Reevaluation of Flex Base in the Ft. Worth District

Report 3931-1

Research Project
7-3931

Texas
Department
of Transportation

FM 1810

WISE COUNTY

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
7-3931		
4. Title and Subtitle REEVALUATION OF FLEXIBLE BASE IN THE FORT WORTH DISTRICT		5. Report Date December 2000 6. Performing Organization Code
7. Author(s) Richard S. Williammee, Jr., P.E. George L. Thomas, P.E.		8. Performing Organization Report No. 7-3931
9. Performing Organization Name and Address Texas Department of Transportation Fort Worth District 2501 S.W. Loop 820 Fort Worth, TX 76133		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Section/ Construction Division P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered In-House, September 98 to December 2000 14. Sponsoring Agency Code: 601

15. Supplementary Notes

Project conducted in cooperation with the Federal Highway Administration.

16. Abstract

Flexible base has been a predominant aggregate blend used in roadway structures for many years. It has served as a cheaper material for low to medium volume roads. The Fort Worth District has had some recent roadway failures that have been directly linked to failure of the flexible base. Recent assumptions attributed this to a wide range of triaxial values between the coarse and fine limits of the District's gradation band. Laboratory testing of the typical gradation confirmed this. A new large stone gradation was proposed and accepted to use in a test section on a construction project in Wise County. The section was constructed in August, 1999, and FWD data collected in September, 1999 and October, 2000.

17. Key Words		18. Distribution Statement	
Flexible base, aggregate, segregation, triaxial		No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	
19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Final Report/Project 7-3931

Reevaluation of Flex Base

in the Fort Worth District

By

Richard S. Williammee, Jr., P.E.

George L. Thomas, P.E.

Special Project Engineers

and

Andrew J. Wimsatt, Ph.D, P.E.

Research Assistant

Prepared for and by

Texas Department of Transportation
Fort Worth District

December 20, 2000

TABLE OF CONTENTS

LIST OF ATTACHMENTS

DISCLAIMER

CHAPTER 1 - PROBLEM

1.0 FLEXIBLE BASE PROBLEM STATEMENT

The Fort Worth District of the Texas Department of Transportation has historically strayed from the standard triaxial classifications for flexible base as described in the 1993 Standard Specification book. The method specified by the District has been one of gradation, PI, and Wet Ball Mill control but no triaxial testing. In recent years, it has been discussed that the District "standard" flexible base requirement has not provided an adequate support structure for the overlying bituminous or concrete courses based on a triaxial perspective. Additionally, as water has infiltrated from the surface, sides, and subgrade, the flexible base has been weakened to a failure mode in a short period of time assisted by the larger volumes and heavier loads added to the highway system. An initial geotechnical analysis of the District "standard" flexible base requirement revealed that the percent fines (passing the 0.075 (No.200) sieve) were not controlled, thereby allowing an aggregate supplier to inject any amount that the product could withstand and still meet the PI and Wet Ball Mill requirements. In a research paper by Jorenby and Hicks ("Design and Performance of Flexible Pavements, 1986, Transportation Research Board Record 1095), it was found that if fines are increased to approximately 13 percent, the strength of the base is reduced by about 40 percent and at approximately 24 percent fines, the base "is acting much like the subgrade material." Because of these factors, the conclusion was that with as much as 35 percent variation allowed in the gradation of the fines, the final flexible base layer would not maintain it's shear strength (Triaxial Class determined by TxDOT Test Procedure TEX-117-E) over the entire range of allowable gradations and fines contents.

CHAPTER 2 - OBJECTIVE

2.0 PROJECT OBJECTIVE

The objective of this research project was to determine whether the District's current TxDOT Item 247, Flexible Base "standard" broad-band gradation and the high allowable percent passing the 0.075mm (No. 200) sieve is creating unacceptable variations in the material's shear strength as determined by TxDOT Test Method TEX-117-E. This may be creating an unreliable factor for use in pavement designs.

A demonstration project was also proposed, accepted, and constructed to test a new flexible base gradation from which laboratory tests indicated an improved Triaxial Class (shear strength).

CHAPTER 3 - TASKS

3.0 RESEARCH TASKS

This research was accomplished by performing the following tasks:

Task 1: Perform laboratory tests on a flexible base mixed in the laboratory using aggregates obtained from one of the locally used producers.

NOTE: Three gradations were put together to follow the upper, median, and lower gradation limits currently being used. Each of these samples were subjected to the following tests:

TEX-110-E, Part I –
Determination of Particle Size Analysis of Soils (Gradation)

TEX-104,105,106-E –
Determination of Liquid and Plastic Limit and Method of Calculating the Plasticity Index of Soils (Atterberg Limits)

TEX-113-E –
Laboratory Compaction Characteristics and Moisture Density Relationship of Base Materials and Cohesionless Sands (Proctor)

TEX-117-E –
Triaxial Compression Tests for Disturbed Soils and Base Materials

Task 2: Prepare an interim report describing the results from Task 1.

Task 3: Perform Task 1 on two other local aggregate producers' materials.

Task 4: Perform Task 1 on a proposed new gradation envelope designed from results of Tasks 1 and 3.

Task 5: Meet with local aggregate producers to solicit their input in regard to a new proposed gradation according to their crushing capability and relative cost compared to the current gradation.

Task 6: Meet with District Design and Construction personnel to present results of Tasks 1-5 of this research for approval to place test sections on a demonstration project.

Task 7: Prepare a final report and the plan notes for the test sections.

Task 8: Assist with the construction of the test sections and document all aspects of constructability and field testing.

CHAPTER 4 – FINDINGS

4.0 RESEARCH FINDINGS

A. Laboratory results

TASKS 1 and 2

GRADATION	TxDOT TEST METHOD	RESULTS	
Coarse and Fine	TEX-104/106-E	Both gradations: LL=22; PI=6	
Coarse	TEX-110-E	45.0 mm	95%
		22.4	65
		4.75	25
		0.425	20
		0.075	18
Fine	TEX-110-E	45.0 mm	100%
		22.4	95
		4.75	60
		0.425	35
		0.075	28
Coarse	TEX-113-E	Maximum Density = 126.3 pcf (2023.13 kg/m^3)	
		Optimum Moisture = 5.9%	
Fine	TEX-113-E	Maximum Density = 130.2 pcf (2085.60 kg/m^3)	
		Optimum Moisture = 4.9%	
Coarse	TEX-117-E	Triaxial Class= 1.9	
Fine	TEX-117-E	Triaxial Class= 3.5	

Attachment A shows the 0.45 Power Gradation Chart for the current Fort Worth District's "standard" flexible base specification and the test data for the lower (coarse) gradation and the upper (fine) gradation.

TASK 3

Attachments B, C, and D show the 0.45 Power Gradation Charts for the three local aggregate pits sampled and tested.

TASK 4

Attachment E shows the 0.45 Power Gradation Chart for the proposed Fort Worth District flexible base specification.

Attachments F, G, and H show the 0.45 Power Gradation Charts for the three local aggregate pits after modification and testing.

TASK 5

Attachment I lists questions and answers from a meeting held with the local aggregate producers.

TASK 6

Attachment J shows the 0.45 Power Gradation Chart for the proposed Fort Worth District flexible base gradation after a meeting with the appropriate decision-making personnel.

TASK 7

The following plan notes were incorporated into a demonstration project using the proposed flexible base gradation. The project was FM 1810 from SH 101 in Chico east to FM 1655 South in Wise County. The project Control-Section-Job designation was 1751-01-016 and the project number was STP 99(10)R. The notes for Specification Item 247 were as follows:

> Item 247 (TY A GR 6). This project is being used to test a new flexible base gradation. Because of the nature of the test, crushed concrete will not be permitted as a substitute for Ty. A crushed stone.
>
> From Station 1+100.000 to Station 1+900.000, the material shall conform to the limitations shown below:

Retained On Sq. Sieve	Percent Passing By Weight
102 mm	100
76 mm	80-100
38 mm	50-75
9.5 mm	15-40
0.425 mm	0-10

Adding to or enriching the fraction passing the 0.425 mm (No. 40) is prohibited.

Plasticity Index	12 max., 0 min.
Liquid Limit	45 max.
Wet Ball Mill	50 max.

The minimum increase in the material passing the 0.425 mm sieve resulting from the Wet Ball Mill test shall not exceed 20 percent.

Owing to the coarse nature of this base material, special care should be exercised to prevent segregation during spreading and working to finish elevations.

The Engineer may accept the gradation determined at the aggregate supplier's plant as determined by the plant QC personnel in lieu of all other determination of gradation. The purpose of this is to reduce the chance of segregation affecting the gradation. This clause does not apply to any other section of the work on this project.

The above gradation does not apply to any other section of work on this project.

The flexible base in this test section shall be installed as a single lift 305 mm (12") thick using **ordinary compaction**. The material shall be sprinkled and rolled as directed by the Engineer. Compaction equipment shall be approved by the Engineer. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas and recompacting by sprinkling and rolling. The use of vibratory sheepsfoot rollers is recommended for the first several passes followed by two- or three-axle steel wheel compacting equipment. Note that the use of ordinary compaction applies only to this section of roadway from Sta. 1+100.000 to Sta. 1+900.000.

From Station 4+000.000 to Station 4+800.000, the material shall conform to the limitations shown below :

Retained On Sq. Sieve	Percent Passing By Weight
45 mm	95 - 100
22.4 mm	65 - 95
4.75 mm	25 - 60
0.425 mm	20 – 35

Plasticity Index	12 max., 4 min.
Liquid Limit	45 max.
Wet Ball Mill	50 max.

The minimum increase in the material passing the 0.425 mm sieve resulting from the Wet Ball Mill test shall not exceed 20 percent.

The flexible base in this test section shall be installed in one or more equal lifts for a total of 305mm (12") in thickness using **density control**.

The addition of field sand will not be permitted.

B. Test Sections Results

TASK 8

3 passes of water ⇒ 7.0% Air Voids with a nuclear gauge.

Falling Weight Deflectometer (FWD) data obtained from the two test sections on September 1, 1999 revealed the following values:

Regular 12" thick flex base - 171 ksi eastbound and 190 ksi westbound
Large stone 12" thick flex base - 40 ksi eastbound and 64 ksi westbound

Falling Weight Deflectometer (FWD) data obtained from the two test sections on October 13, 2000 revealed the following values:

Regular 12" thick flex base - 82 ksi eastbound and 112 ksi westbound
Large stone 12" thick flex base - 69 ksi eastbound and 93 ksi westbound

The Construction Division, Materials and Tests Section, Soils and Aggregates Branch offered the use of their Humboldt Stiffness Gauge to obtain data for ongoing testing they are doing with the device. Attachment K shows the data and plot of their findings.

CHAPTER 5 – OBSERVATIONS

5.0 OVERALL OBSERVATIONS

The test results from Tasks 1 and 2 from Section 4.0 above clearly show a significant difference in Triaxial Class (and therefore in shear strength also) throughout the whole range of gradations allowed by the District's "standard" specification. Since the Triaxial Class of the base material is used by Design to determine the pavement thickness, a variation from 1 to 3.5 is not acceptable.

The project roadway subgrade was cement stabilized.

The flexible base was made from Pioneer Bridgeport aggregate at their Bridgeport pit.

The subgrade was covered with flexible base up to 12", graded, compacted, then watered.

The large rock segregated to the edges.

Even on the typical 6" flexible base section, the larger rock segregated out to the sides. A grader was used to push the aggregate back up into the main section.

The initial thought was for the need to get water all the way to the bottom in order to obtain density throughout the section. The Contractor predicted that the water would quickly go straight down to the bottom. This proved to be correct with the initial compaction by the pneumatic roller.

The Contractor wanted to experiment with a CMI to add water while mixing based on recent work with the 6" flexible base on the same project and getting density in 2 days.

The CMI trial left the flexible base more segregated. The large rock came to the surface and the fines went down as predicted.

The fine aggregate did not display any binding characteristics.

The Contractor compacted the flexible base with a sheep's foot roller in the vibratory mode.

The best method appeared to be to dump out the flexible base into a stockpile and blade.

The section where the traffic was running looked rough but acted tight.

The Contractor nicknamed the section "Cobble Stone Hill".

The Contractor liked the product and thought it was stout and would stay.

Ordinary compaction did not require a density curve (proctor). Compaction required proof rolling (no weight required by specification but contractor used loaded water truck).

The second round of watering displayed movement in the flexible base when the vibratory sheep's foot roller went over it. A steel wheel vibratory roller was run over the flexible base and this significantly smoothed down the surface.

Some rock was crushed/broken but mainly with the sheep's foot roller, not the steel wheel roller.

After the second compaction, water was not penetrating as fast.

The flexible base segregated again when the grader was used to bring the section to the plan grade.

Fines were brought to the surface with the vibratory steel wheel roller.

The longitudinal joints were segregated as in HMAC.

The outside edge moved minimally after the rollers went over the section.

The State Inspector said that the FM1810 12" Density Control test section from Sta. 4+000 to Sta. 4+800 was constructed normally and achieved density with normal compaction techniques.

The test area had sections of large stones only on the surface which were not bound by the fines. The traffic appeared to be pulling the rocks loose and rolling them around. The initially segregated areas appeared to be worse due to the loose rocks.

The triaxial value of the final flexible base gradation used on the test section was 1.0.

The District uses 60 ksi as the stiffness for flexible base when developing pavement designs.

In regard to the stiffness data, it was stated that conventional flexible base has higher stiffness values than the large stone flexible base. The large stone section has better drainage.

CHAPTER 6 - SUMMARY

6.0 RESEARCH SUMMARY

This research project was developed to test the District's current flexible base requirement, identify any potential strength problems, develop a coarser gradation to add strength and potentially lower costs due to less crushing, and place a test section to evaluate it's short, intermediate, and long range effects on the pavement life.

The testing of local aggregate sources against the current specifications revealed a major difference in triaxial values between the fine and coarse sides of the gradation bands resulting in an unknown pavement performance potential.

A new gradation was developed and tested in the laboratory with encouraging results for a 4" maximum gradation. A committee reviewed and discussed the results and agreed that this was an acceptable criteria to use for a demonstration test section.

The triaxial class of the flexible base was improved from a worst case of 3.5 to a best case of 1.0 on the material actually produced for the project. The gradation produced followed the fine limit of the new gradation band which indicates that a triaxial value of 1.0 can be used with confidence in the pavement designs even if the coarse limit of the new gradation band is followed.

Past FWD data on current roadways has demonstrated that the flexible base values are lower as the roadway gets older and water brings in less desirable soil material from the sides and subgrade material thus filling in the voids and reducing the flexible base strength. A large stone gradation would mitigate this event and allow the roadway to last longer.

The stiffness is not as high as conventional flexible base but may last longer due to better drainage qualities from the large stone gradation.

The test section proved that the committee's assumptions were correct. With some design and construction changes, this type of layer would be beneficial in adding strength to the entire roadway section while eventually lowering the costs for material production and roadway construction. Higher triaxial and FWD values are expected to allow the District the ability to lessen some of the overlying layer thicknesses thereby saving money in these more costly layers. Additional testing of this section and more sections constructed on other roadway projects should determine if higher triaxial and FWD values are indeed obtained. If they are not, additional aspects of this gradation such as permeability will be considered as part of the pavement design.

CHAPTER 7 - RECOMMENDATIONS

7.0 OVERALL RECOMMENDATIONS

1. Cover with the next course as soon as the flexible base is brought to final grade and compacted.

2. Leaving the flexible base open to traffic appears detrimental. Need to roll the travel lanes before placing the next course to "seat" the large rocks again.

3. Need more fines to help bind and keep the large rocks on top from pulling out. Need to add additional fines into the segregated surface areas, remix, and recompact.

4. Too much compaction pushes the fines toward the bottom of the layer.

5. When loading the trucks, place the aggregate in layers to lessen the segregation.

6. Pull the trucks forward when unloading to mitigate further segregation due to stockpiles. Recommend requiring live bottoms or belly dumps.

7. Recommend working the edge as little as possible to avoid additional segregation.

8. Recommend requiring a vibratory steel wheel roller for one pass to smooth out the rough surface.

9. Specify that any surface that had traffic on it must be scarified before the final compaction.

10. Recommend a course of fine aggregate be added to smooth the surface before placing the next layer.

11. Water Truck ⇒ Sheep's Foot Roller ⇒ Pneumatic Roller ⇒ Steel Wheel Roller

12. As part of the design of the roadway, specify how to backfill the edges to daylight water to avoid trapping it in the base course.

CHAPTER 8 – ATTACHMENTS

8.0 ATTACHMENTS A-K

ATTACHMENT A

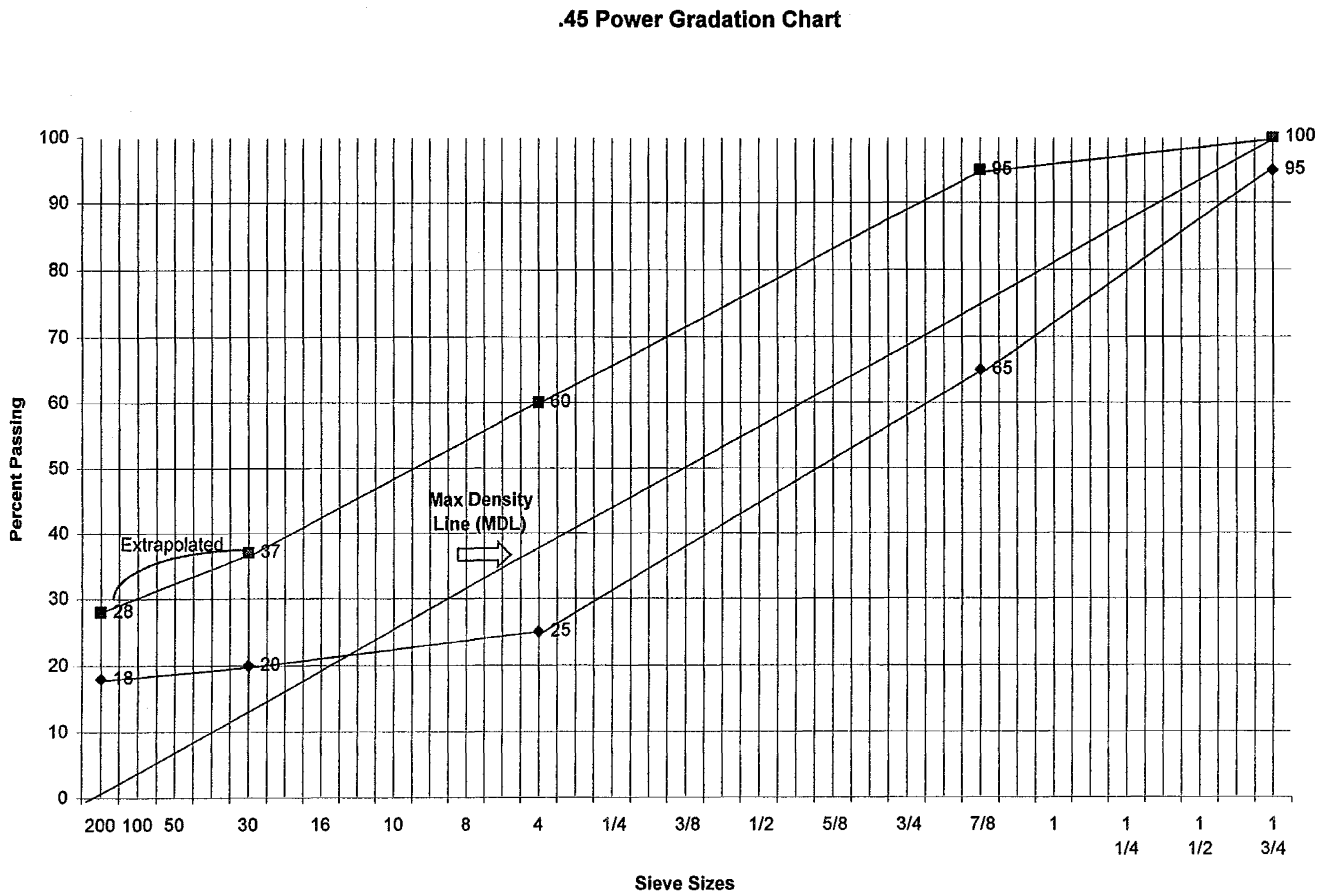
RESULTS OF TEXAS TRIAXIAL TEST

CRUSHED STONE FLEXIBLE BASE

CURRENT DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

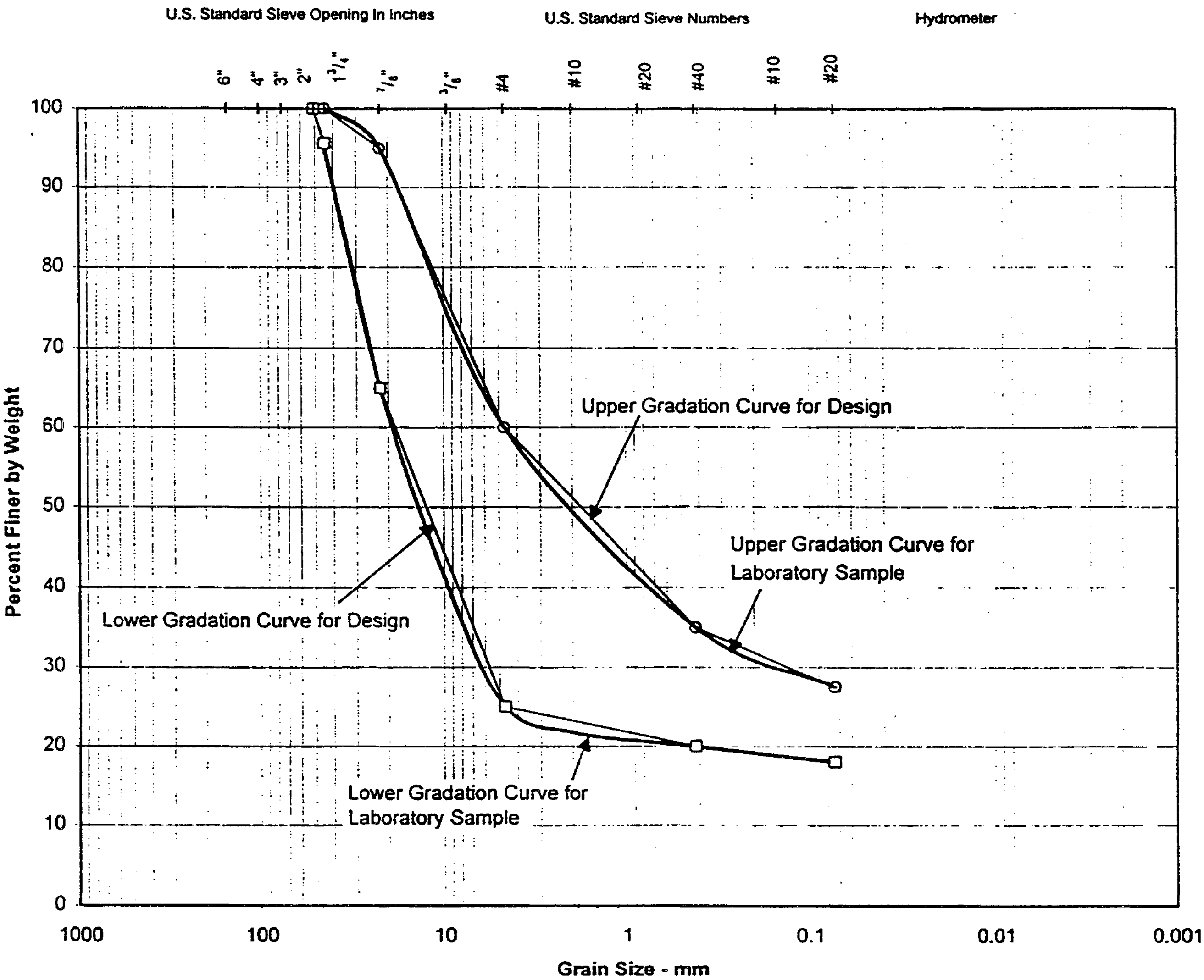
PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)



