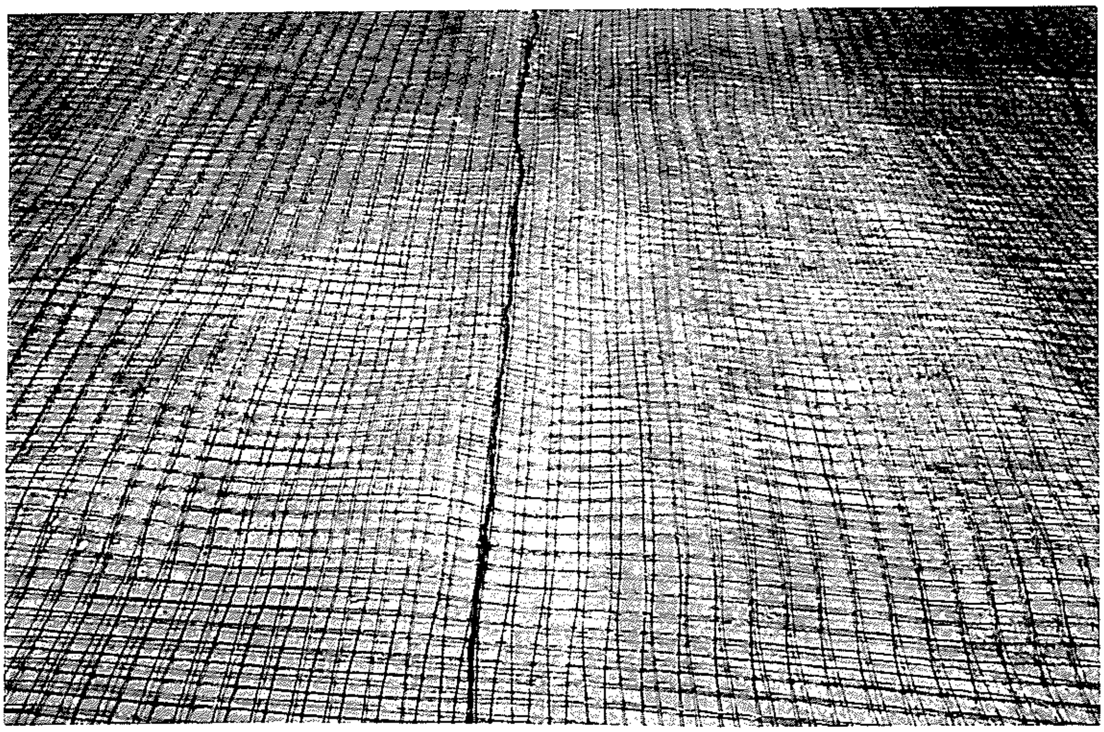


Figure 3
Tenax geogrid

STAGE ONE CONSTRUCTION

Stage one of the project extends from the west end of the project to station 139+00. For this portion of the project, the contract required haul trucks to enter on Carondalet Street (station 109+87) and exit on Wilkinson Street (station 166+75). This restriction placed a large number of truck passes on the base course (figure 4). It should be noted that the amount of truck traffic placed on the base course was much greater than was placed on the contractor's initial test sections. Soon after construction, a large portion of the base course began pumping and rutting (figure 5). Many areas experienced local base failures with the Tenax geogrid rupturing and becoming exposed at the surface (figure 6) A graphical representation of the failed locations is given on the layout sheet in appendix A. Of the 12,995 square feet of eight inch base course constructed on stage one of the project, 3140 square feet required excavation and repair. This amounted to an unacceptable 24 percent of the base constructed.

Figure 4
Haul truck traffic

Figure 5
Base course failures

Figure 6
Local base failure with ruptured Tenax MS220 geogrid

There was a concern that the individual layers of Tenax geogrid were failing independently and not acting as a single unit. To investigate this, several holes were excavated in the areas of pumping subgrade to expose the geogrid. This investigation did not reveal any separation of the geogrids.

The repair consisted of removing the base course, grid and weak soil to a depth of twenty inches and replacing with fly ash stabilized gravel over new geogrid (figure 7). This increased the aggregate thickness over the geogrid from eight to twenty inches. Payment was made based on a twelve inch subgrade layer and eight inches of base course.

An unanswered question remained as to whether the single layer geogrid used in the contractor's test section would have prevented subgrade pumping and subsequent base failures. An attempt to answer this question was attempted in two of the failed areas. Station 141+24 to station 142+06 was repaired with an eight inch base course placed on a Tensar BX1200 geogrid. Tensar BX1200 geogrid is stronger than both the Tenax MS220 geogrid used in stage one or the Tensar BX1100 geogrid used in the contractor's test sections. Another small repair was placed at the intersection of Lakeshore Drive and Carroll. The mainline section performed satisfactorily while the small repair at the intersection failed (figure 8). The results were inconclusive.