Item 247 (Ty. A, Gr. 6) Gradation
Currently Used in District 2 (Fort Worth)

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Texas Triaxial Tests

Symbol	Target Gradation	% Gravel Size	% Sand Size	% -#200	LL	PI	USCS
-o-	Upper Gradation	40.0	32.5	27.5	22	6	GC-SC
-□-	Lower Gradation	75.0	7.0	18.0	22	6	GC
Material Description		Light gray Crushed Stone.					
Material Type	Flex Base TYA, GR6		Material Source	Pioneer-Bridgeport (Stockpile)			

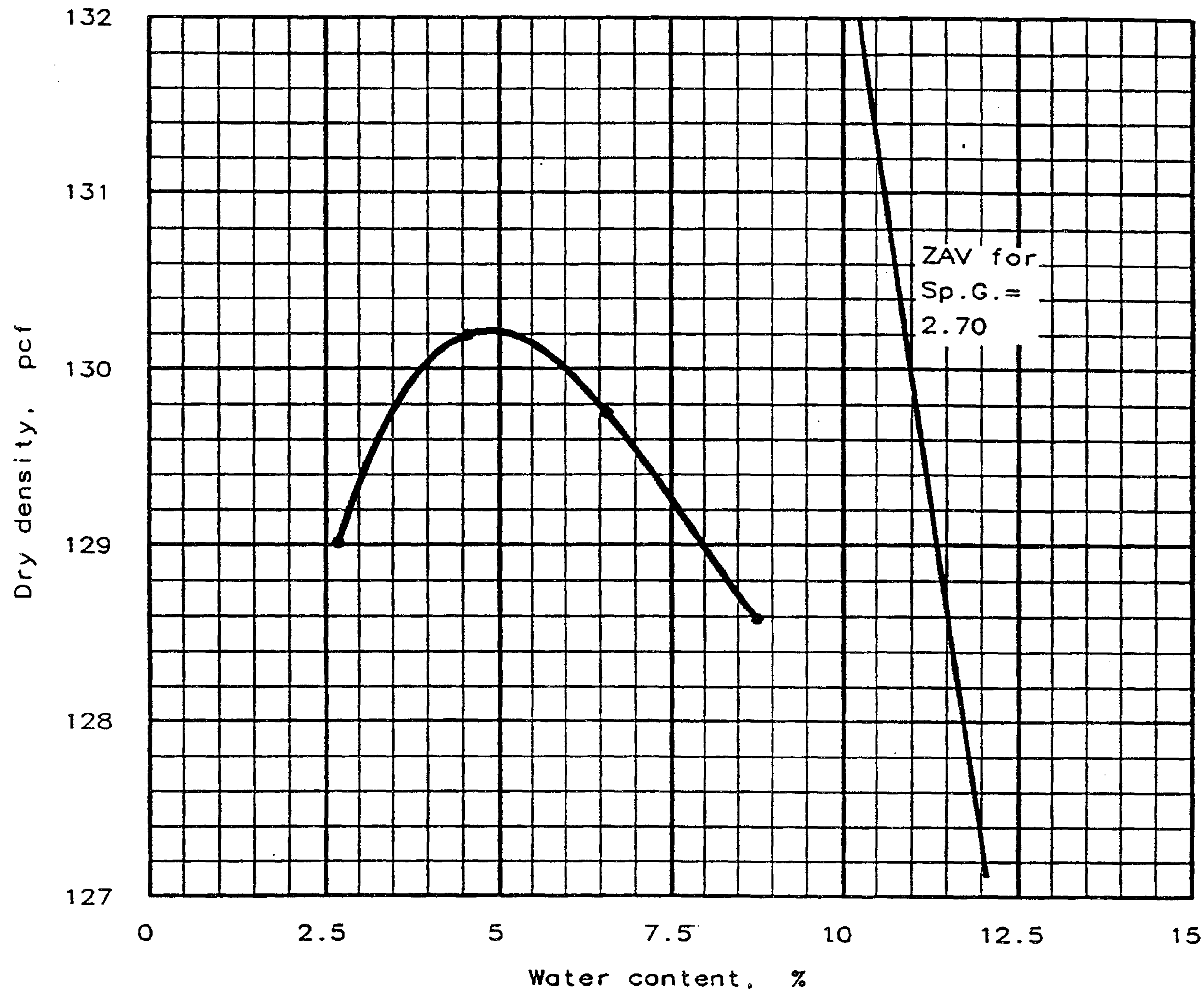
Lab No.	02-96-364
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-047

FIGURE 1

TERRA-MAR, INC.

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex 113-E

Maximum Dry Density = 130.2 pcf

Optimum Moisture Content = 4.9%

Material Type	USCS	% > #4	% < #200	LL	PI
Flex Base TYA, GR6	GC-SC	40.0	27.5	22	6
Material Source	Pioneer-Bridgeport (Stockpile)				
Material Description	Light Gray Crushed Stone - Upper Gradation				

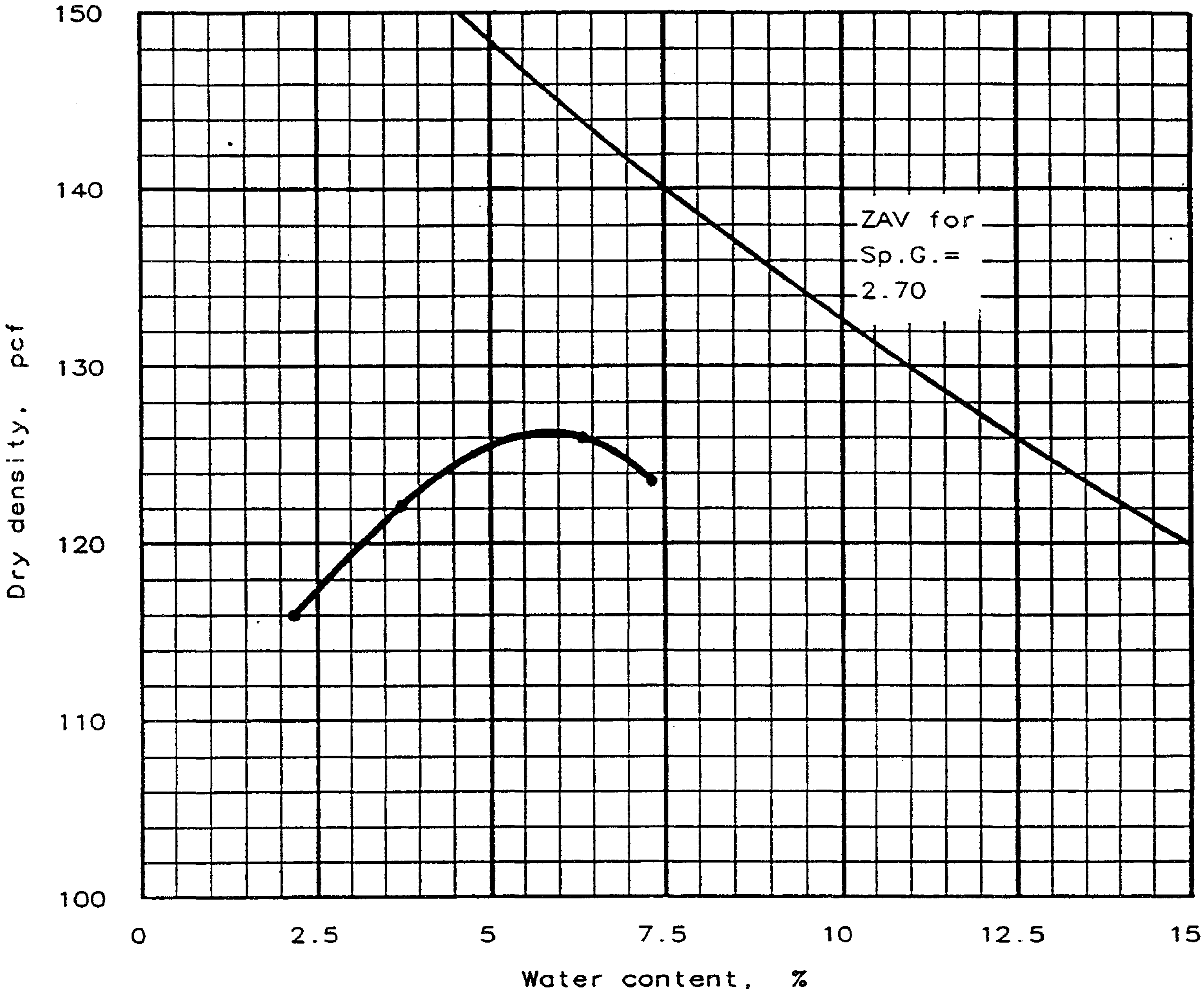
Lab No.	02-96-364
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-047

FIGURE 2

TERRA-MAR, INC.

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex 113-E

Maximum Dry Density = 126.3 pcf Optimum Moisture Content = 5.9%

Material Type	USCS	% > #4	% < #200	LL	PI
Flex Base TYA, GR6	GC	71.4	14.0	22	6
Material Source	Pioneer-Bridgeport (Stockpile)				
Material Description	Light Gray Crushed Stone - Lower Gradation				

Lab No.	02-96-364
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-047 FIGURE 3

TERRA-MAR, INC.

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA. GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6)

	Lower Gradation (GC)	Upper Gradation (GC-SC)
Optimum Moisture	5.9%	4.9%
Maximum Dry Density	126.3 pcf	130.2 pcf

Optimum moisture and maximum dry density determined from TxDOT method Tex 113-E at a compactive effort of 13.3 ft-lb/in^3.

Sample Type	Spec. No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
		w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
LOWER GRADATION (GC) TEXAS TRIAXIAL CLASS 1.9	1	6.0	140.8	10	5.5	140.5	0	56.5	3.2	0.2
	2	5.8	140.7	10	5.4	140.7	3	91.2	3.9	0.0
	3	5.9	139.4	10	5.1	139.4	15	158.2	4.0	0.0
	4	6.2	134.1	10	4.5	134.2	20	184.7	5.8	0.1
	5	5.8	138.8	10	5.7	136.9	5	117.9	6.3	1.4
	6	5.3	138.4	10	5.5	138.2	10	131.5	4.0	0.2
	7	5.6	139.0	10	5.3	136.6	0	31.0	2.1	1.8
UPPER GRADATION (SC) TEXAS TRIAXIAL CLASS 3.5	1	4.3	133.4	10	8.2	131.9	0	9.0	1.5	1.2
	2	4.3	134.3	10	7.6	134.4	20	105.8	5.9	0.0
	3	3.8	134.2	10	7.3	133.1	15	90.9	5.8	0.8
	4	4.1	132.7	10	7.8	131.2	10	75.7	5.7	1.2
	5	4.1	131.9	10	7.7	131.7	5	51.5	4.8	0.2
	6	4.1	133.7	10	7.8	133.3	3	40.1	2.8	0.3
	7	3.6	135.2	10	7.2	135.0	0	10.1	1.1	0.2

** Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E.

DE96-047 FIGURE 4

TERRA-MAR, INC.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (LOWER GRADATION)

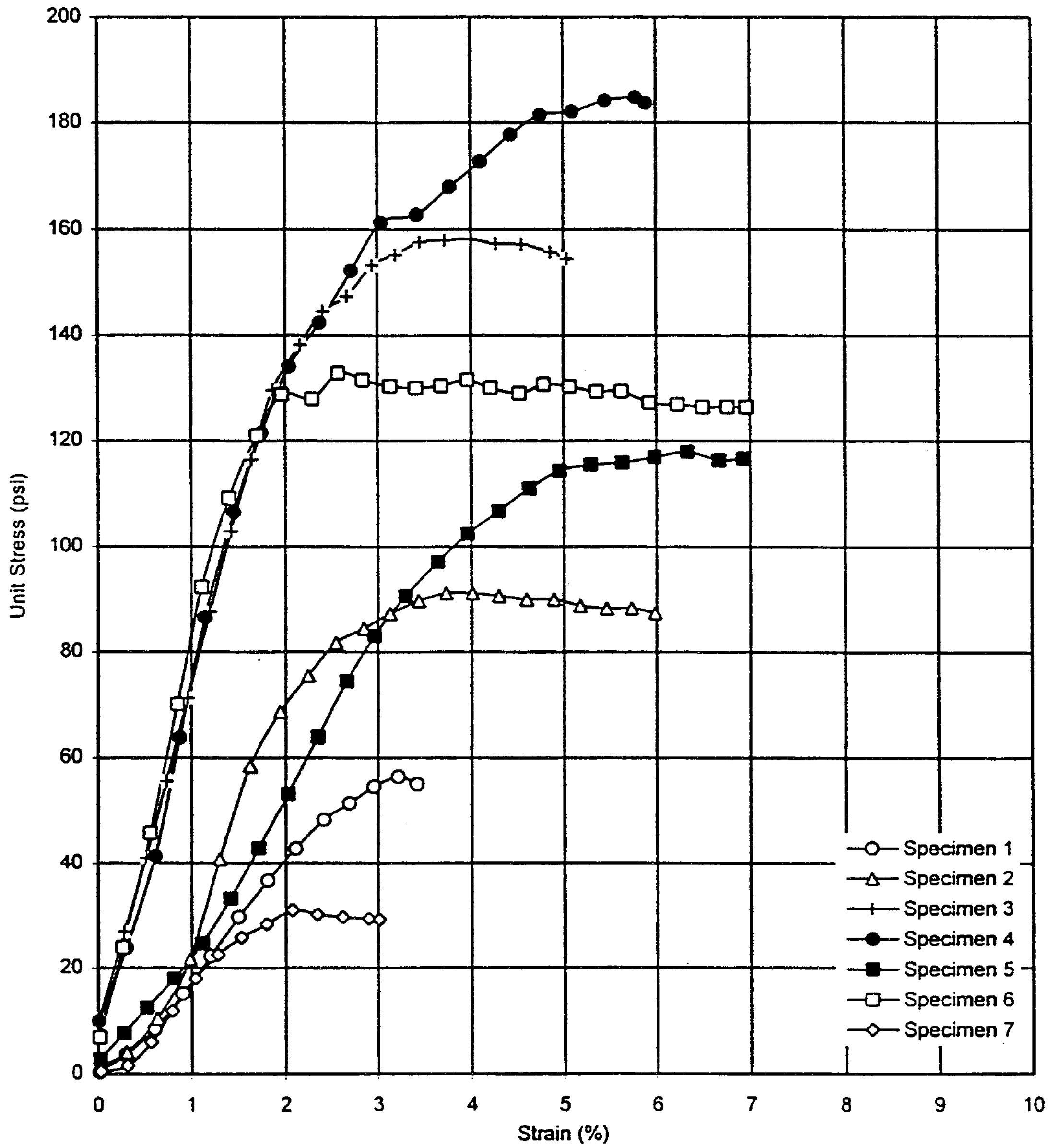
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Lower Gradation.

Optimum Moisture: 5.9% Maximum Dry Density: 126.3 pcf at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	3	15	20	5	10	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-047 **FIGURE A-1**

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (LOWER GRADATION)

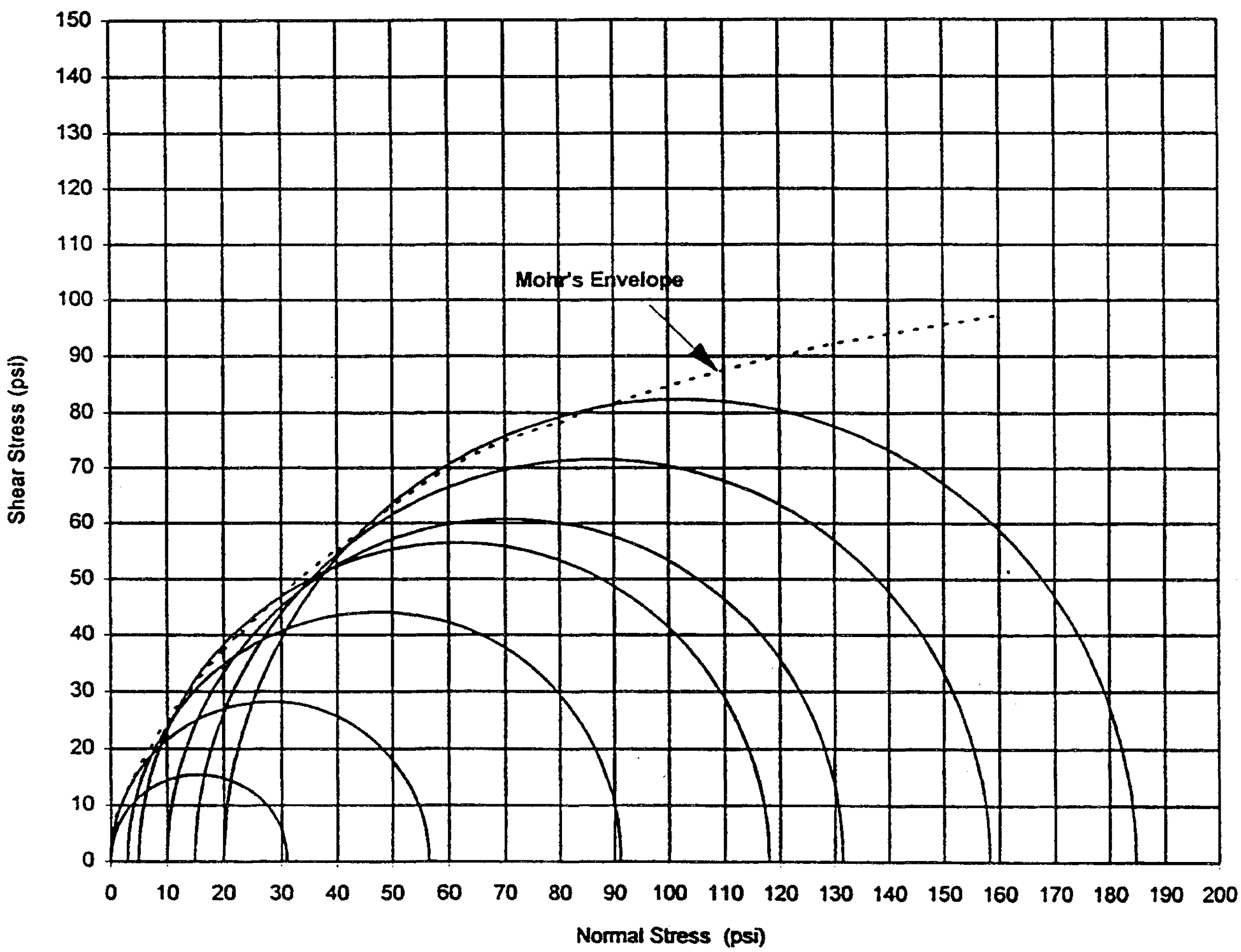
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Lower Gradation.