Figure 7
Excavation for repairs

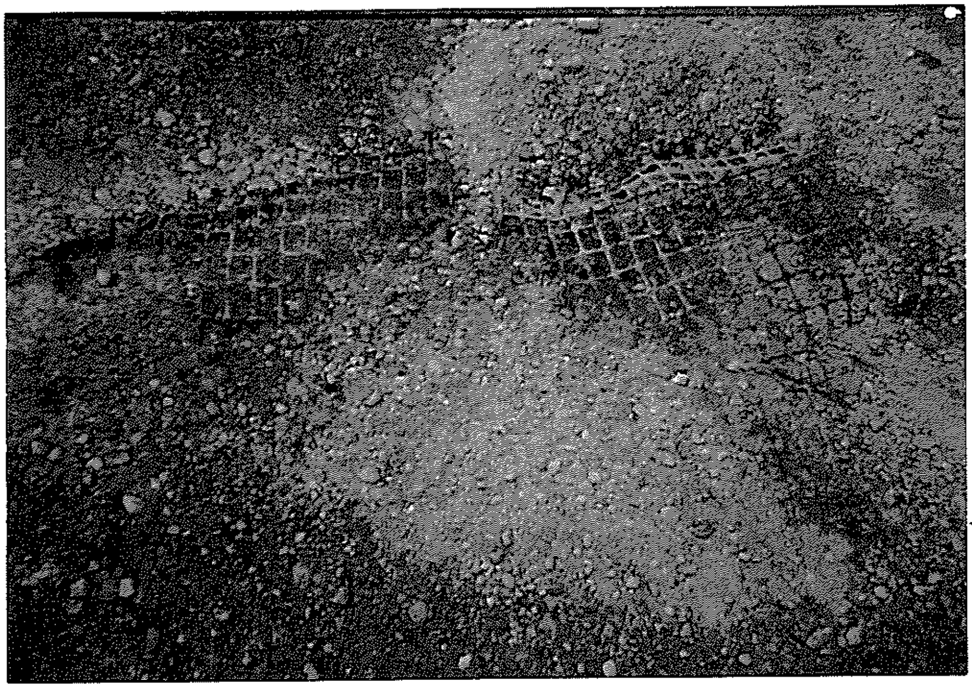


Figure 8
Local base failure with ruptured Tensar BX1200 geogrid

STAGE TWO REDESIGN

There were not enough funds available in the contract to increase the thickness of the aggregate between the geogrid and the pavement to twenty inches for the remainder of the project. Prior to starting phase two of the project, a design analysis was performed by the authors to determine what thickness of aggregate would be adequate to handle the construction loads. The Tensar Technical Note TTN:BR5, *Design Guideline for Subgrade Improvement Under Dynamic Loading with Tensar Geogrids* was used. The required parameters includes wheel load, tire pressure and soil shear strength. To simulate the construction haul vehicles, a dual wheel load of 9,000 pounds and a tire pressure of 80 psi was used. Since the geotechnical analysis did not provide soil shear strength testing, the values used in the redesign was back calculated using the present base failures. The TTN design chart was also checked using the soil consistency classifications taken from the geotechnical report. The majority of the failures occurred over medium clayey sand and silts in the vicinity of borings A-3, A-4 and A-6, over a soft clay near boring A-7 and over a loose sand near boring A-5. Back calculating the minimum soil strength necessary to support the loads with eight inches of base on a Tensar BX1100 geogrid, the soil strength was determined to be approximately six psi(figure 9). Using table 1 of the Tensar TTN:BR5, *Guide for Estimating Subgrade Soil Strengths (Fine Grain Soils)*, a shear strength of six psi falls within the upper range of a medium consistency soil. A copy of this table can be found in appendix D. Therefore, any soil shear strength less than six psi would be susceptible to failures. Using the median value for the strength consistency ranges, the minimum aggregate thickness for the base course in the areas of borings A-3, A-4 and A-6 (medium sandy clay - 5.2 psi) would be nine inches. The minimum aggregate thickness in the areas of borings A-7 and A-5 (soft clay, loose sand - 2.6 psi) would be fourteen inches (figure 10). Considering an aggregate thickness of eight inches was constructed, base failures were understandable.

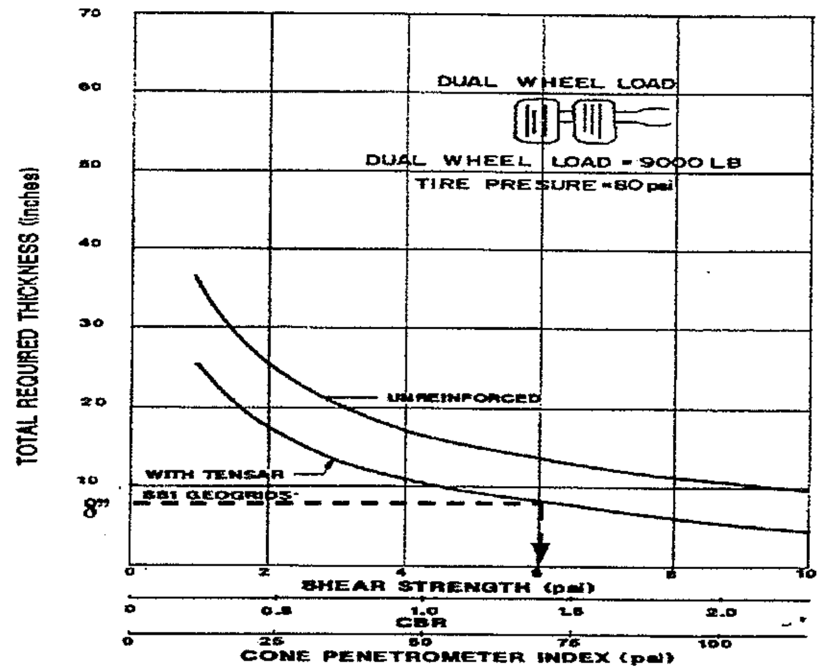


Figure 2 Thickness Requirements for 9,000 lb. Dual Wheel Loads.