Optimum Moisture: 5.9% Maximum Dry Density: 126.3 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-047

FIGURE A-2

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (LOWER GRADATION)

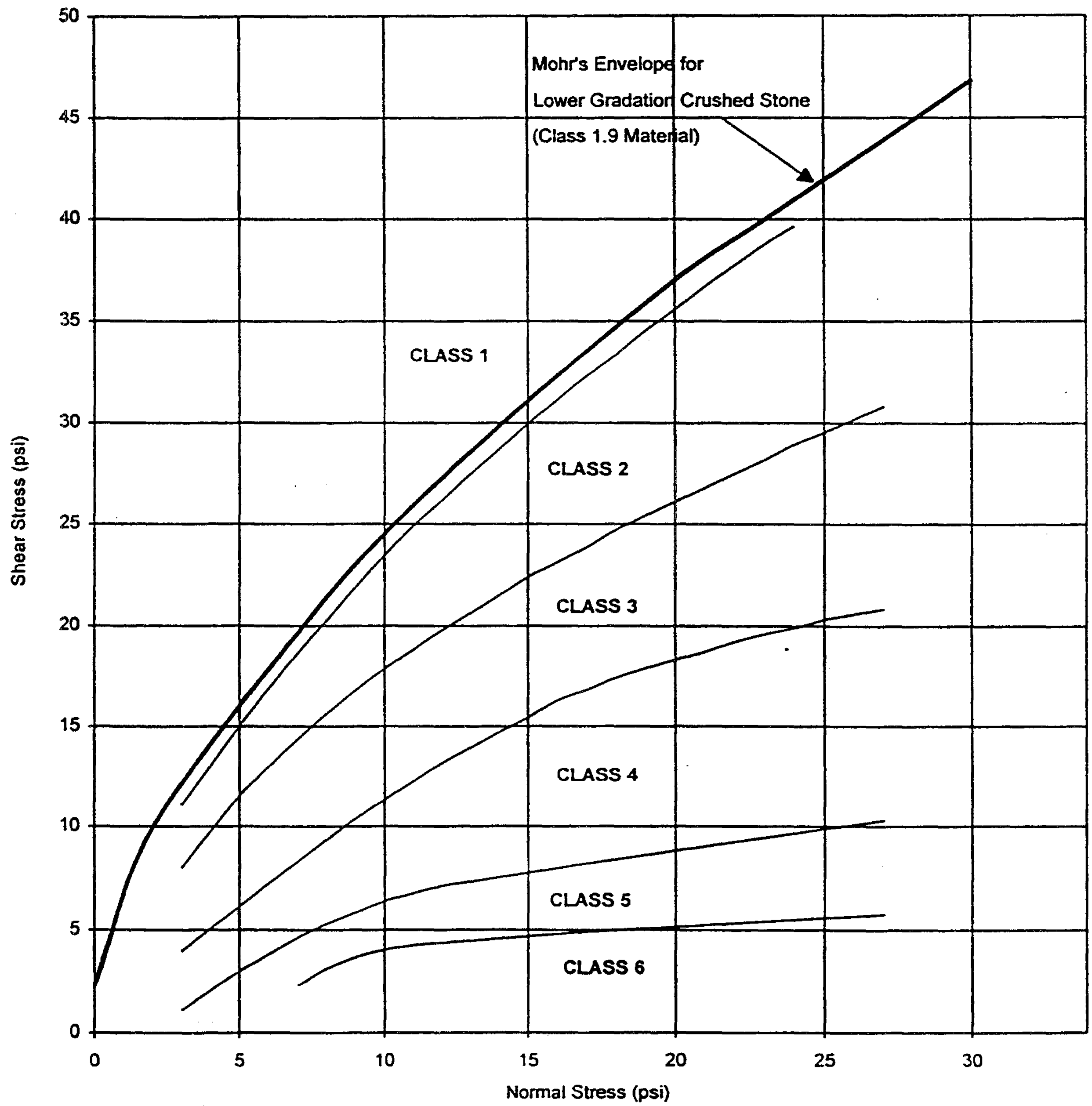
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Lower Gradation.

Optimum Moisture: 5.9% Maximum Dry Density: 126.3 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-047

FIGURE A-3

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (UPPER GRADATION)

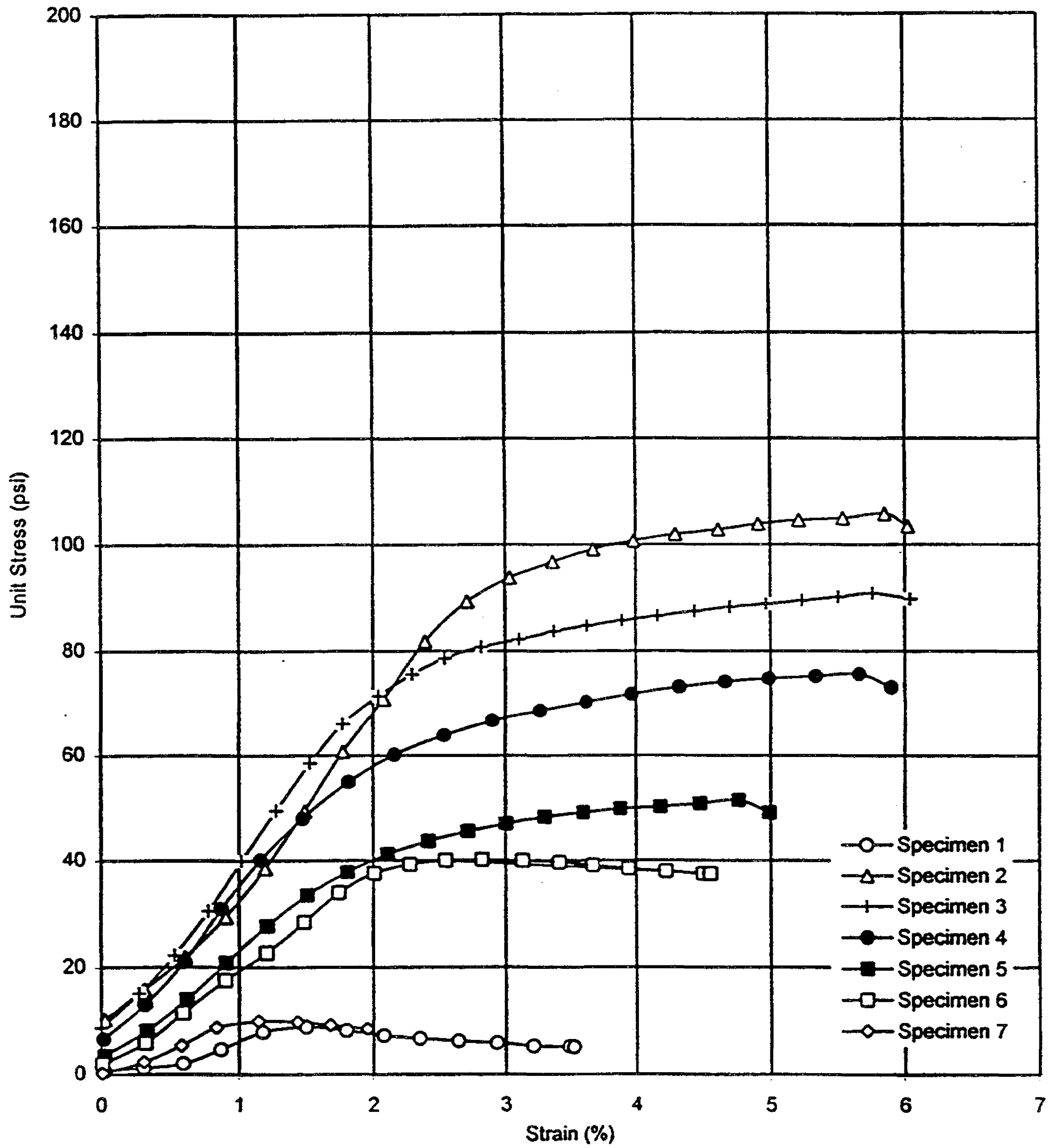
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Upper Gradation.

Optimum Moisture: 4.9% Maximum Dry Density: 130.2 pcf at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	20	15	10	5	3	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-060

FIGURE A-4

TERRA-MAR, INC.

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (UPPER GRADATION)

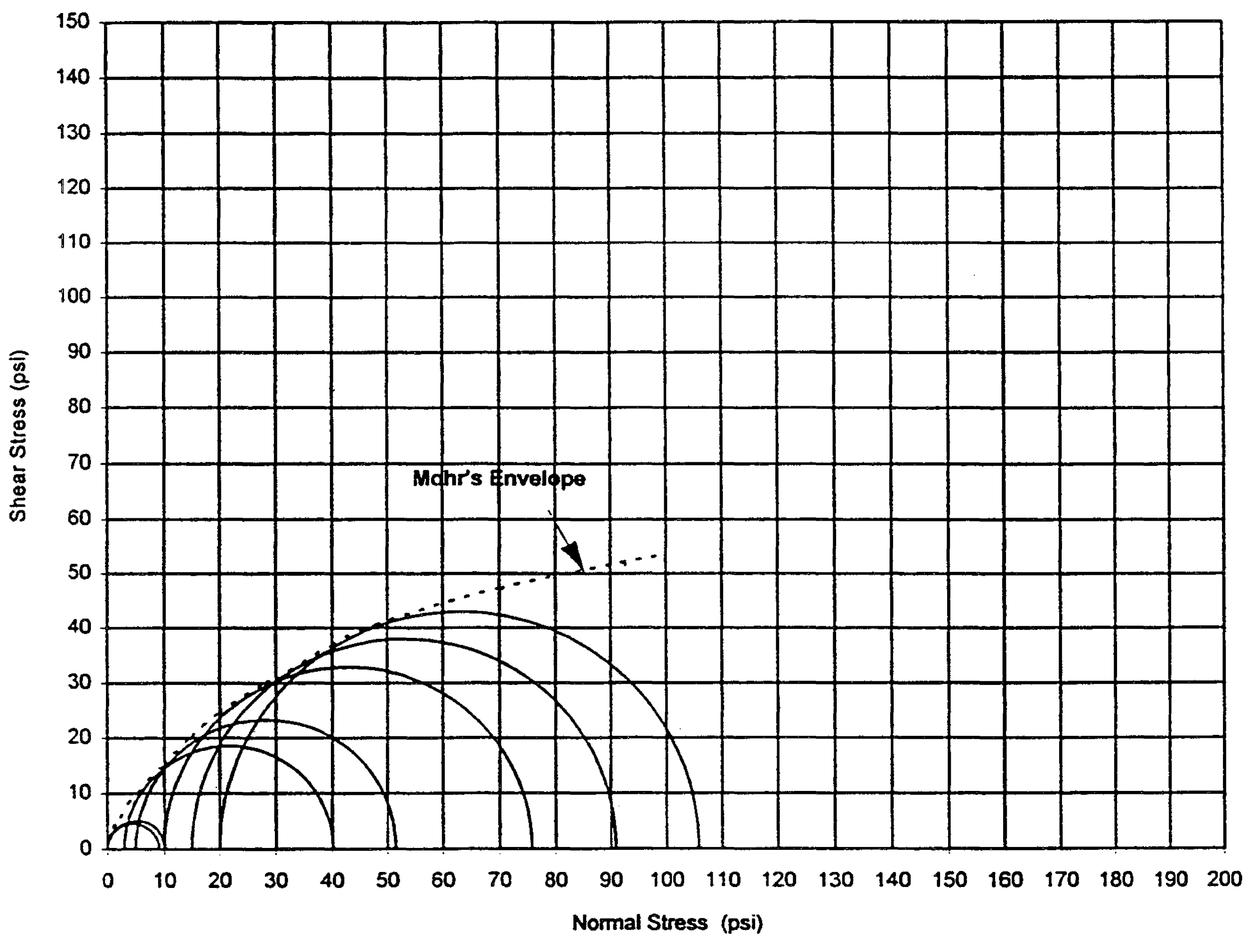
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Upper Gradation.

Optimum Moisture: 4.9% Maximum Dry Density: 130.2 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-060

FIGURE A-5

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (UPPER GRADATION)

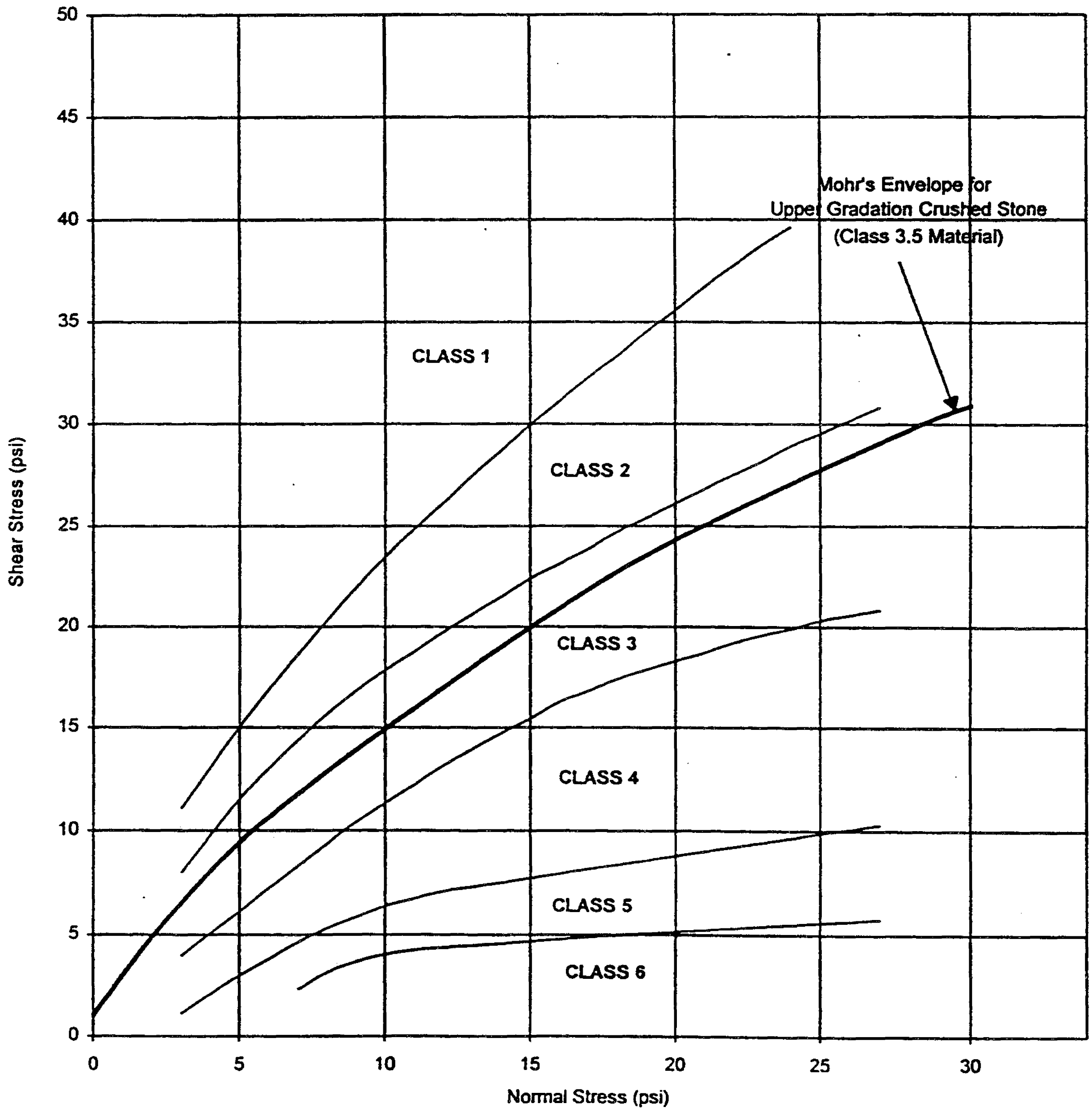
Lab No.: 02-96-364 County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL=22, PI=6) - Upper Gradation.

Optimum Moisture: 4.9% Maximum Dry Density: 130.2 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-060

FIGURE A-6

TERRA-MAR, INC.

RESULTS OF TEXAS TRIAXIAL TEST

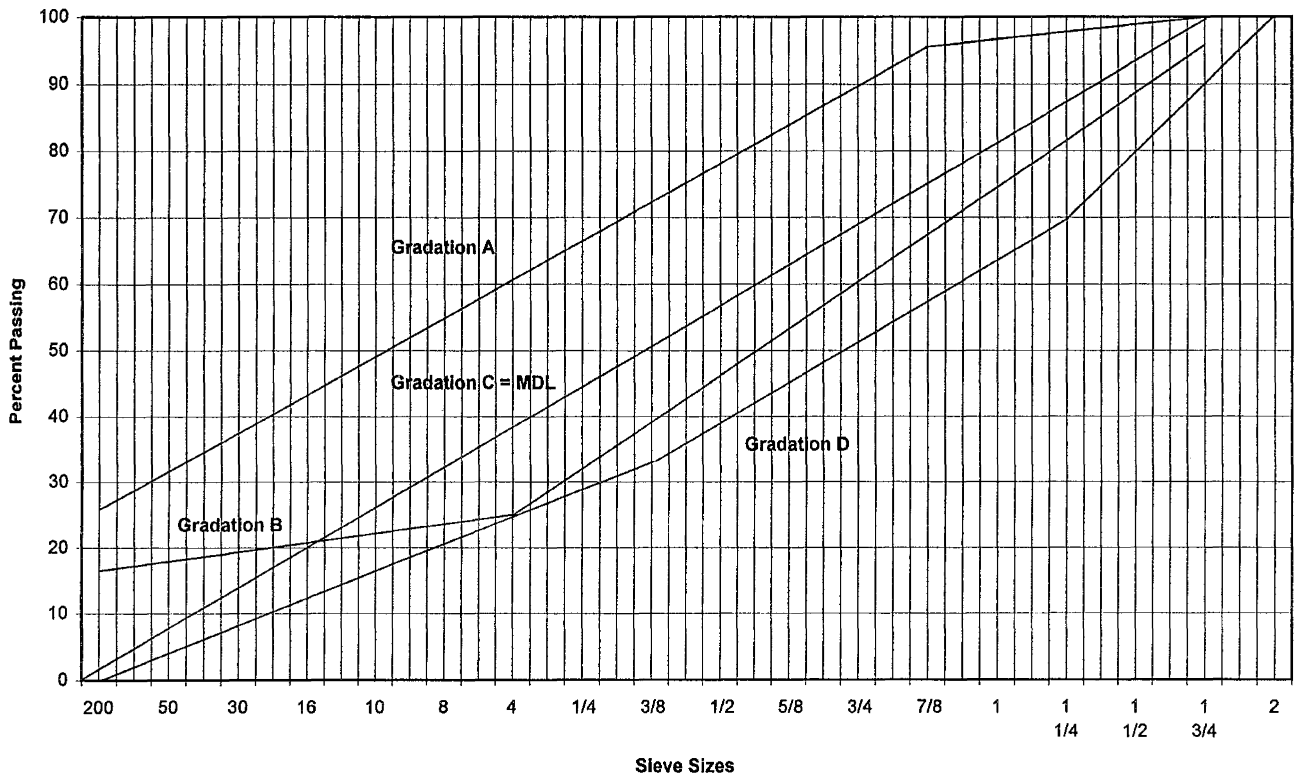
CRUSHED STONE FLEXIBLE BASE

CURRENT DISTRICT GRADATION AT MAXIMUM DENSITY LINE (MDL) AND COARSER THAN CURRENT LIMITS

PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931 (IN-HOUSE RESEARCH)

.45 Power Gradation Chart

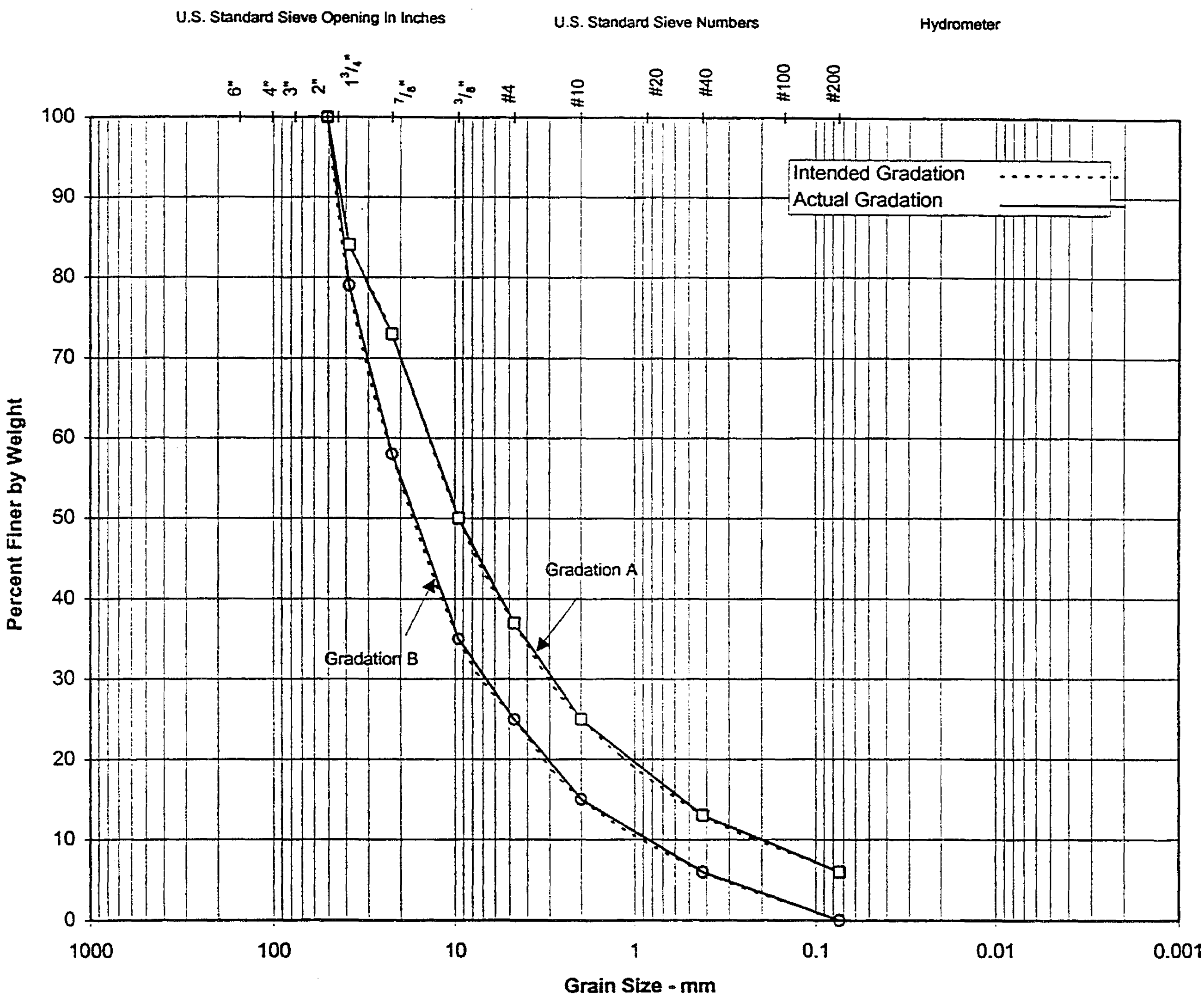


Triaxial Class

Gradation	Class
A	3.5
B	1.9
C	1.8
D	No Data (ND)

PIT A

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Pioneer Bridgeport Stockpile

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
-□-	GC	63.0	31.0	6.0	17	13	4
-o-	GP - GW	75.0	25.0	0.0	NP*	NP*	NP*
Material Type	Flex Base TYA GR6		**Material Source**		Pioneer-Bridgeport (Stockpile)		

* Non Plastic.