Figure 9
Back-calculation to estimate soil strength

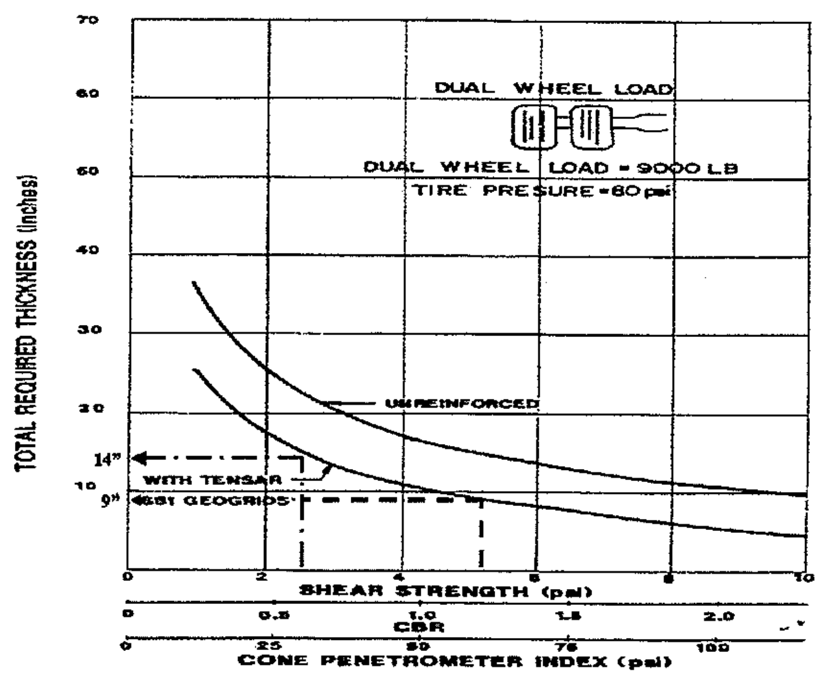


Figure 2 Thickness Requirements for 9,000 lb. Dual Wheel Loads.

Figure 10
Stage one minimum reinforced aggregate thickness from design chart

Another contributing factor for the failures could have been with the size of the aggregate used on this project. The aggregate gradation curves were plotted along with the range of preferred aggregate size as recommended by Tensar Earth Technologies (figure 11). Based on the overlap of the gradation curves, most of the aggregate used on the project had a smaller diameter than recommended. This could have resulted in a more moisture sensitive base with a lower bearing capacity than desired.

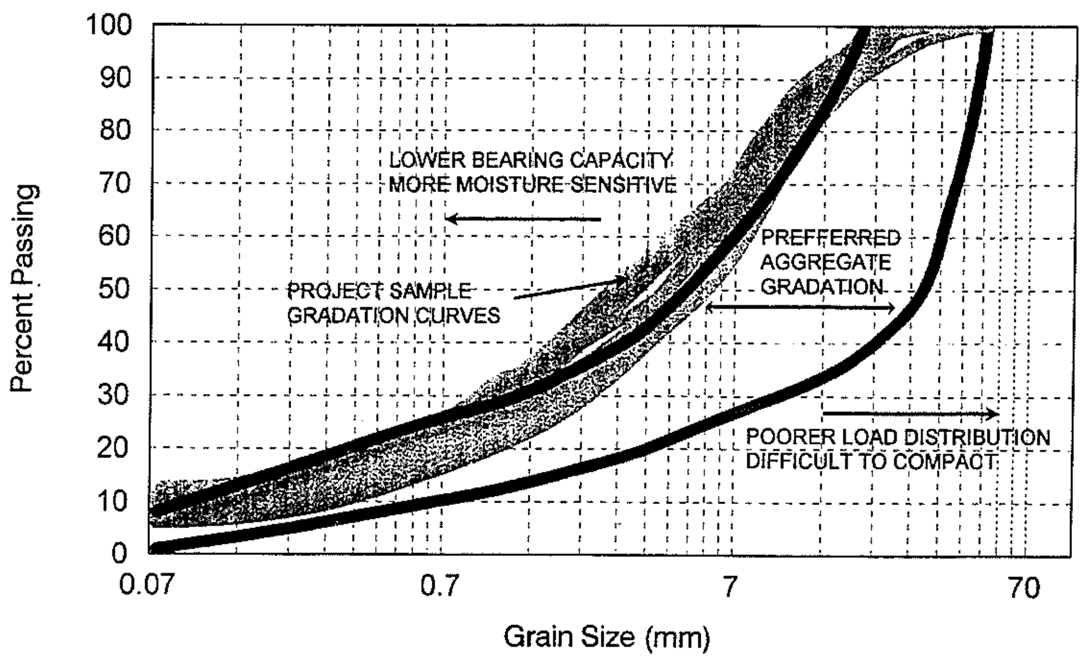


Figure 11
Base course gradation

The subgrade soils on stage II of the project consists of extreme strength differences from very soft to soft clays near borings A-8, A-11 and A-15 to medium stiff sandy clays near borings A-9, A-13 and A-14 to stiff sandy clays at borings A-10 to A-12. Considering the numerous failures on stage I, the lower range of the medium soils with a strength of 3.5 psi was chosen as the average soil design strength. With this strength an unreinforced section would require nineteen inches of aggregate and a reinforced section with geogrid would require twelve inches of aggregate (figure 12). Therefore the base course thickness on stage II of the project was plan changed to twelve inches. As indicated in the correspondence to initiate the plan change, future patching may still be required with this thickness. In areas of very soft soils or in areas subject to high traffic, some failures were still anticipated. Although there was some amount of risk with the twelve inch base thickness it was selected because it was the most economical alternative considering the remaining funds available in the contract. Any over-run would require matching funds from the city of Mandeville.