Lab No.	02-96-364 PB
County	Fort Worth District Laboratory
Control	02-70-0510

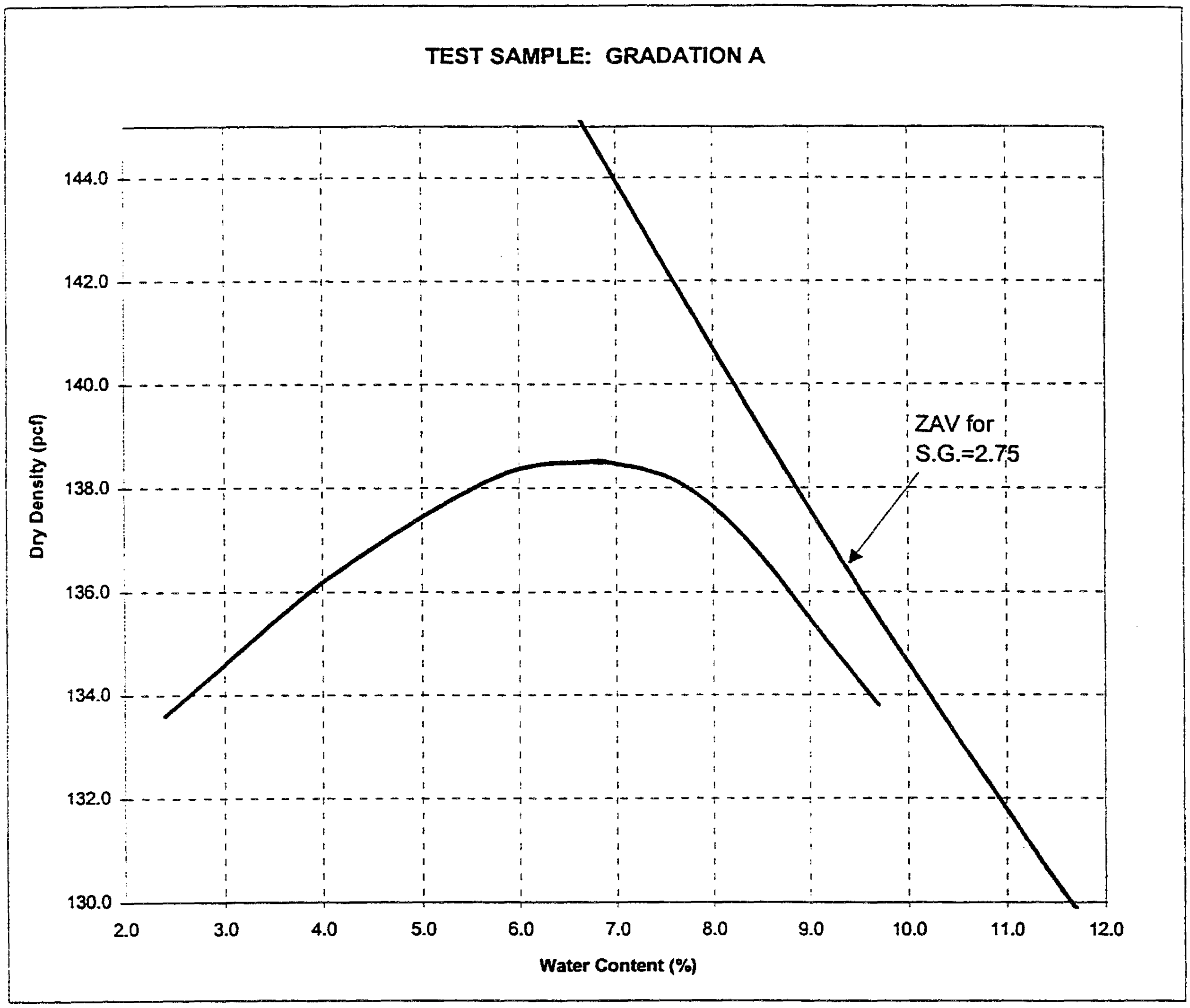
NOTE: The stockpile was batched based on particle size using 2", 1-1/2", 7/8", 3/8", No. 4, No. 10, No. 40 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE96-085

FIGURE 1

TERRA-MAR, INC.

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 138.5 pcf Optimum Moisture Content = 6.7%

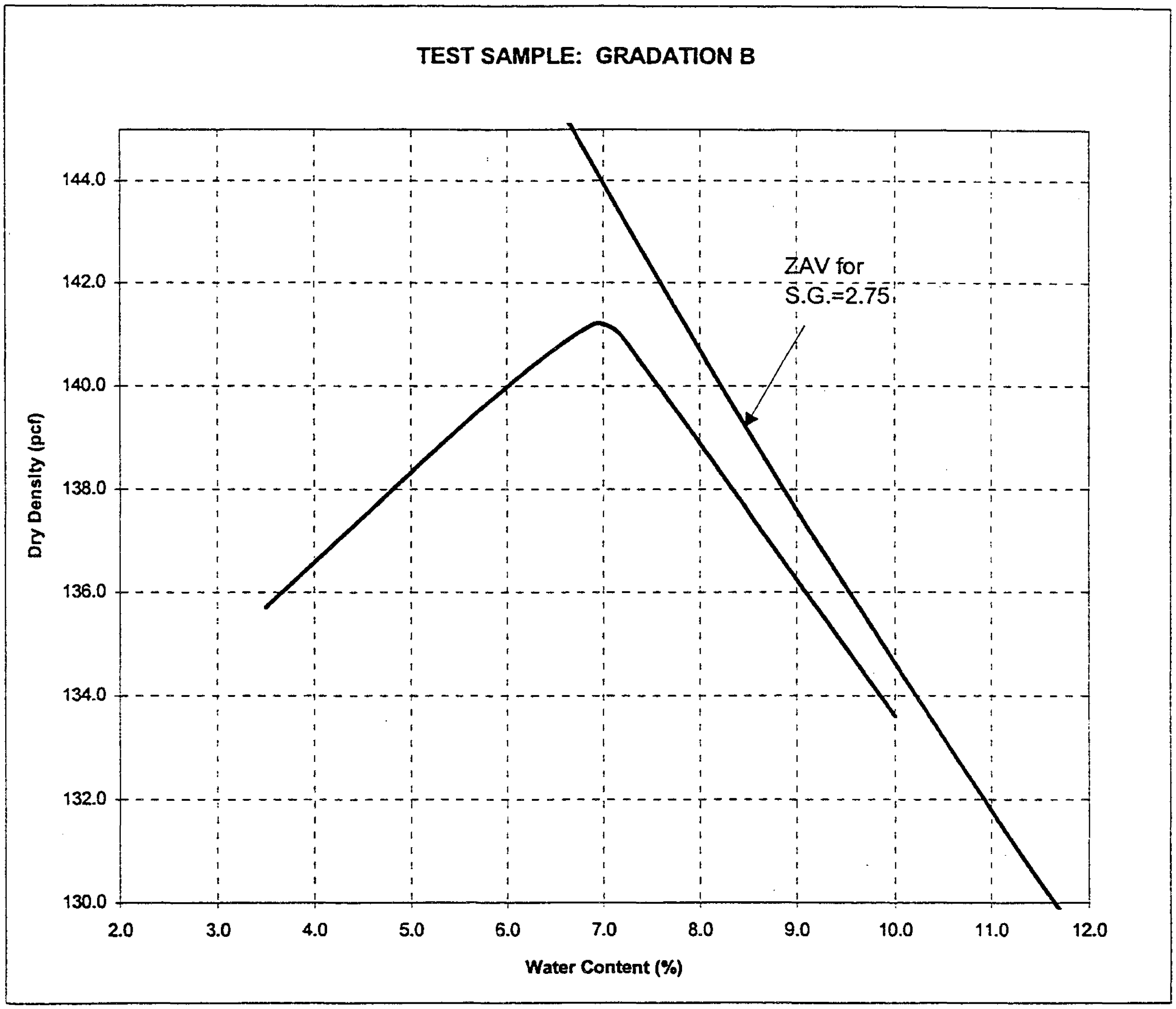
Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation A	GC	63.0	6.0	17	4
Material Type	Flex Base TYA GR6				
Material Source	Pioneer-Bridgeport (Stockpile)				

Lab No.	02-96-364 PB
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-085

FIGURE 2

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 141.2 pcf Optimum Moisture Content = 6.9%

Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation B	. GP - GW	75.0	0.0	NP*	NP*
Material Type	Flex Base TYA GR6				
Material Source	Pioneer-Bridgeport (Stockpile)				

* Non Plastic.

Lab No.	02-96-364 PB
County	Fort Worth District Laboratory
Control	02-70-0510

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE (GRADATION A)

Lab No.: 02-96-364 PB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL= 17, PI= 4) - Gradation A (GC)

Optimum Moisture: 6.7% Maximum Dry Density: 138.5 pcf at Compactive Effort: 13.3 ft-lb/in^3

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	6.2	143.4	10	5.5	142.5	0	36.8	2.8	0.0
2	6.5	141.6	10	5.7	140.1	15	171.8	4.9	0.0
3	6.8	141.6	10	5.8	140.2	0	29.2	3.2	0.0
4	6.8	141.3	10	5.8	141.5	5	93.3	5.4	-0.1
5	6.7	137.8	10	5.8	136.6	7	134.5	5.3	-0.1
6	6.6	138.9	10	5.8	139.7	3	108.6	4.5	0.0
7	6.8	138.8	10	5.7	136.6	10	155.1	5.3	0.0

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E. Initial portion of the stress-strain curve was corrected for end effects.

NOTE: Specimens of the Gradation B material were non plastic and could not be extruded sucessfully from the compaction test mold. For this reason, a second series of Texas Triaxial tests could not be performed.

STRESS-STRAIN DIAGRAM

CRUSHED STONE FLEX BASE (GRADATION A)

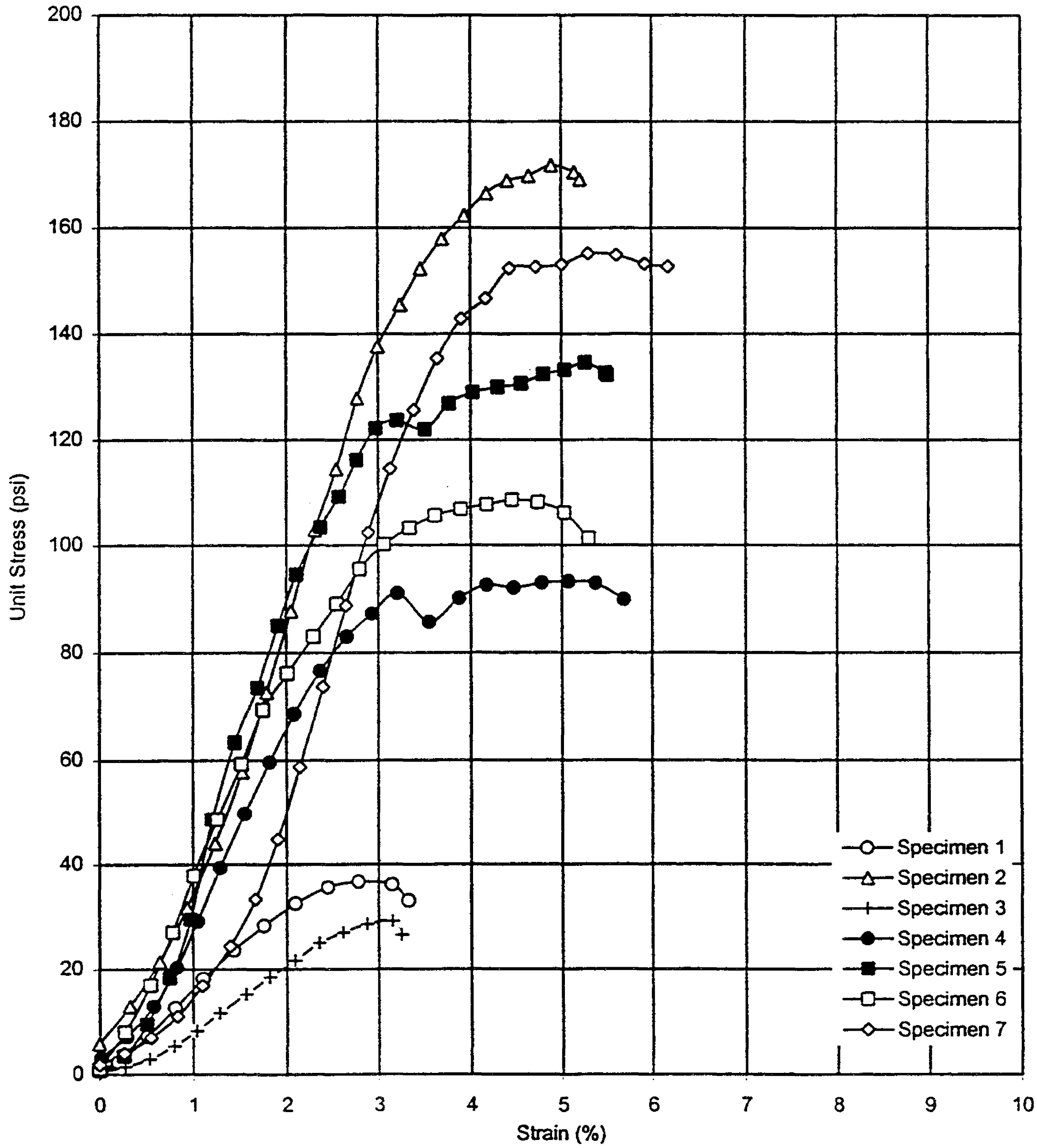
Lab No.: 02-96-364 PB   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL= 17, PI= 4) - Gradation A (GC)

Optimum Moisture: 6.7%   Maximum Dry Density: 138.5 pcf   at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	15	0	5	7	3	10

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-085   FIGURE A-1

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (GRADATION A)

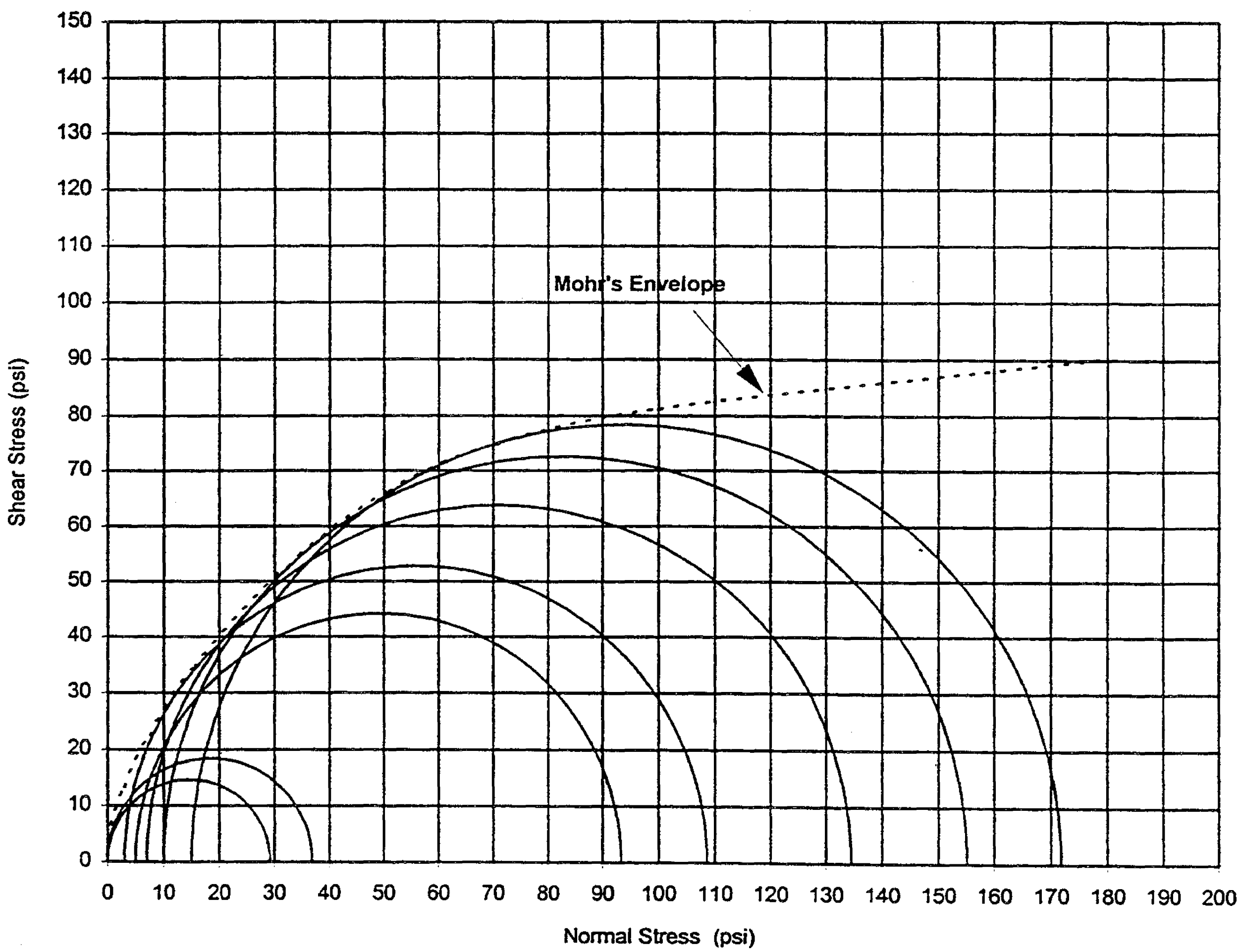
Lab No.: 02-96-364 PB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL= 17, PI= 4) - Gradation A (GC)

Optimum Moisture: 6.7% Maximum Dry Density: 138.5 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-085

FIGURE A-2

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (LOWER GRADATION)