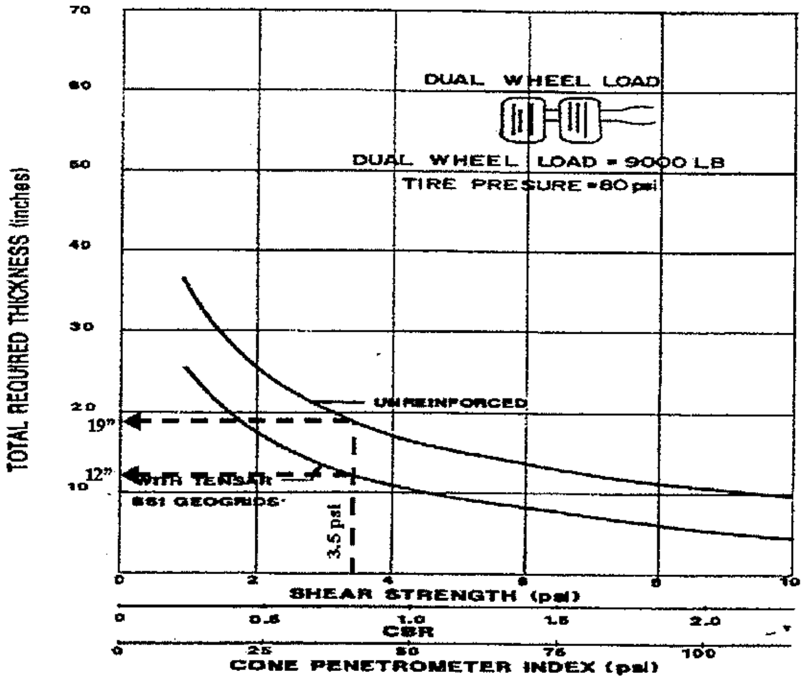


Figure 2 Thickness Requirements for 9,000 lb. Dual Wheel Loads.

Figure 12
Stage two aggregate thickness design

STAGE TWO CONSTRUCTION

To reduce the risk of large failures, the city of Mandeville agreed to allow more access routes to the project. This change considerably reduced the number of trucks passes on the base course. The role the multiple layer geogrid played in the stage I failures was still a concern. To try to answer this question, the contractor was required to place different grid types at the beginning of the stage II construction. Approval to continue use of the multiple layer geogrid for the remainder of the project would not be given until performance of these sections were reviewed. By varying the grid type and base thicknesses, field performance of each section could be compared. The base course configurations are shown in table 2.

With the increase in aggregate thickness and less construction traffic, stage II was completed with far less base failures than in stage I. As expected, there were still pockets of soft areas that needed repairs. However, of the 15,956 square yards of base course constructed, only 298 yards needed repair. Repairs for stage II was less than two percent of total constructed as compared to 24 percent for stage I. Table 3 presents the failures in each individual test sections. A graphical representation of the failed areas is shown on the layout sheet given in appendix A.

TABLE 2
Stage two base course sections

Station	Length	Geogrid	Base thickness
139+00 - 140+45	145 ft	Tensar BX1100	8 inches
140+45 - 141+24	79 ft	Tenax MS220	12 inches
141+24 - 142+06	82 ft	Tensar BX1200	12 inches
142+06 - 150+05	799 ft	Tensar BX1100	12 inches
150+05- 181+89 (end)	3,184 ft	Tenax MS220	12 inches

Similar strength geogrid types with the twelve inch base sections of stage II compared favorably with each other. The Tensar BX1100 geogrid produced failures in 2.8 percent of the base course area constructed while the Tenax MS220 geogrid produced failures in 1.4 percent. Tensar BX1200, a higher modulus geogrid, exhibited better performed with no failures in the mainline test sections. It should be noted that there were no failures in the adjacent section between station 140+45 and 141+24 with Tenax MS220. The better performance could possibly be attributed to other factors, i.e. better subgrade or less traffic. Therefore, with such a short section of Tensar BX1200, it would be difficult to make the conclusion that the higher strength geogrid would have prevented any failures for the entire project.

TABLE 3
Stage two test section results

Station	Geogrid	Base thickness inches	Total area sq. yds.	Failed area sq. yds.
139+00 - 140+45	Tensar BX1100	8	548	50
140+45 - 141+24	Tenax MS220	12	298	0
141+24 - 142+06	Tensar BX1200	12	261	0
142+06 - 150+05	Tensar BX1100	12	2937	82
150+05- 181+89	Tenax MS220	12	11,912	166
Total			**15,956**	**298**

A field inspection of the project two years after completion indicated all pavement sections to be performing adequately. There is no evidence of any subgrade or base failures. Figure 10 shows the completed project.

Figure 13
Completed project two years after construction

CONCLUSIONS

Geogrids can be used successfully for subgrade stabilization under permanent pavements. To be successful, proper designs incorporating existing soil conditions and anticipated loading need to be performed. Subgrade soil strength should be determined from laboratory tests or cone penetrometer tests.

Tenax MS220 and Tensar BX1100, geogrids of similar tensile modulus, performed equally in the field when exposed to similar conditions.

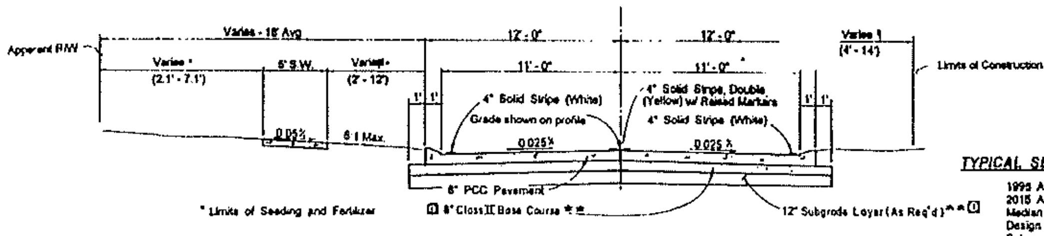
For the geogrids to have a better chance of success on weak subgrades, the appropriate base course aggregate size should be specified in the contract.

Caution should be taken when specifying geogrids under the base course for asphalt pavements. Although failures were reduced in stage II which allowed the concrete pavement to be constructed, achieving density on an asphalt pavement would have been difficult. An additional geogrid subgrade layer would be required to resist movements from pumping actions.

Appendix A

FAP No	STATE PROJ. No.	PARISH	SHEET NO
M-9958(007)	742-07-0095	ST. TAMMANY	2

14



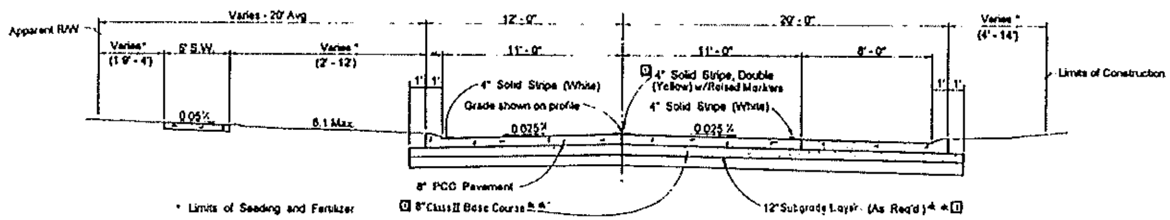
TYPICAL 24' SECTION

2 LANE SECTION

STA.	to	STA.
100 + 83.73	to	109 + 48.73
116 + 09	to	120 + 04
141 + 90	to	142 + 59
164 + 93	to	165 + 23
175 + 85.51	to	177 + 85

TYPICAL SECTION DESIGN DATA

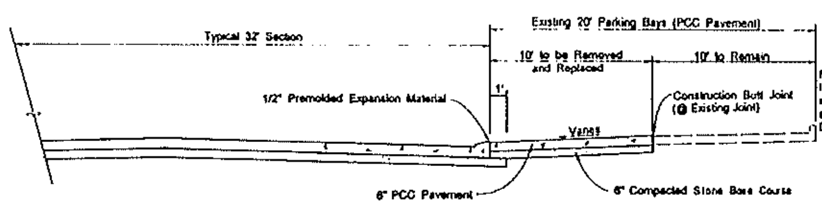
1995 ADT = 1,200
2015 ADT = 1,800
Median Year ADT = 1,500
Design Class = Urban UL - 2
Subgrade Modulus,k = 320
Working Stress, Ff = 450
Depth (D) Required = 6.5"
Depth (D) Provided = 8.0"



TYPICAL 32' SECTION

2 LANE SECTION
w/ PARKING LANE

STA.	to	STA.
110 + 28.91	to	116 + 35
120 + 84	to	128 + 99.30
130 + 97.30	to	141 + 30
143 + 19	to	164 + 33
165 + 83	to	173 + 98.73
178 + 45	to	180 + 18.28

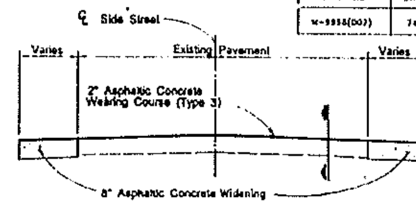


NOTE
If existing concrete has to be removed at places other than where joints exist, a full depth cut shall be made at No Direct Payment.

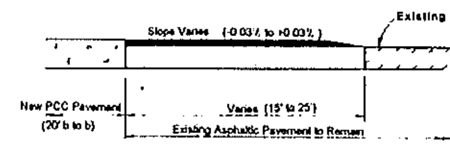
TYPICAL SECTION at PARKING BAYS

STA.	to	STA.
132 + 36	to	135 + 32
136 + 14	to	137 + 41
138 + 26	to	139 + 62
145 + 89	to	147 + 37
149 + 90	to	150 + 81
156 + 11	to	158 + 71

* Only Allowable Options are Asphaltic Concrete, Shell, Stone, Recycled P.C.C. or Crushed Gravel.

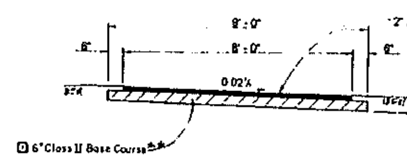


SIDE STREET TYPICAL SECTION



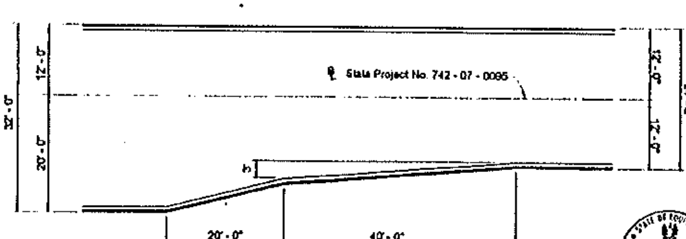
See Geometric Details Sheets 33-35

SIDE STREET TYPICAL SECTION



NOTE:
Seeding and fertilizing for jogging path construction is a No Direct Payment item to be included in other appropriate items.

JOGGING PATH - SECTION



PARKING LANE TRANSITION DETAIL

NOTES:

1. The City of Mandeville is the owner of all land on the South side of the project to the edge of Lake Pontchartrain.
2. Limits of Construction shown on the South side of the Project are for limits of seeding and fertilizing, and do not include the Jogging Path work, or the perpendicular drainage pipes extending from the roadway to the lake's seawall.
3. Vibratory equipment will not be allowed on this project to achieve required density.