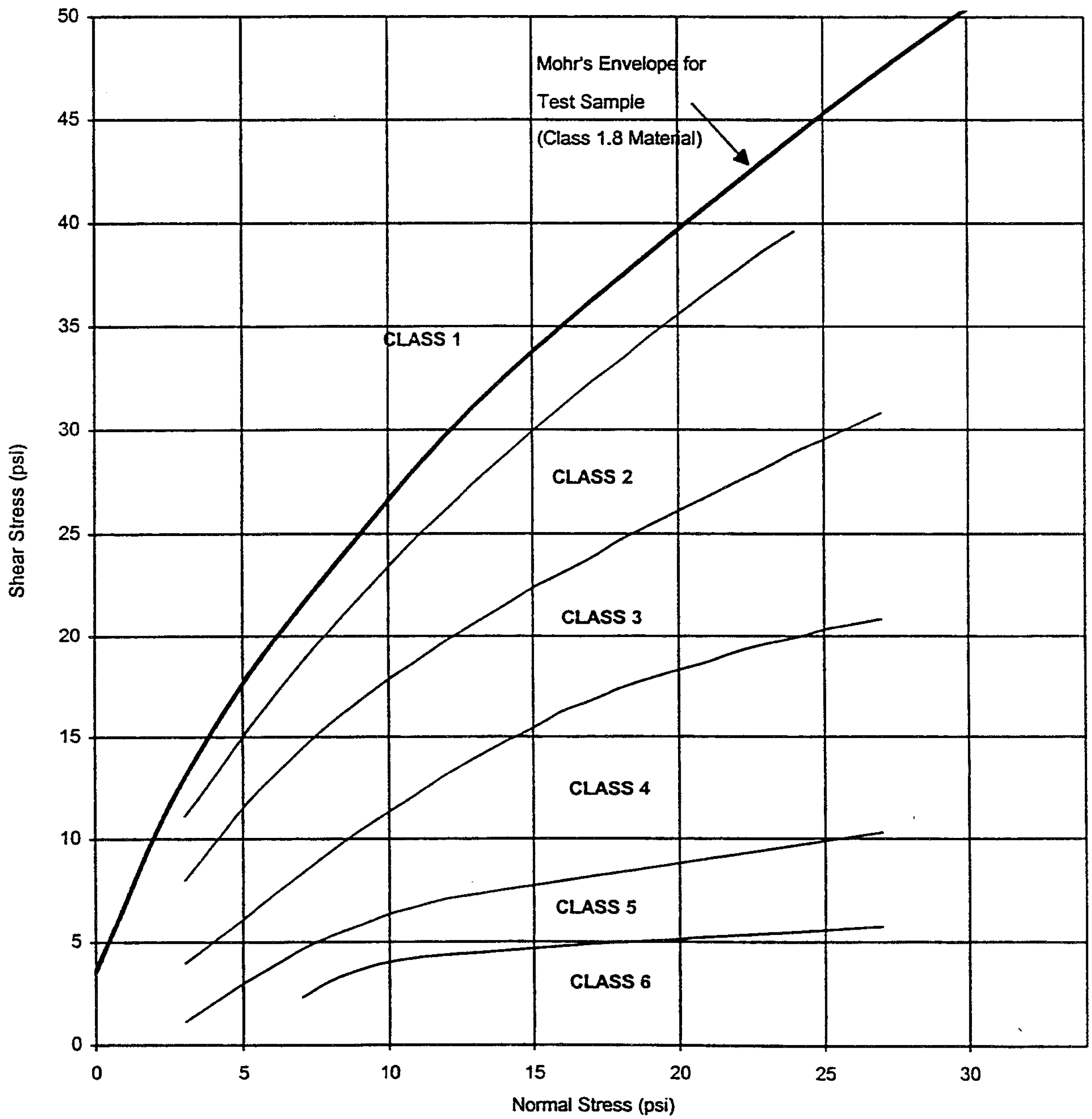
Lab No.: 02-96-364 PB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Pioneer-Bridgeport (Stockpile)

Description: Light Gray Crushed Stone (LL= 17, PI= 4) - Gradation A (GC)

Optimum Moisture: 6.7% Maximum Dry Density: 138.5 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-085

FIGURE A-3

ATTACHMENT C

RESULTS OF TEXAS TRIAXIAL TEST

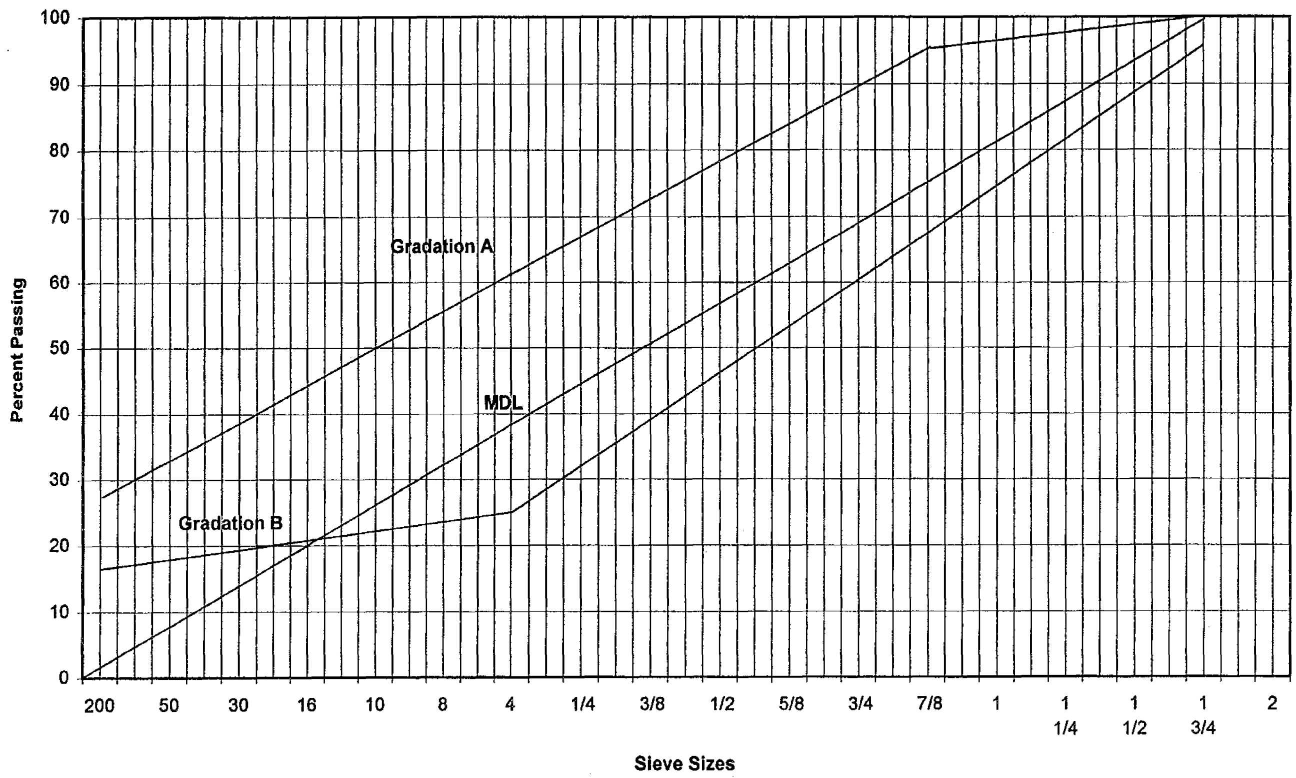
CRUSHED STONE FLEXIBLE BASE

CURRENT DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

VULCAN GILBERT

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

.45 Power Gradation Chart

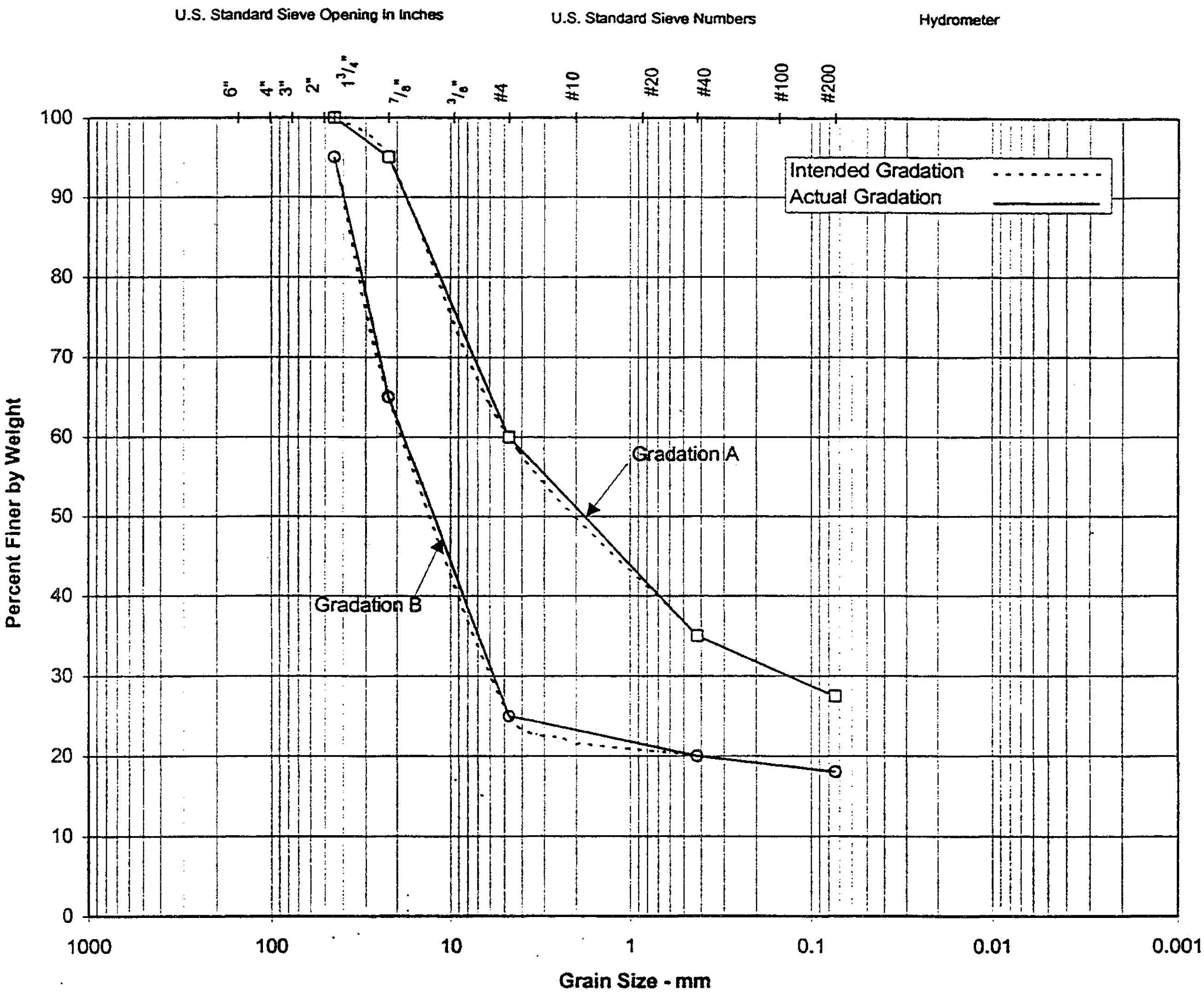


Triaxial Class

Gradation	Class
A	2.8
B	3.0

PIT B

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Vulcan Gilbert Pit - Pit B

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
—□—	GC	40.0	32.5	27.5	20	15	5
—○—	GC	75.0	7.0	18.0	24	17	7
Material Type	Flex Base TYA GR6		**Material Source**	Vulcan Gilbert Pit - Pit B			

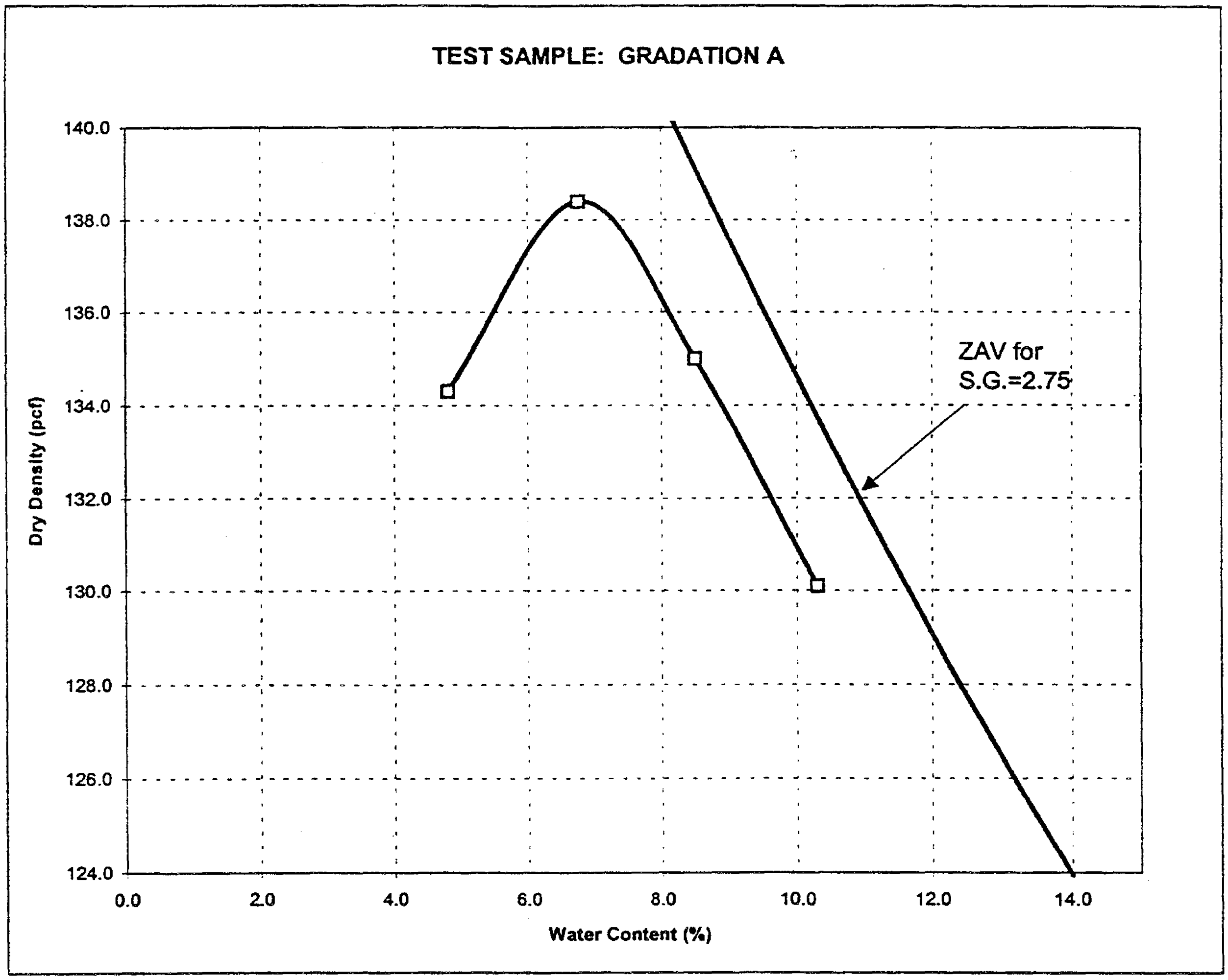
Lab No.	02-96-364 VG
County	Fort Worth District Laboratory
Control	02-70-0510

NOTE: The stockpile was batched based on particle size using 1-3/4", 7/8", No. 4, No. 40 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE96-094

FIGURE 1

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 138.5 pcf   Optimum Moisture Content = 6.6%

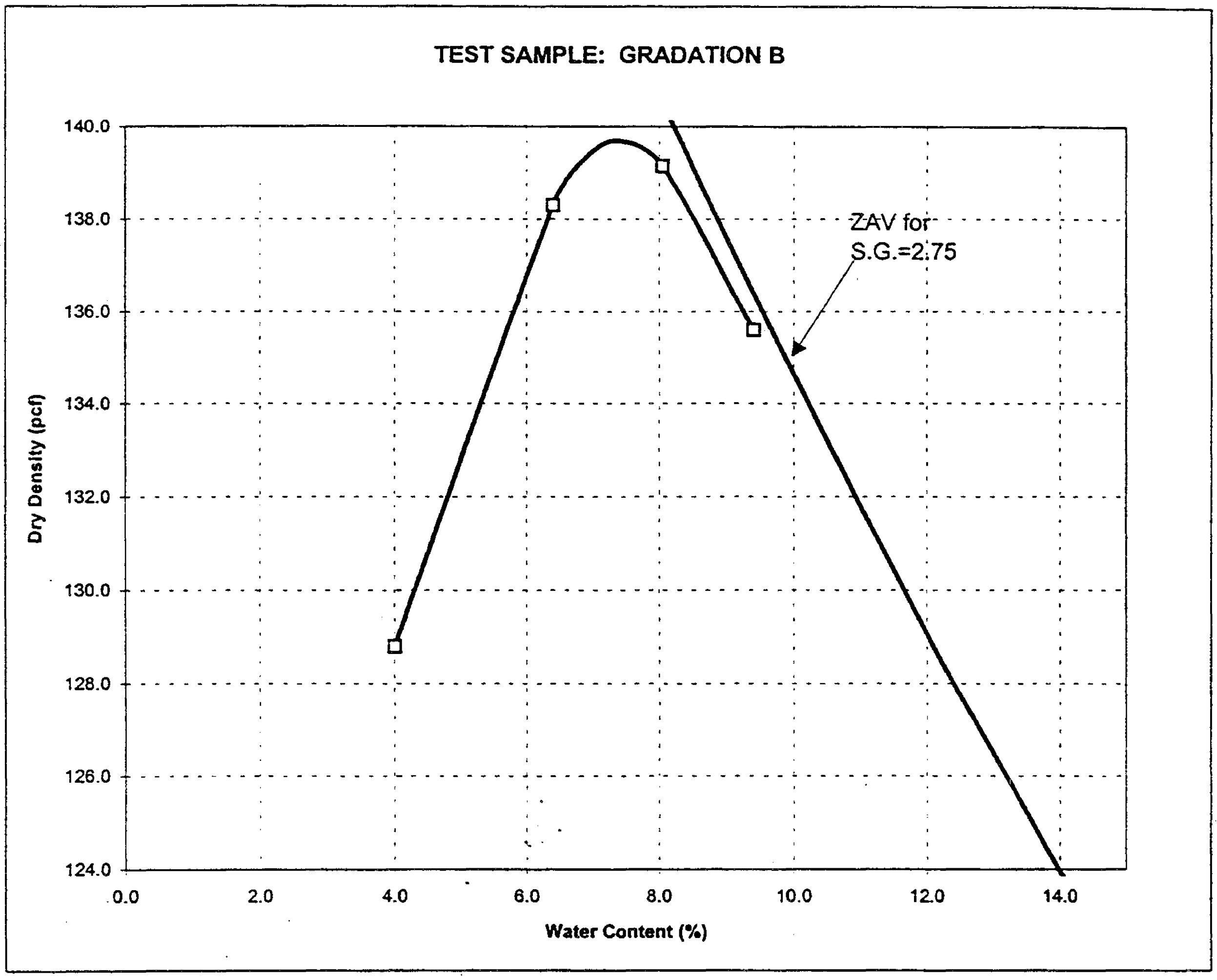
Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation A	GC	40.0	27.5	20	5
Material Type	Flex Base TYA GR6				
Material Source	Vulcan Gilbert Pit - Pit B				

Lab No.	02-96-364 VG
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-094

FIGURE 2

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 139.7 pcf Optimum Moisture Content = 7.3%

Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation B	GC	75.0	18.0	24	7
Material Type	Flex Base TYA GR6				
Material Source	Vulcan Gilbert Pit - Pit B				

Lab No.	02-96-364 VG
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-094 FIGURE 3

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE (GRADATION A)

Lab No.: 02-96-364 VG   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 20, PI= 5) - Gradation A (GC)

Optimum Moisture: 6.6%   Maximum Dry Density: 138.5 pcf   at Compactive Effort: 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 2.8

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	6.0	139.4	10	6.5	138.2	0	20.1	3.2	0.4
2	6.6	138.4	10	6.8	136.3	3	61.6	5.9	0.8
3	7.5	137.7	10	6.4	134.1	5	64.0	7.3	0.9
4	6.3	138.9	10	6.6	133.3	10	90.0	7.4	0.1
5	7.0	139.5	10	6.1	137.1	15	147.2	7.5	0.2
6	6.6	138.7	10	6.8	134.4	20	139.5	7.5	0.1
7	6.0	138.7	10	6.4	138.1	0	25.2	3.6	0.0

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E. Initial portion of the stress-strain curve was corrected for end effects.