DATE	DESCRIPTION	BY
6-27-95	Gen. Rev.	HKT

REVISIONS

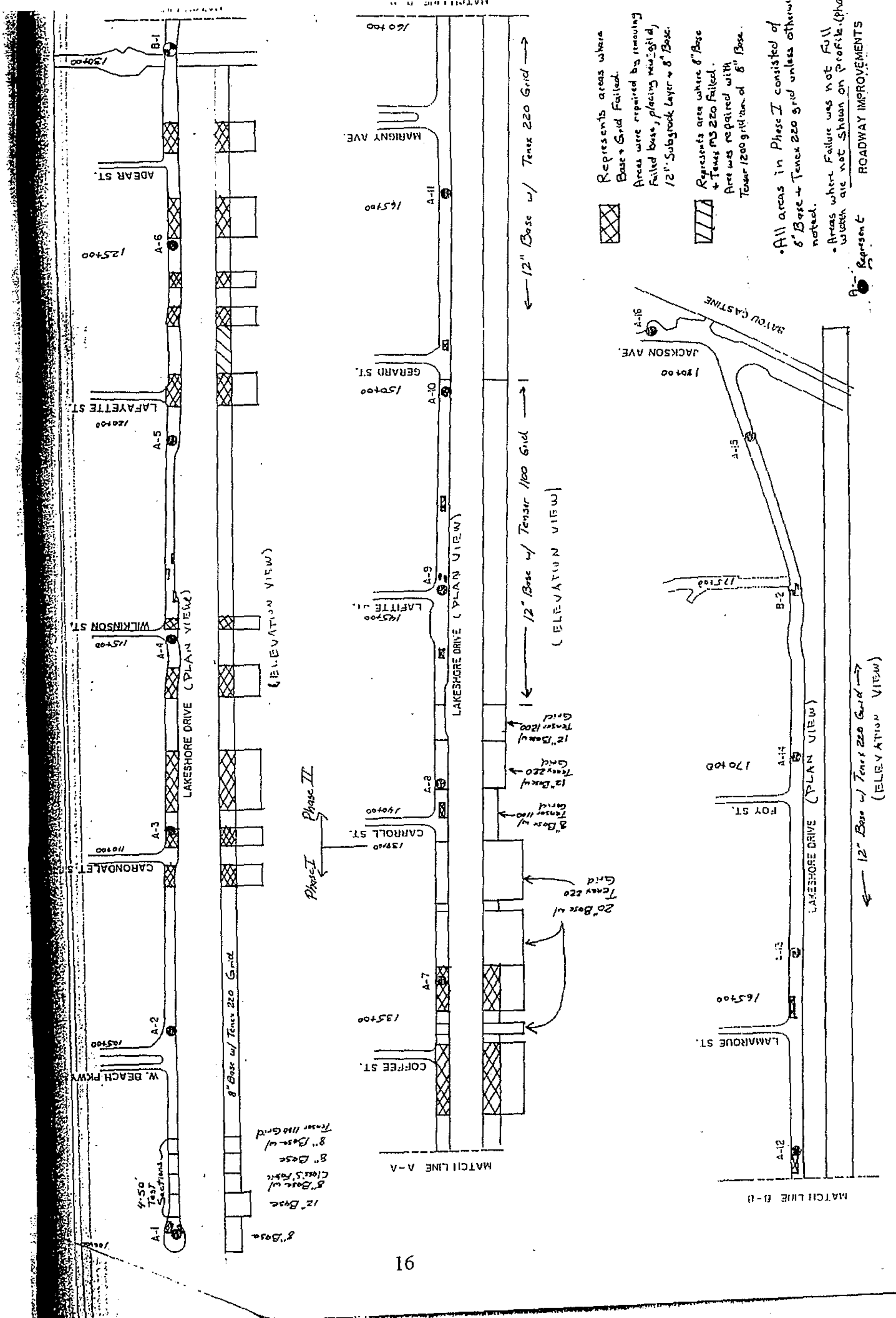
STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

TYPICAL SECTIONS and DETAILS

CORTECH, INC.

C.A.C.	R.P.S.	
R.A.M.	R.J.M.	1-23-95

Appendix B



LAKESHORE DRIVE (PLAN VIEW)
(ELEVATION VIEW)
8" Base w/ Tenex 220 Grid
Phase I
Phase II
W. BEACH PKWY
CARONDALET ST.
LAFAYETTE ST.
WILKINSON ST.
ADEAR ST.
MARIGNY AVE.
COFFEE ST.
CARROLL ST.
LAFITTE ST.
GERARD ST.
LAMAROUE ST.
FOY ST.
JACKSON AVE.
BAYOU CASTINE
4-50' Test Sections
8" Base
12" Base
8" Base w/ Class 5 Fabric
8" Base w/ Tensar 1100 Grid
20" Base w/ Tenex 220 Grid
8" Base w/ Tensar 1100 Grid
12" Base w/ Tenex 220 Grid
12" Base w/ Tensar 1200 Grid
12" Base w/ Tensar 1100 Grid
12" Base w/ Tenex 220 Grid
MATCH LINE A-A
MATCH LINE B-B
Represents areas where Base + Grid Failed.
Areas were repaired by removing failed base, placing new grid, 12" Subgrade Layer + 8" Base.
Represents area where 8" Base + Tenex MS 220 Failed. Area was repaired with Tensar 1200 grid and 8" Base.
• All areas in Phase I consisted of 8" Base + Tenex 220 grid unless otherwise noted.
• Areas where Failure was not Full width are not shown on Profile.
ROADWAY IMPROVEMENTS

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS
ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 1/22 & 2/4/92 Boring: A1-A3 Refer To "Legends & Notes"