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE (GRADATION B)

Lab No.: 02-96-364 VG County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 24, PI= 7) - Gradation B (GC)

Optimum Moisture: 7.3% Maximum Dry Density: 139.7 pcf at Compactive Effort: 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 3.0

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	7.6	137.9	10	6.7	135.7	0	14.9	2.5	0.1
2	7.6	139.3	10	6.8	139.6	15	146.2	5.0	0.4
3	7.7	141.3	10	6.8	137.3	5	78.7	3.1	0.7
4	7.7	138.8	10	6.7	134.9	10	108.3	7.2	0.3
5	7.5	140.6	10	6.8	140.4	0	22.7	2.1	0.1
6	7.7	139.3	10	6.7	138.3	3	56.6	5.2	0.0
7	7.5	139.2	10	6.7	140.6	20	156.2	6.9	0.2

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (GRADATION A)

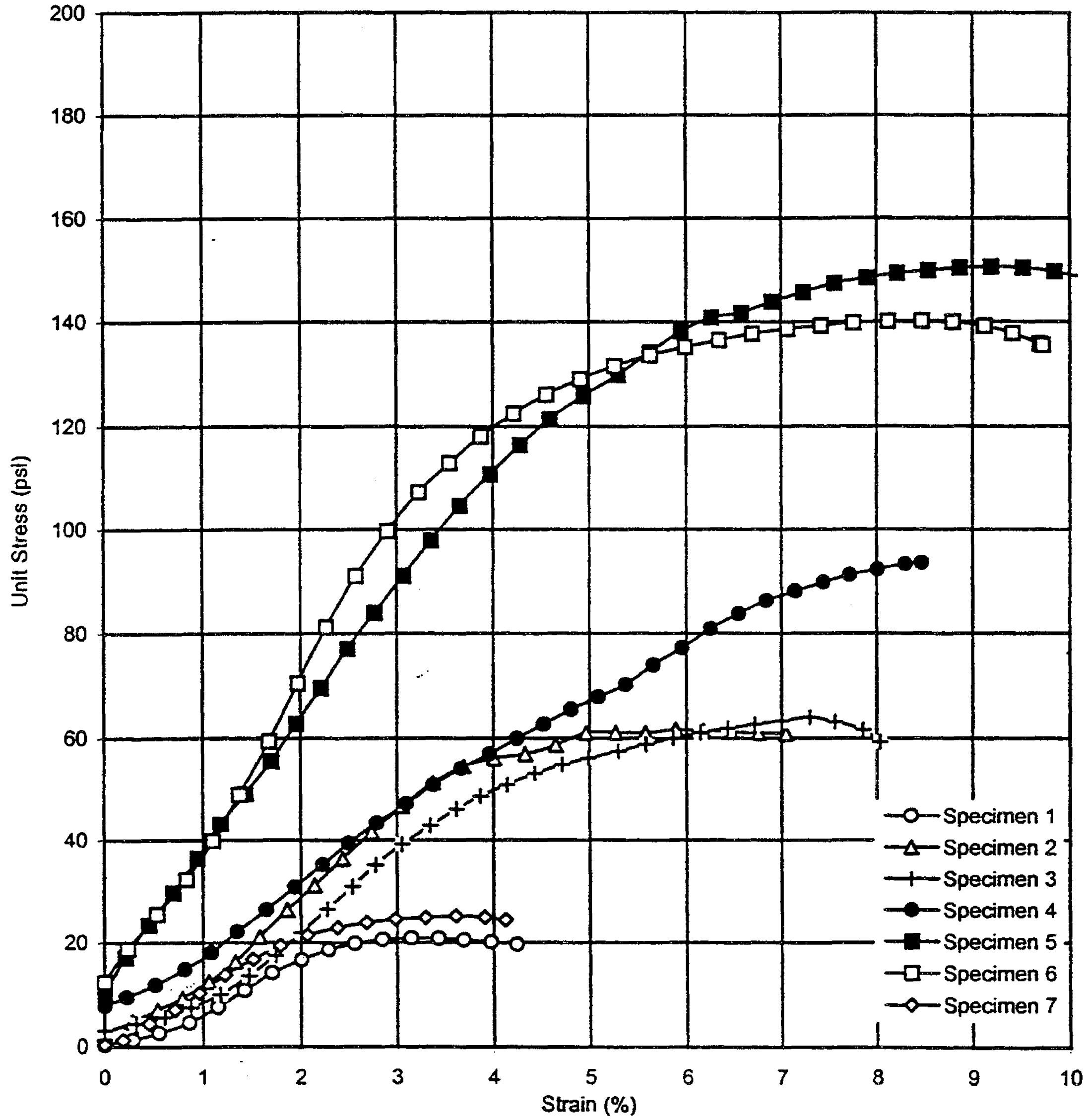
Lab No.: 02-96-364 VG County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 20, PI= 5) - Gradation A (GC)

Optimum Moisture: 6.6% Maximum Dry Density: 138.5 pcf at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	3	5	10	15	20	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-094

FIGURE A-1

TERRA-MAR, INC.

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (GRADATION A)

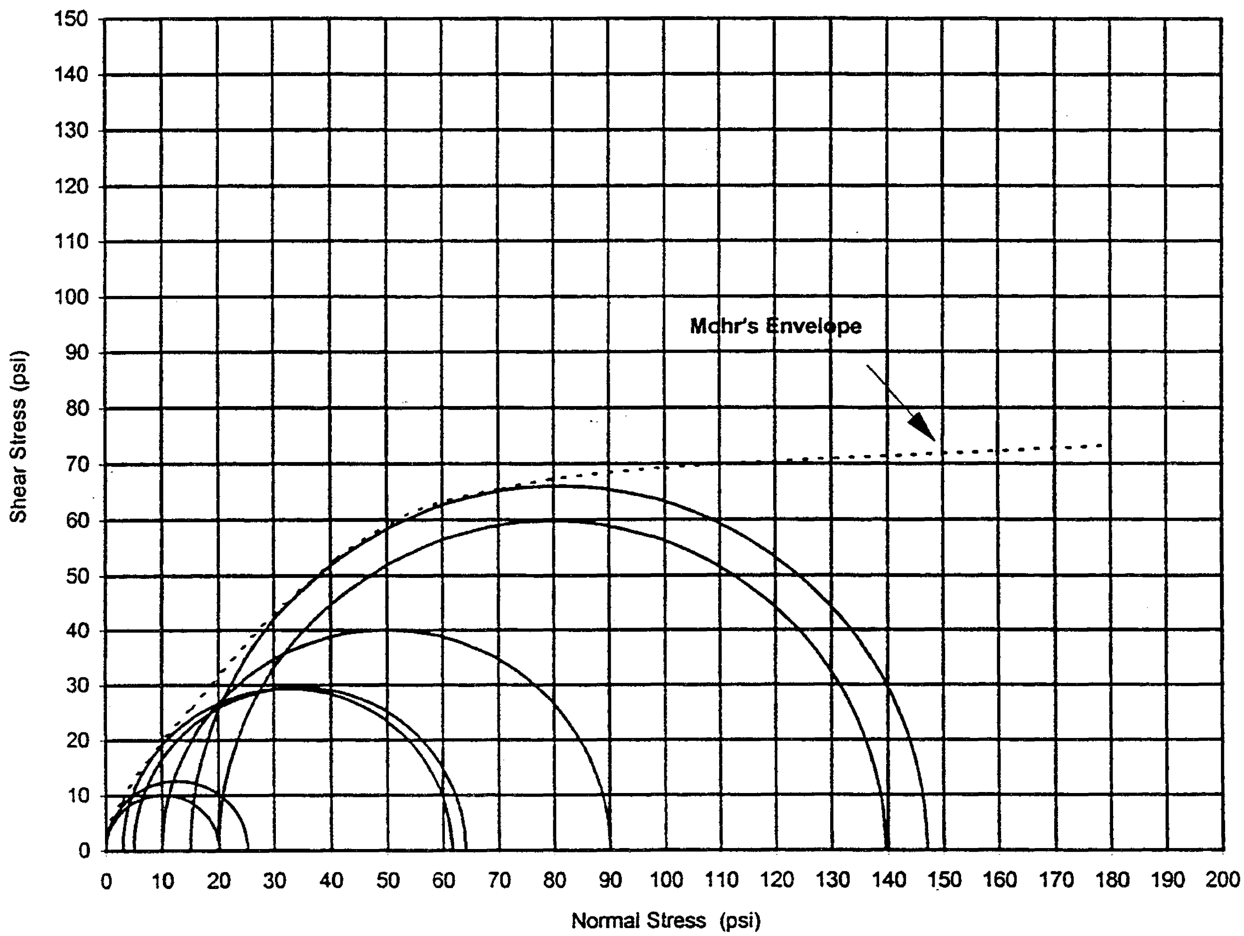
Lab No.: 02-96-364 VG   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 20, PI= 5) - Gradation A (GC)

Optimum Moisture: 6.6%   Maximum Dry Density: 138.5 pcf   at Compactive Effort: 13.3 ft-lb/in^3



TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (GRADATION A)

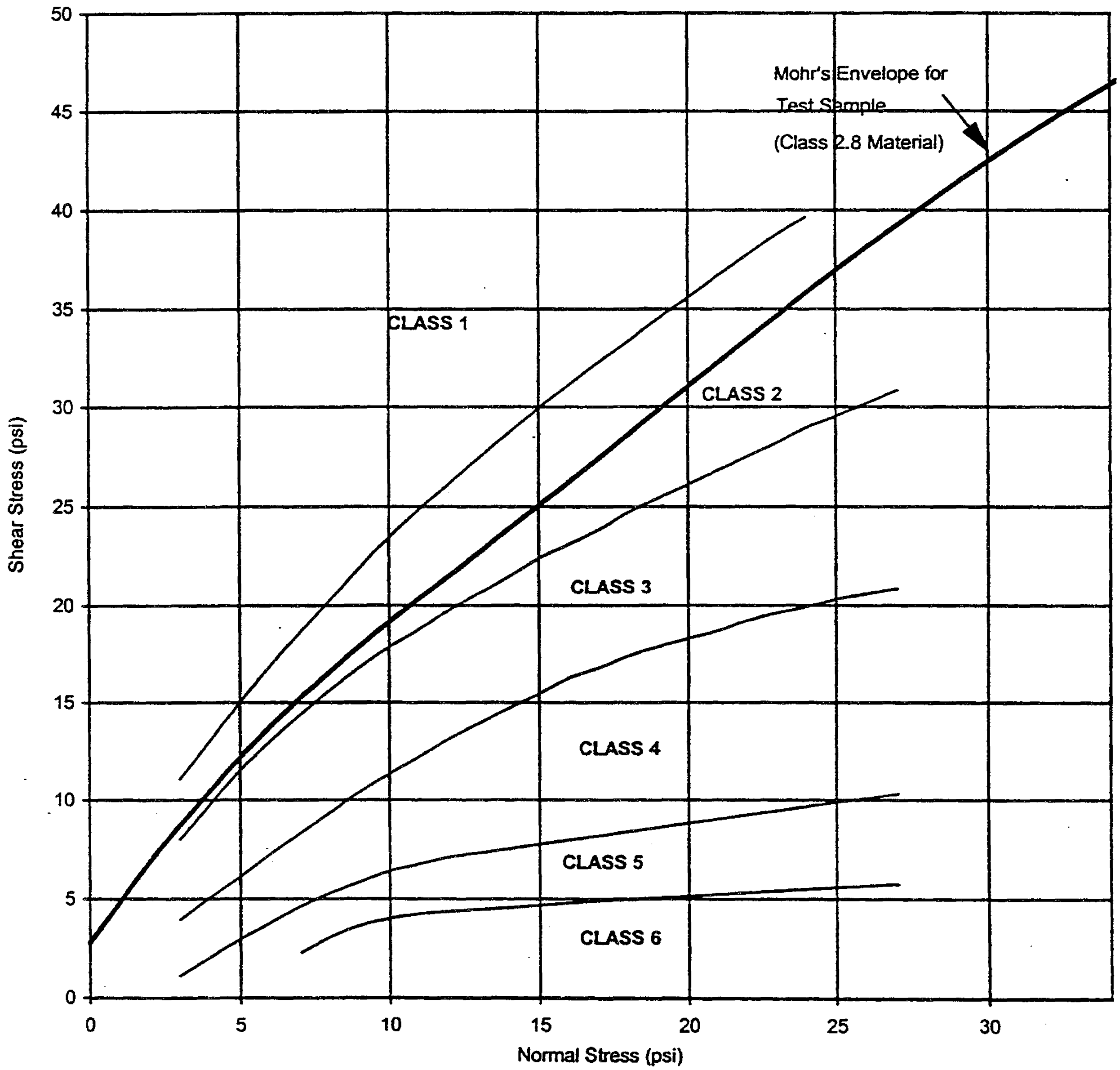
Lab No.: 02-96-364 VG County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 20, PI= 5) - Gradation A (GC)

Optimum Moisture: 6.6% Maximum Dry Density: 138.5 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-094

FIGURE A-3

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (GRADATION B)

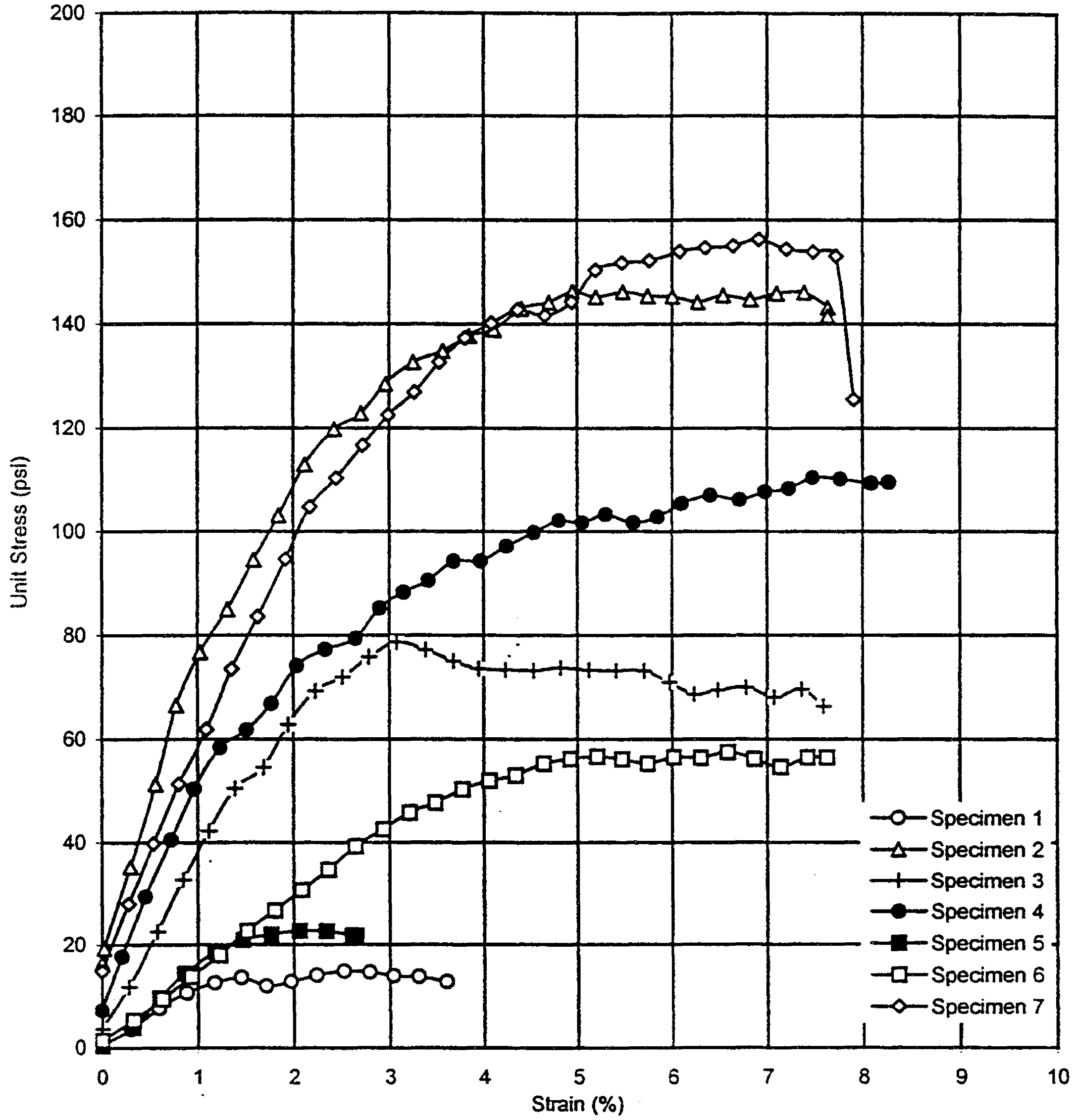
Lab No.: 02-96-364 VG   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 24, PI= 7) - Gradation B (GC)

Optimum Moisture: 7.3%   Maximum Dry Density: 139.7 pcf   at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	15	5	10	0	3	20

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-094   FIGURE A-4

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (GRADATION B)

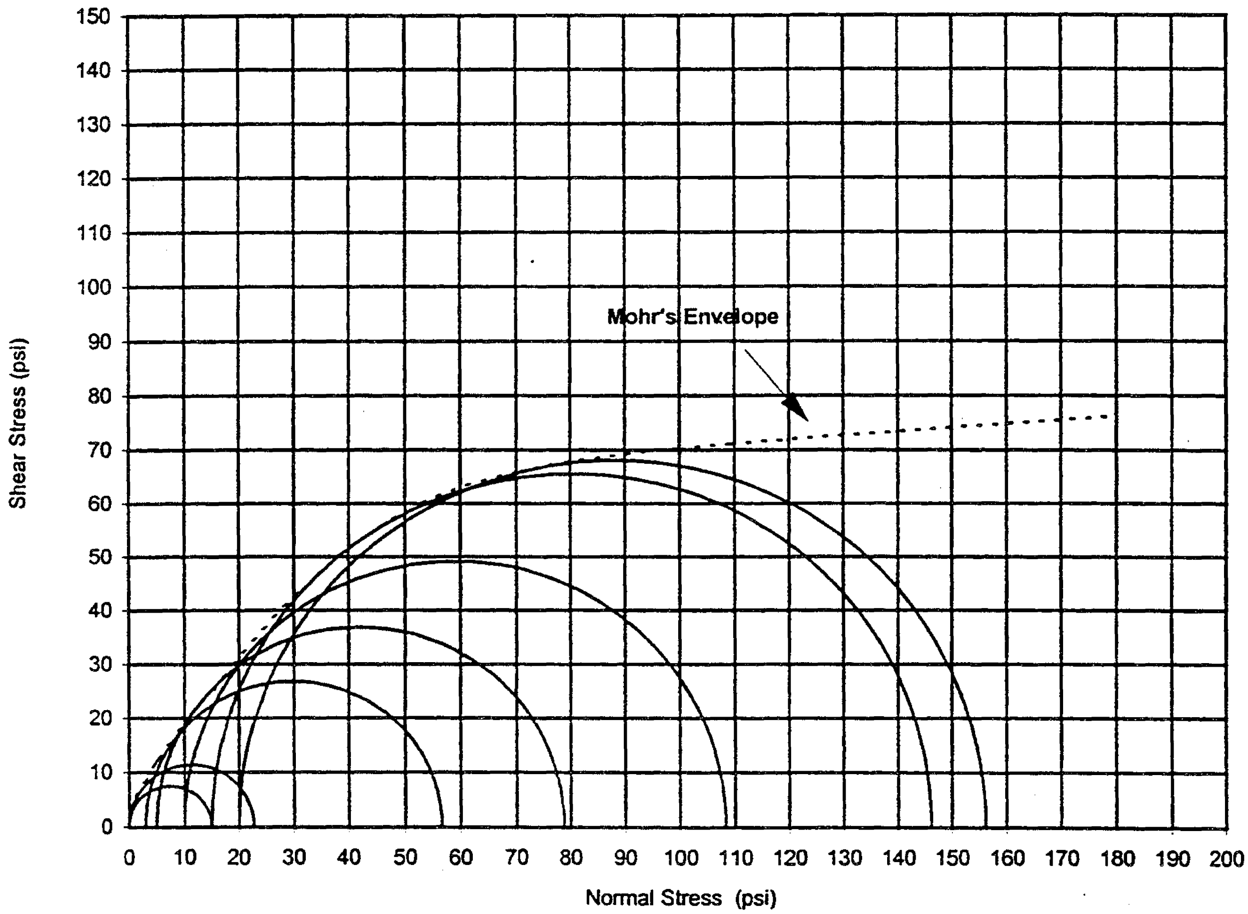
Lab No.: 02-96-364 VG County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 24, PI= 7) - Gradation B (GC)

Optimum Moisture: 7.3% Maximum Dry Density: 139.7 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-094

FIGURE A-5

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (GRADATION B)

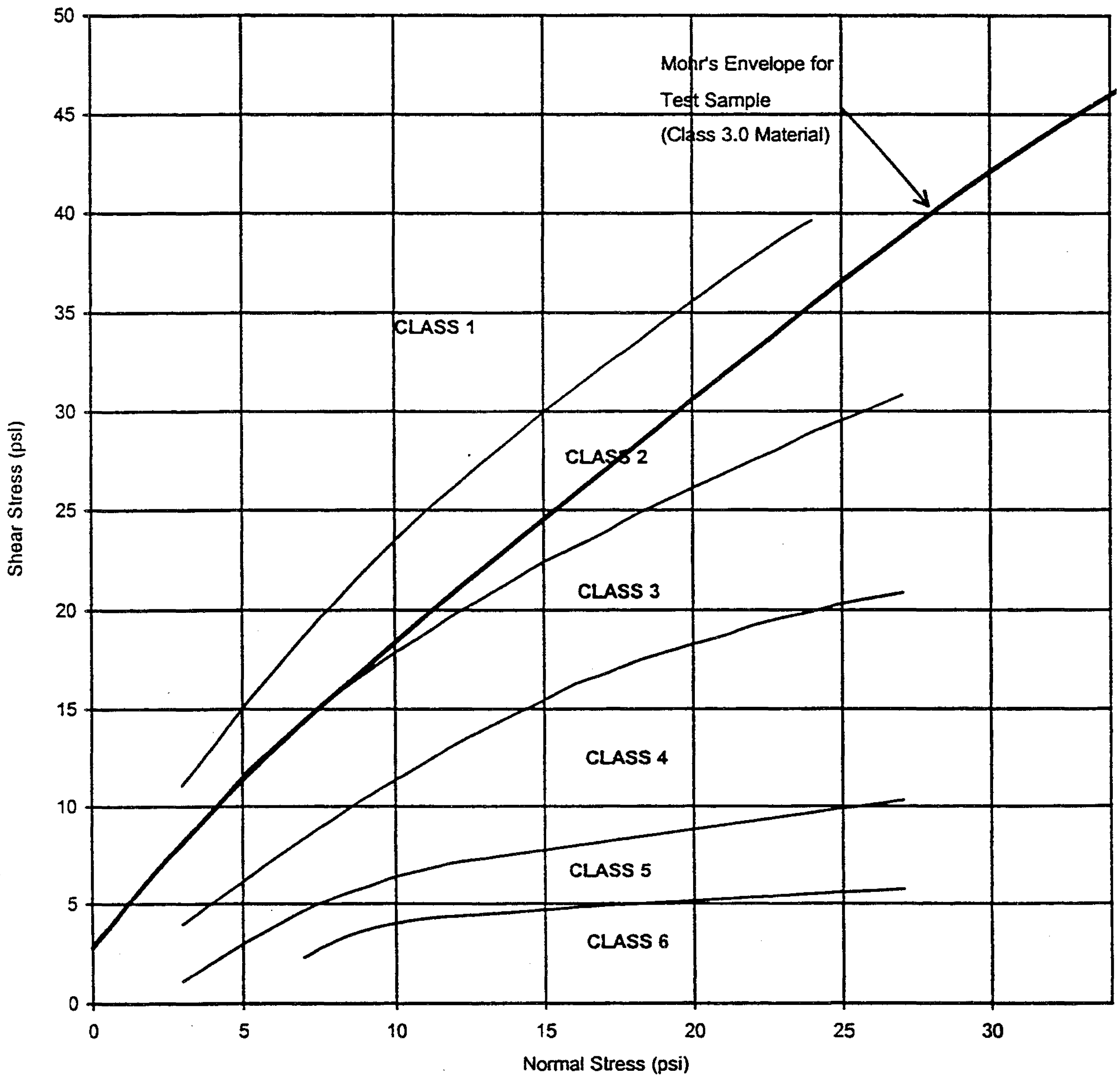
Lab No.: 02-96-364 VG County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 24, PI= 7) - Gradation B (GC)

Optimum Moisture: 7.3% Maximum Dry Density: 139.7 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-094

FIGURE A-6

TERRA-MAR, INC.

ATTACHMENT D

RESULTS OF TEXAS TRIAXIAL TEST

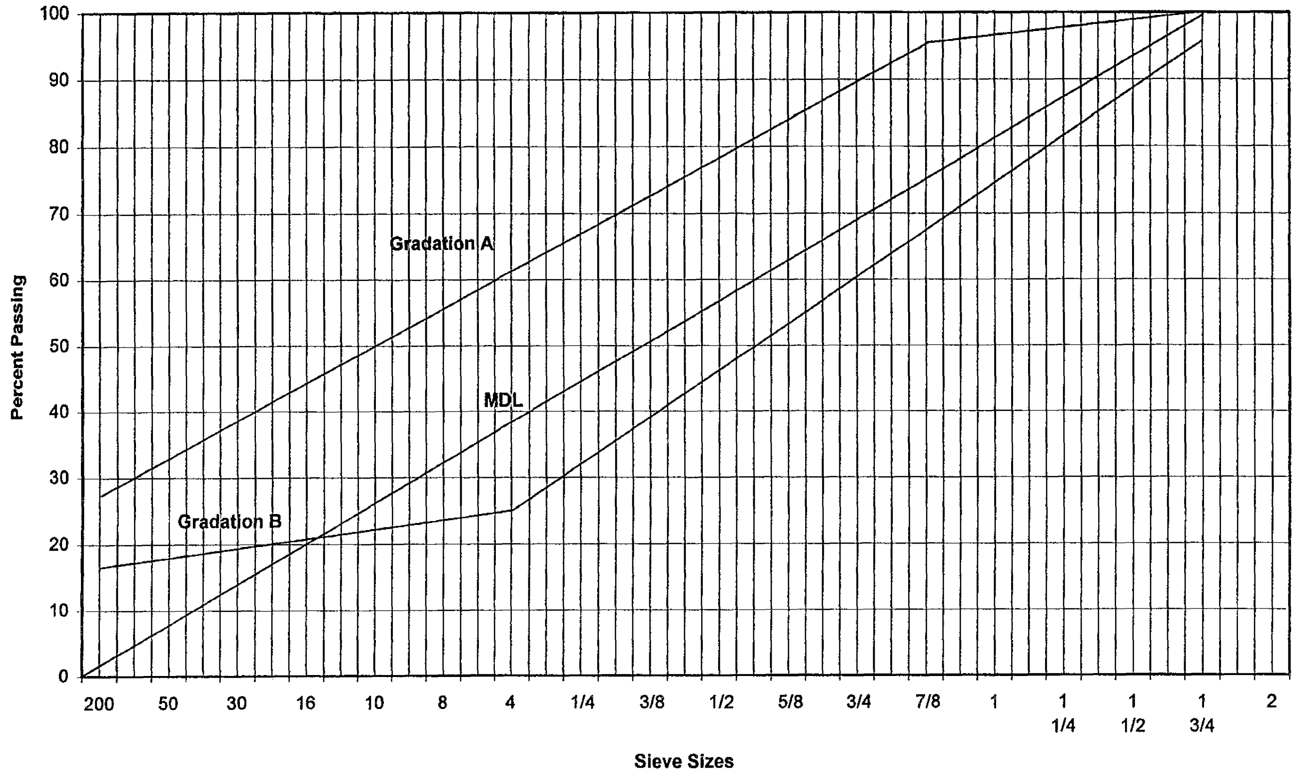
CRUSHED STONE FLEXIBLE BASE

CURRENT DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

ARNOLD BLUM

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

.45 Power Gradation Chart

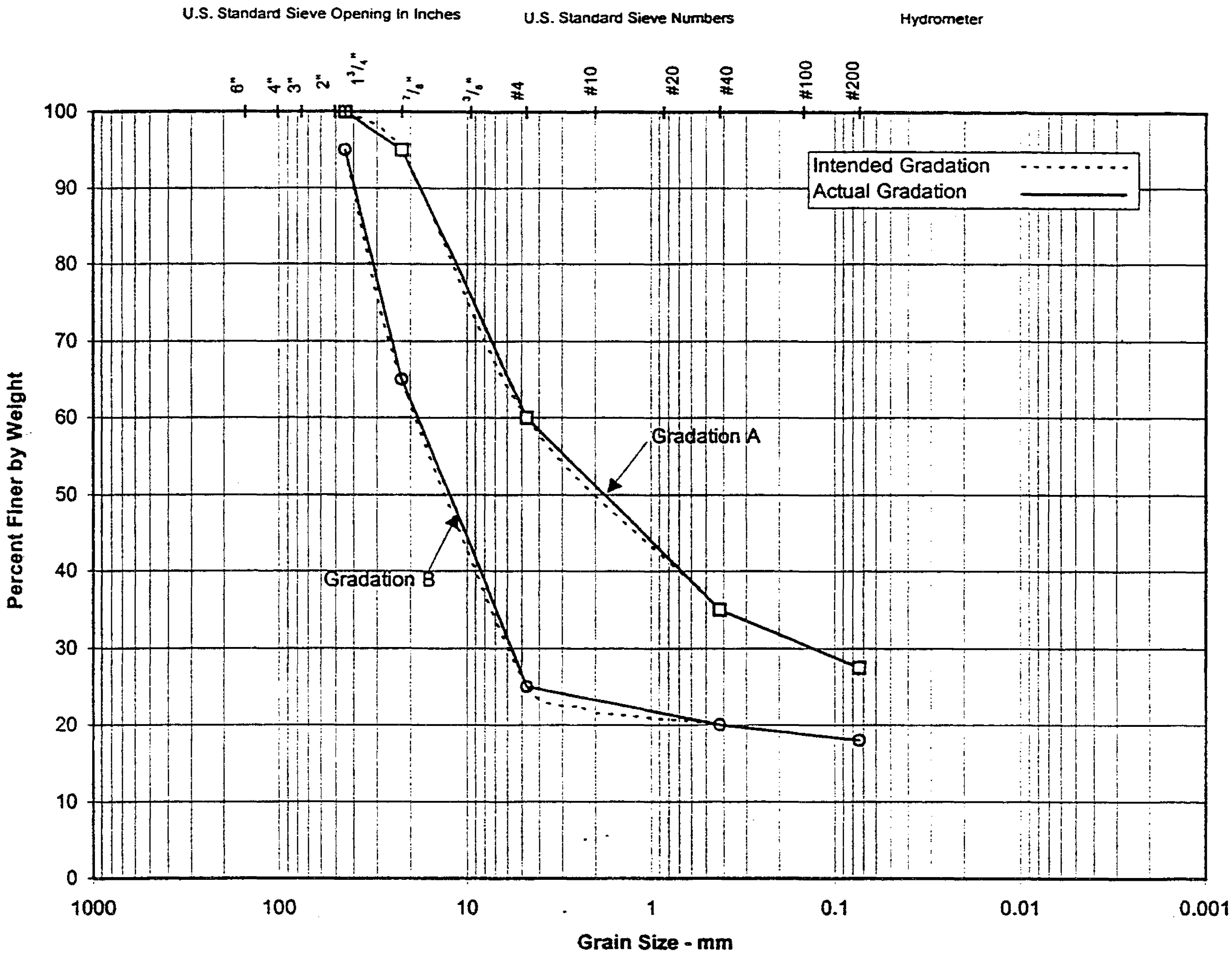


Triaxial Class

Gradation	Class
A	3.0
B	2.5

PIT C

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Arnold Crushed Stone - Blum Pit (Pit C to be determined)

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
-□-	GC	40.0	32.5	27.5	18	16	2
-○-	GC	75.0	7.0	18.0	19	16	3
Material Type	Flex Base TYA GR6		**Material Source**	Arnold Crushed Stone - Blum Pit			

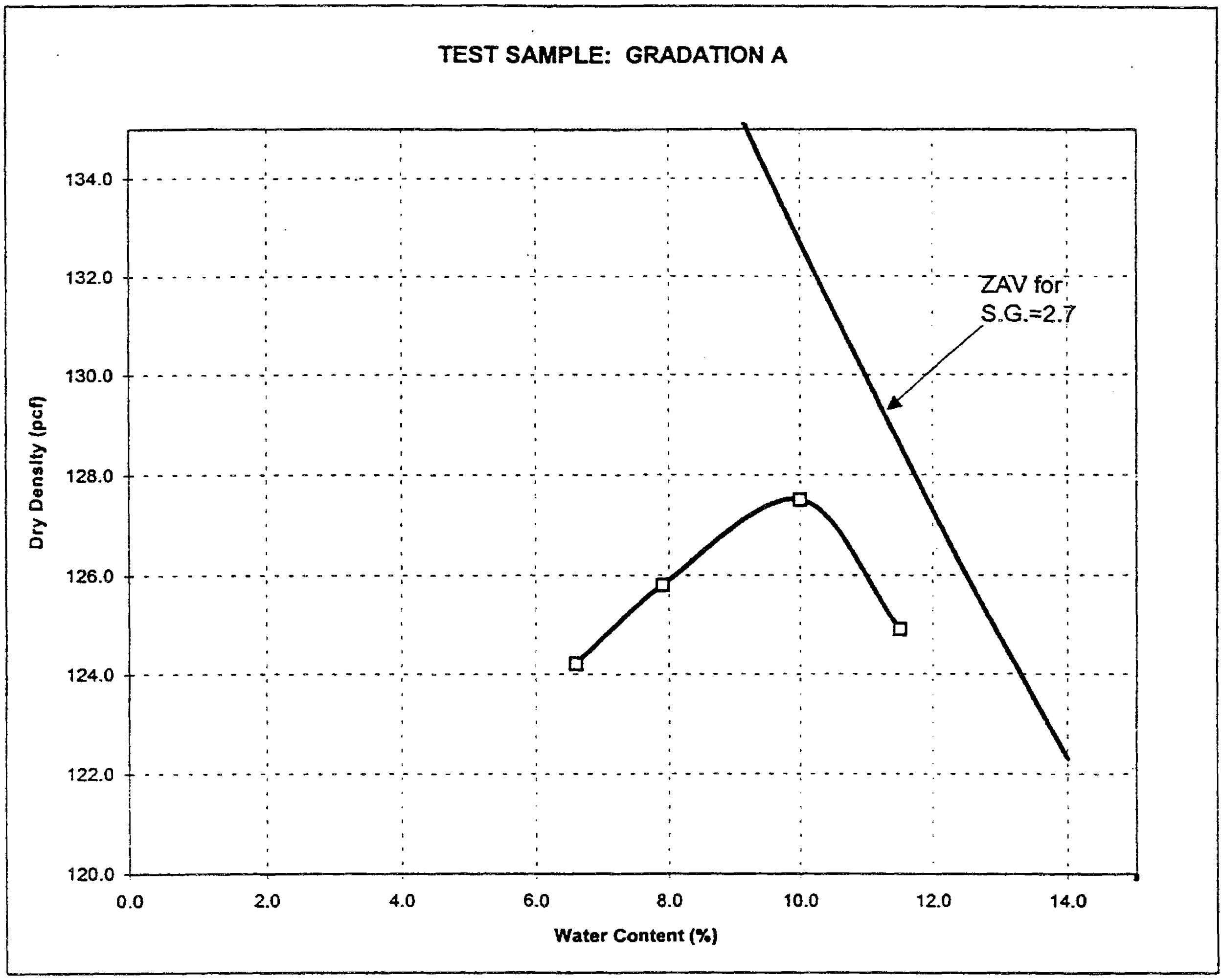
Lab No.	02-96-364 AB
County	Fort Worth District Laboratory
Control	02-70-0510

NOTE: The stockpile was batched based on particle size using 1-3/4", 7/8", No. 4, No. 40 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE96-095

FIGURE 1

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 127.6 pcf Optimum Moisture Content = 9.9%

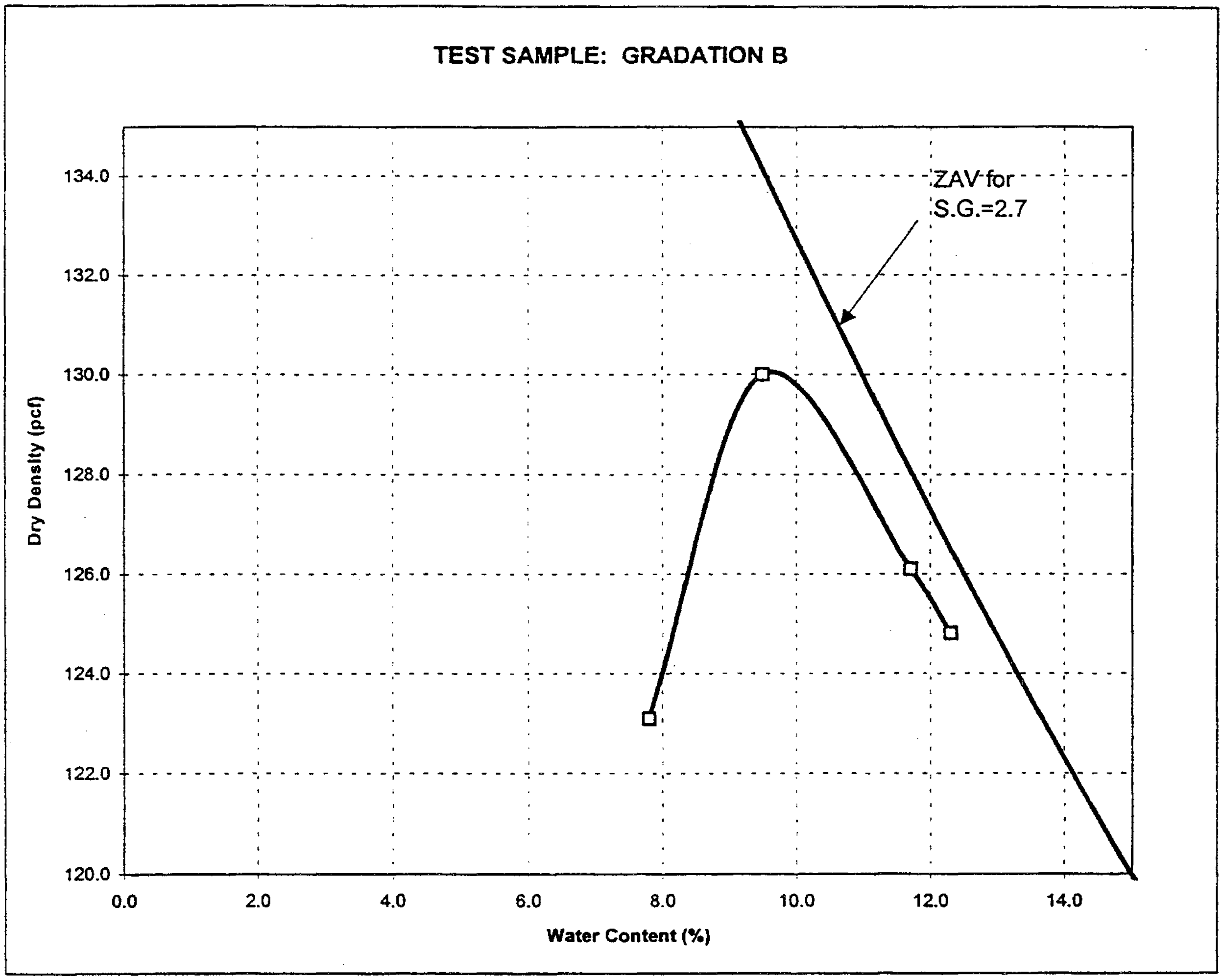
Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation A	GC	40.0	27.5	18	2
Material Type	Flex Base TYA GR6				
Material Source	Arnold Crushed Stone - Blum Pit				

Lab No.	02-96-364 AB
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-095

FIGURE 2

MOISTURE-DENSITY RELATIONSHIP TEST



Test Specification: Tex-113-E

Maximum Dry Density = 130.1 pcf Optimum Moisture Content = 9.6%

Test Sample	USCS	% > #4	% < #200	LL	PI
Gradation B	GC	75.0	18.0	19	3
Material Type	Flex Base TYA GR6				
Material Source	Arnold Crushed Stone - Blum Pit				

Lab No.	02-96-364 AB
County	Fort Worth District Laboratory
Control	02-70-0510

DE96-095 **FIGURE 3**

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE (GRADATION A)

Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 18, PI= 2) - Gradation A (GC)

Optimum Moisture: 9.9% Maximum Dry Density: 127.6 pcf at Compactive Effort: 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 3.0

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	10.3	127.7	10	10.8	127.1	0	23.3	1.9	0.5
2	9.9	127.4	10	10.8	127.8	3	52.0	3.9	-0.4
3	9.8	128.5	10	10.7	128.0	5	73.2	5.4	0.4
4	9.7	129.0	10	10.4	128.2	10	92.5	4.6	0.6
5	10.4	126.2	10	10.8	126.3	15	116.1	4.9	-0.1
6	9.5	128.8	10	10.6	128.3	20	107.7	5.3	0.3
7	10.0	127.4	10	10.7	126.6	0	25.8	1.9	0.6

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E.

DE96-095

FIGURE 4

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE (GRADATION B)

Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 3) - Gradation B (GC)

Optimum Moisture: 9.6% Maximum Dry Density: 130.1 pcf at Compactive Effort: 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 2.5

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	9.2	129.0	10	9.0	130.3	3	68.0	4.5	0.0
2	9.2	129.0	10	9.1	130.3	5	86.1	3.4	0.0
3	9.4	127.4	10	9.2	128.7	10	110.5	3.8	0.0
4	9.2	128.4	10	9.0	130.0	15	137.1	4.5	-0.1
5	9.2	126.7	10	9.0	128.8	20	132.1	4.8	-0.1
6	9.0	132.5	10	8.8	129.6	0	37.0	2.1	0.0
7	9.2	130.6	10	8.9	132.3	0	27.7	2.6	0.0

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E. Initial portion of the stress-strain curve was corrected for end effects.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (GRADATION A)

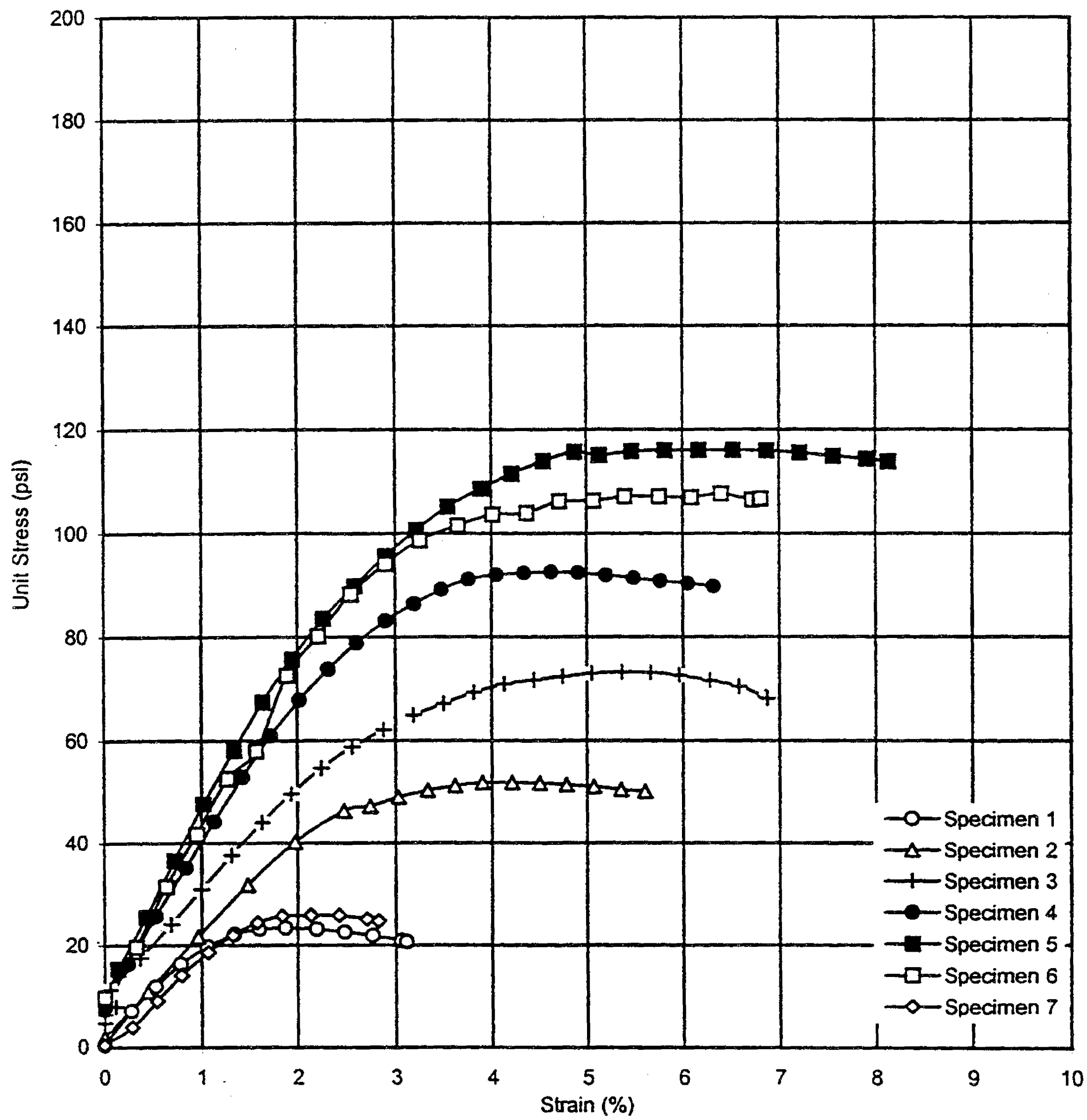
Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 18, PI= 2) - Gradation A (GC)