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density Dry	Density Wet	Shear Tests Type	Ø	C	Atterberg Limits LL	PL	PI		Other Tests
					AUGER BORING A-1														
0					6" Asphalt pavement		1	1											
					Medium dense sand w/gravel (fill)	CH	2	2	47						87	29	58		
					Medium stiff gray & tan clay w/sand pockets & organic matter	CL	3	4	37										
5					Soft gray sandy clay w/sand pockets														
					Stiff tan & gray sandy clay w/small concretions & few roots	CL	4	6											
							5	8	26										
10					Water encountered at 3.5'														
					AUGER BORING A-2														
0					6" Asphalt pavement		1	1											
					Dense sand & shells (fill)	SP	2	2											
					Loose tan & gray sand w/clayey sand layers, shells, & gravel (fill)	CH	3	4	39										
5					Soft dark gray clay w/sandy clay layers, wood & roots	CL	4	6	30										
					Very soft dark gray sandy clay w/roots	CH	5	8											
					Stiff tan & gray clay w/sand pockets														
10					Water encountered at 2.5'														
					AUGER BORING A-3														
0					6" Asphalt pavement	SC	1	1											
					Medium dense gray & tan clayey sand w/gravel (fill)	CL	2	2	21										
					Medium stiff gray & tan sandy clay w/sand layers	CL	3	4											
5						CL													
					Soft gray sandy clay		4	6	23										
					Stiff gray, tan & red sandy clay w/few shell fragments		5	8											
10					Water encountered at 4.5'														

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS

ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 2/4/92 Boring: A4-A6 Refer To "

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density Dry	Density Wet	Shear Tests Type	Shear Tests Ø	Shear Tests C	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI
					AUGER BORING A-4												
0					6" Asphalt pavement												
					Medium dense tan & gray clayey sand w/gravel, shells & cinders (fill)	SC	1	2	8						21	17	4
					Medium compact gray & tan sandy silt w/cinders & roots	ML	2	4	17								
5					Stiff tan, gray & red sandy clay w/clayey sand layers & pockets	CL	3	6	26								
							4	8									
10					Water encountered at 4.5'												
					AUGER BORING A-5												
0					6" Asphalt pavement												
					Medium dense tan clayey sand w/gravel & shells (fill)	SC	1	2									
					Loose to medium dense tan clayey sand w/gravel	SC	2	4	12								
5					Medium dense tan clayey sand w/few roots	SC	3	6									
					Medium dense tan & gray sand	SP	4	8									
10					Water encountered at 4.5'												
					AUGER BORING A-6												
0					6" Asphalt pavement		1	1									
					Medium dense tan & gray silty sand w/gravel (fill)	SM	2	2									
					Medium stiff tan & gray sandy clay	CL	3	4	19								
5					Stiff gray & tan sandy clay	CL	4	6									
					Stiff gray & tan clay w/clayey sand layers	CH	5	8	58								
10					Water encountered at 4.5'												

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS
ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 2/4/92 Boring: A7-A9 Refer To "Legends & Notes"

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density Dry	Density Wet	Shear Tests Type	Shear Tests Ø	Shear Tests C	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI		Other Tests
					AUGER BORING A-7														
0					6" Asphalt pavement		1	1											
					Medium dense tan sand w/gravel	CL	2	2	25										
					Soft gray sandy clay w/few shell fragments		3	4	26						39	18	21		
5					Stiff gray & tan clay w/sandy clay layers	CH	4	6											
							5	8											
10					Water encountered at 4.5'														
					AUGER BORING A-8														
0					6" Asphalt pavement		1	1											
					Medium dense tan w/gravel (fill)	CL	2	2	21										
					Very soft tan sandy clay w/trace of organic matter	CL	3	4	24										
5					Very soft tan & gray sandy clay	CH													
					Very stiff gray & tan clay		4	6											
							5	8											
10					Water encountered at 4.5'														
					AUGER BORING A-9														
0					6" Asphalt pavement		1	1											
					Medium dense tan clayey sand w/gravel & roots	CL	2	2	26						41	19	22		
					Medium stiff gray & tan sandy clay w/roots	CL	3	4											
5					Stiff gray & tan sandy clay w/clayey sand pockets		4	6	25										
							5	8											
10					Water encountered at 4.5'														

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS
ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 2/4/92 Boring: A10-A12 Refer To "Legends & Notes"

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density Dry	Density Wet	Shear Tests Type	Shear Tests Ø	Shear Tests C	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI		Other Tests
					AUGER BORING A-10														
0					6" Asphalt pavement		1	1											
					Medium dense gray clayey sand w/shells & gravel (fill)	CL	2	2	29										
					Stiff tan & gray sandy clay	CH	3	4											
5					Stiff tan & gray clay w/sandy clay layers		4	6	28										
							5	8											
10					Water encountered at 4.5'														
					AUGER BORING A-11														
0					6" Asphalt pavement		1	1											
					Medium dense tan & gray clayey sand w/gravel (fill)	CH	2	2	28						52	19	33		
					Soft gray & tan clay w/clayey sand layers & pockets	CL	3	4	27										
5					Soft gray sandy clay w/silty sand lenses & pockets	CL	4	6											
					Stiff gray & tan sandy clay w/clay layers & silty sand lenses		5	8	26										
10					Water encountered at 4.5'														
					AUGER BORING A-12														
0					6" Asphalt pavement		1	1											
					Medium dense tan & gray clayey sand w/gravel & roots (fill)	CL	2	2	29										
					Stiff gray & tan sandy clay w/clayey sand layers & roots	CL	3	4	30										
5					Medium stiff gray sandy clay w/roots	CH	4	6											
					Stiff gray & tan clay w/sandy clay layers		5	8											
10					Water encountered at 4.5'														

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS
ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 2/4/92 Boring: A13-A15 Refer To "Legends & N

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density		Shear Tests			Atterberg Limits		
										Dry	Wet	Type	Ø	C	LL	PL	PI
					AUGER BORING A-13												
0					6" Asphalt pavement		1	1									
					Medium dense tan & gray clayey sand w/gravel (fill)	CL	2	2	18						27	16	11
					Stiff gray sandy clay w/clayey sand layers & roots	CL	3	4	20								
5					Medium stiff tan & gray sandy clay	CL	4	6									
					Very stiff tan & gray sandy clay		5	8	23								
10					Water encountered at 4.5'												
					AUGER BORING A-14												
0					6" Asphalt pavement		1	1									
					Medium dense gray & tan silty sand w/gravel	CL	2	2									
					Medium stiff gray & tan sandy clay w/clay layers	CL	3	4	40								
5					Soft to medium stiff gray & tan sandy clay w/clay layers	CL	4	6									
					Stiff gray & tan sandy clay w/few shell fragments		5	8									
10					Water encountered at 4.5'												
					AUGER BORING A-15												
0					6" Asphalt pavement		1	1									
					Medium dense gray & tan silty sand w/gravel (fill)	CH	2	2	57								
					Soft dark gray clay w/sand lenses, pockets & roots	CL	3	4	29								
5					Medium stiff gray & tan silty clay w/sand pockets & shell fragments		4	6									
					Soft gray clay w/silty sand layers, shells & decayed wood	CH	5	8	41								
10					Water encountered at 4.5'												

EUSTIS ENGINEERING

LOG OF BORING AND TEST RESULTS
ROADWAY IMPROVEMENTS, LAKESHORE DRIVE
MANDEVILLE, LOUISIANA

Ground Elev.: Datum: Gr. Water Depth: See Text Job No.: 11838 Date Drilled: 2/4/92 Boring: A16 Refer To "Legends & Notes"

Scale In Feet	PP	SPT	SPLR	Symbol	Visual Classification	USC	Sample Number	Depth In Feet	Water Content Percent	Density Dry	Density Wet	Shear Tests Type	Shear Tests Ø	Shear Tests C	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI		Other Tests
					AUGER BORING A-16														
0					6" Asphalt pavement		1	1											
					Medium dense tan silty sand w/gravel, shells & decayed wood	SM	2	2											
					Medium stiff dark brown sandy clay w/gravel & roots	CL	3	4	29										
5					Stiff gray & tan clay w/sand pockets & lenses	CH	4	6	33										
							5	8											
10					Water encountered at 4.5'														

22

Appendix C

DOTD Construction Specifications on Geogrid

ITEM S-035, GEOGRID: This item consists of furnishing and placing geogrid reinforcement in the areas shown on the plans prior to placement of base course.

Materials:

(1) General Requirements: The geogrid shall be a biaxially oriented polymer grid structure composed of polypropylene or higher density polyethylene with apertures designed to interlock with the surrounding fill material. The joints at the crossover points of mesh itself, are to be construction activities or under dynamics loads anticipated over the life of the structure. The geogrid shall be resistant to damage during construction, including ultraviolet degradation, and it shall have long-term resistance to chemical and biological degradation caused by the materials being reinforced.

(2) Detailed Requirements:

Property	Test Method	Requirements
Aperture Size,	I.D. Calipered	1.0-2.0 in.
Open Area, min.	COE method	70%
Flexural Rigidity, min.	ASTM D1388-64	250,000 mg-cm
Tensile Modulus, min.	GRI GGI-87	14,000 lb/ft
Junction Efficiency, min.	GRI GG2-87	90%

NOTES:

1. All numerical values represent minimum average roll values required in the designated direction.

2. The contractor shall submit a Certificate of Compliance that the geogrid meets the physical properties outlined above. The Department reserves the right to randomly sample and test geogrid material.

Construction Methods

The goegrid shall be placed in continuous sheets parallel to the centerline. Adjacent sheets of grids shall be overlapped a minimum of 18 inches. Care shall be taken to ensure that sections do not separate during construction.

The grid shall be cut to conform to curved sections as to maintain parallel placement to centerline. Care shall be taken to ensure that excessive buckling of the grid material does not occur. Excess material quantity, if any, required for making curves shall be at no direct pay.

Tracked equipment will not be allowed to operate directly on the grid. Damaged fabric shall be either removed and replaced with new grid or covered with a second layer of grid extending three feet in each direction from the damaged area.

Each grid roll shall be labeled or tagged to provide product identification sufficient for field inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected from ultraviolet light.

Measurement and Pavement

Quantity of Geogrid Reinforcement will be paid by the square yard of covered area at the contract unit price under:

Item S-020, geogrid, per square yard.

Appendix D

TABLE 1

Guide for estimating subgrade soil strengths
(Fine-Grained Soils)

C_u Shear Strength (psf) (psi)	SPT (blows/ft)	Cone Penetrometer	CBR	Estimated Consistency
< 250 (1.7)	< 2	< .24	< 0.4	Very soft (extruded between fingers when squeezed)
250-500 (1.7-3.5)	2-4	24-48	0.4-0.8	Soft (molded by light finger pressure)
500-1000 (3.5-6.9)	4-8	48-96	0.8-1.6	Medium (molded by strong finger pressure)
1000-2000 (6.9-13.9)	8-15	96-192	1.6-3.2	Stiff (readily indented by thumbs, but penetrated with great effort)
2000-4000 (13.9-27.7)	15-30	192-384	3.2-6.4	Very stiff readily indented by thumb nail)
> 4000 (27.7)	> 30	> 384	> 6.4	Hard (indented with difficulty by thumb nail)

(After Portland Cement Association, E. I. DuPort literature and McCarthy, David F., "Essentials of Soul Mechanics and Foundation, 1977.)