Optimum Moisture: 9.9% Maximum Dry Density: 127.6 pcf at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	3	5	10	15	20	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-095 **FIGURE A-1**

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (GRADATION A)

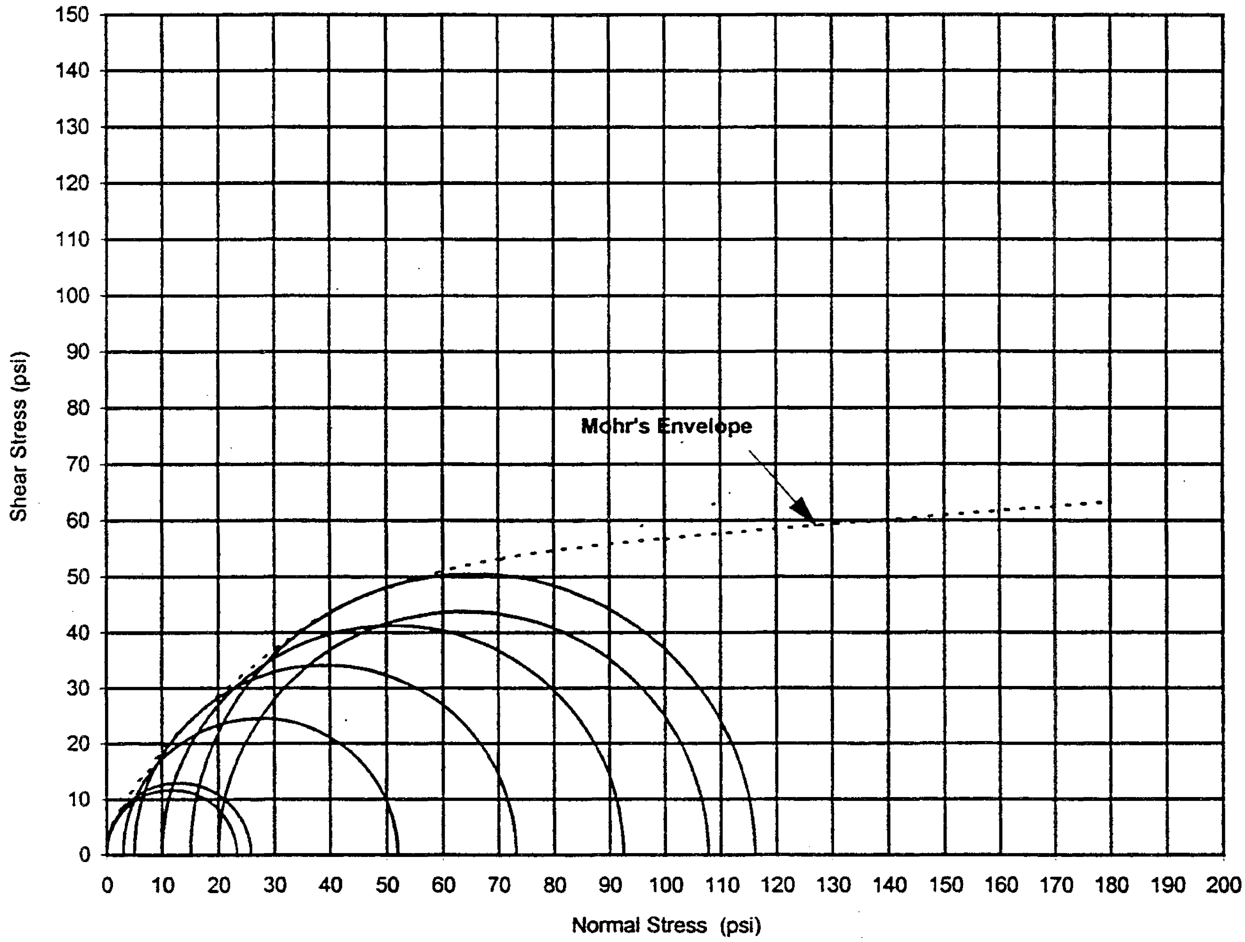
Lab No.: 02-96-364 AB   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 18, PI= 2) - Gradation A (GC)

Optimum Moisture: 9.9%   Maximum Dry Density: 127.6 pcf   at Compactive Effort: 13.3 ft-lb/in^3



DE96-095

FIGURE A-2

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (GRADATION A)

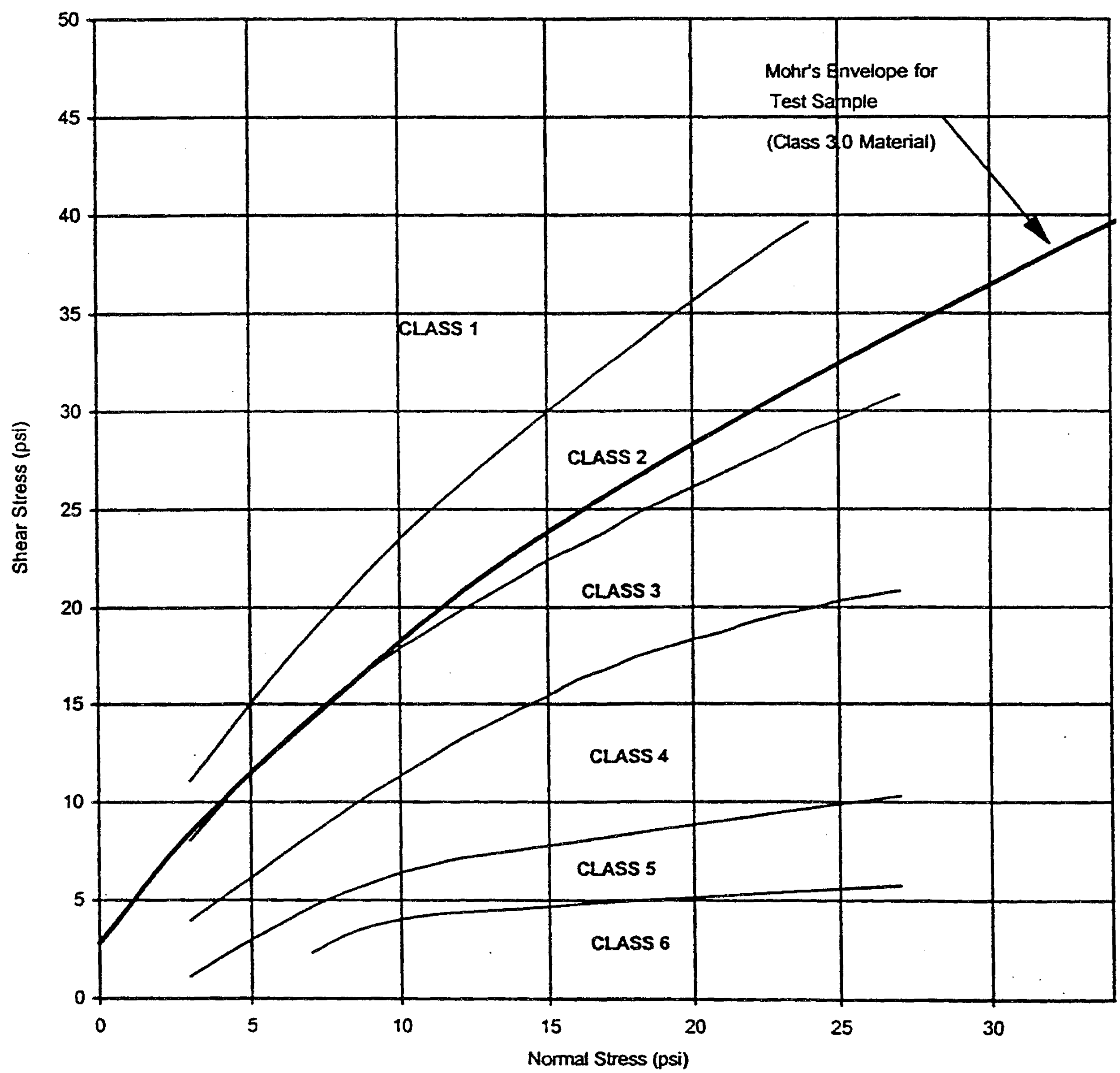
Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 18, PI= 2) - Gradation A (GC)

Optimum Moisture: 9.9% Maximum Dry Density: 127.6 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-095

FIGURE A-3

TERRA-MAR, INC.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE (GRADATION B)

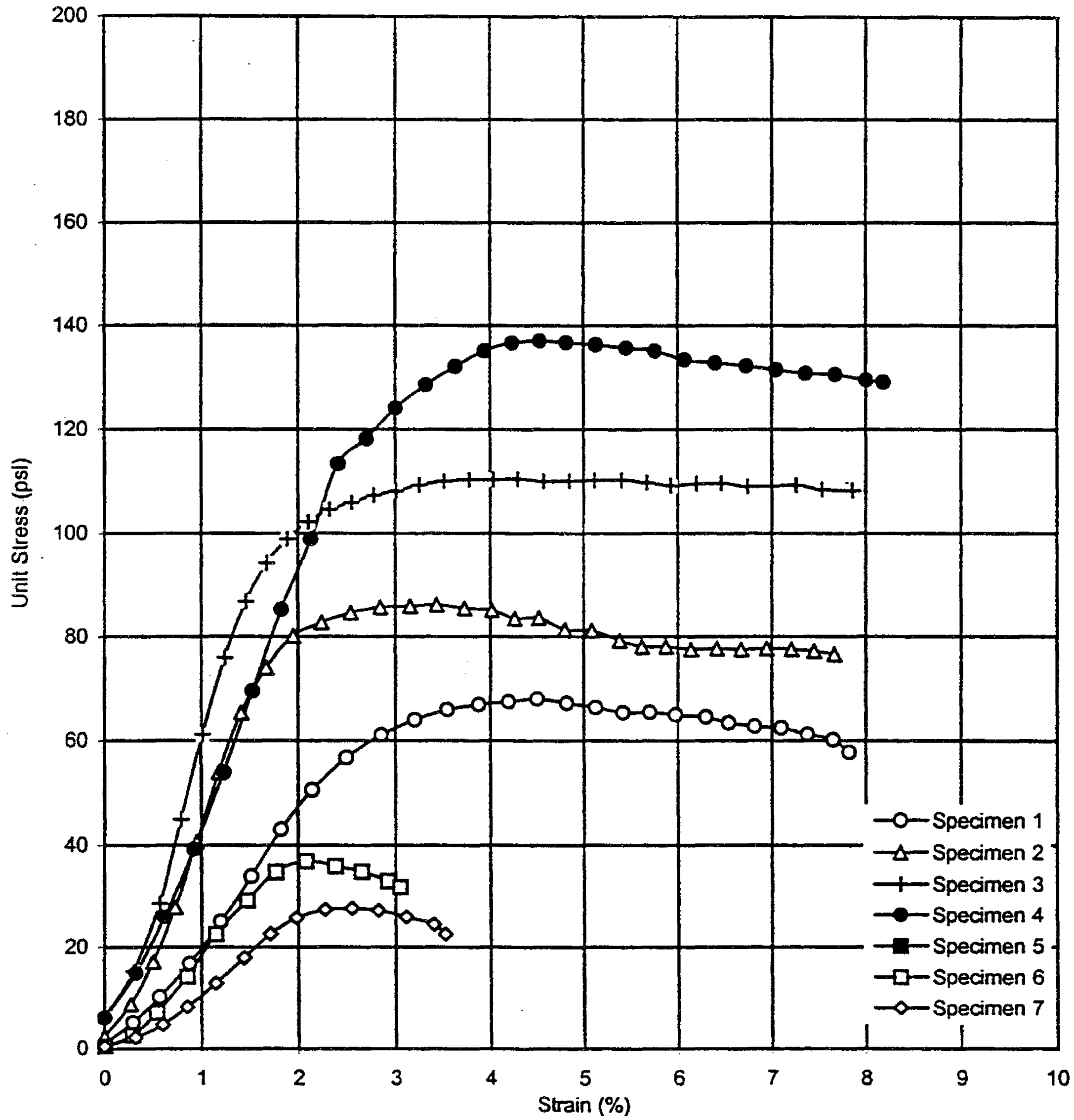
Lab No.: 02-96-364 AB   County: Fort Worth District Lab   Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 3) - Gradation B (GC)

Optimum Moisture: 9.6%   Maximum Dry Density: 130.1 pcf   at Compactive Effort: 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	3	5	10	15	20	0	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE96-095

FIGURE A-4

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE (GRADATION B)

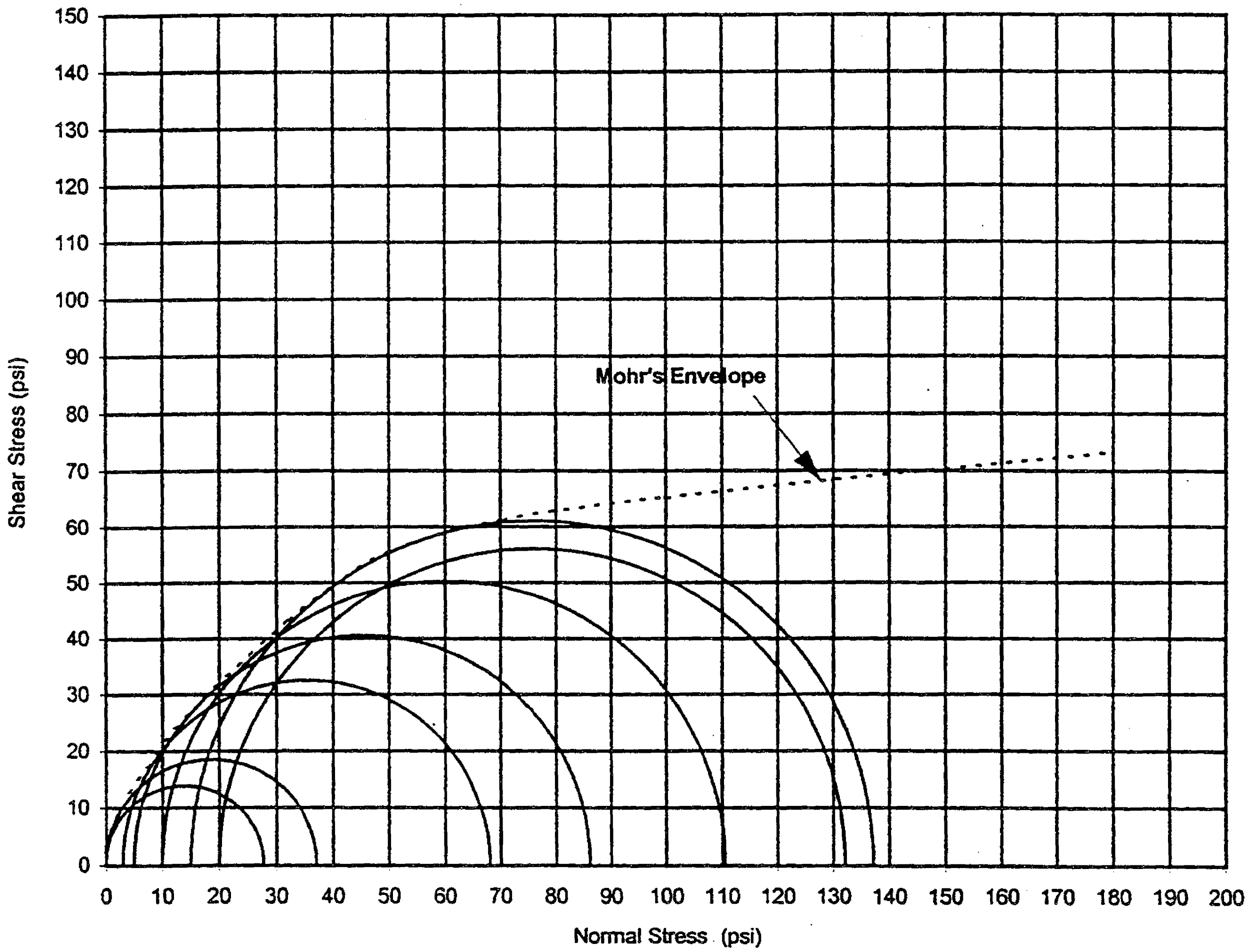
Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 3) - Gradation B (GC)

Optimum Moisture: 9.6% Maximum Dry Density: 130.1 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-095

FIGURE A-5

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (GRADATION B)

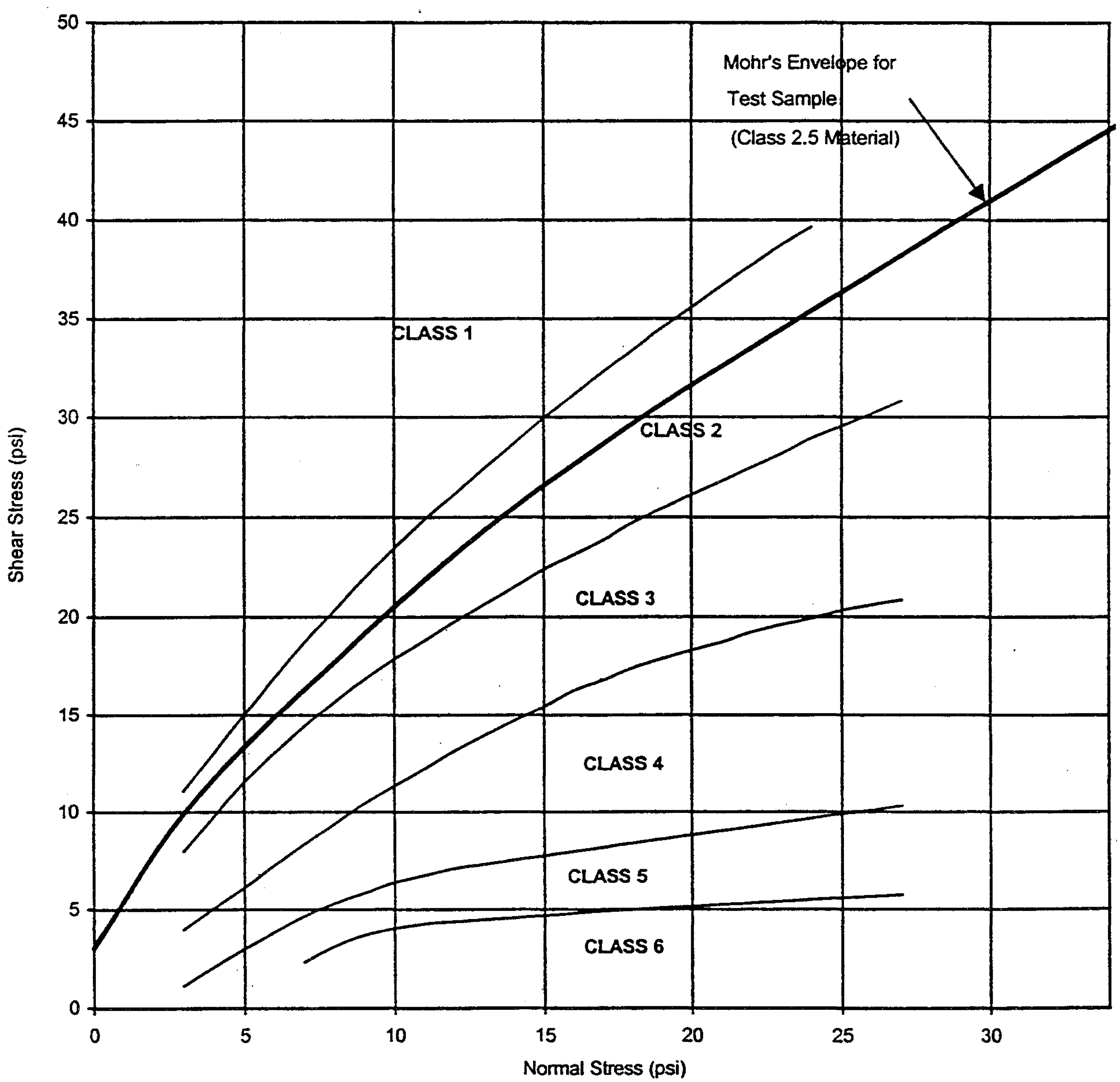
Lab No.: 02-96-364 AB County: Fort Worth District Lab Control: 02-70-0510

Material Type: Flex Base TYA, GR6

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 3) - Gradation B (GC)

Optimum Moisture: 9.6% Maximum Dry Density: 130.1 pcf at Compactive Effort: 13.3 ft-lb/in^3



DE96-095

FIGURE A-6

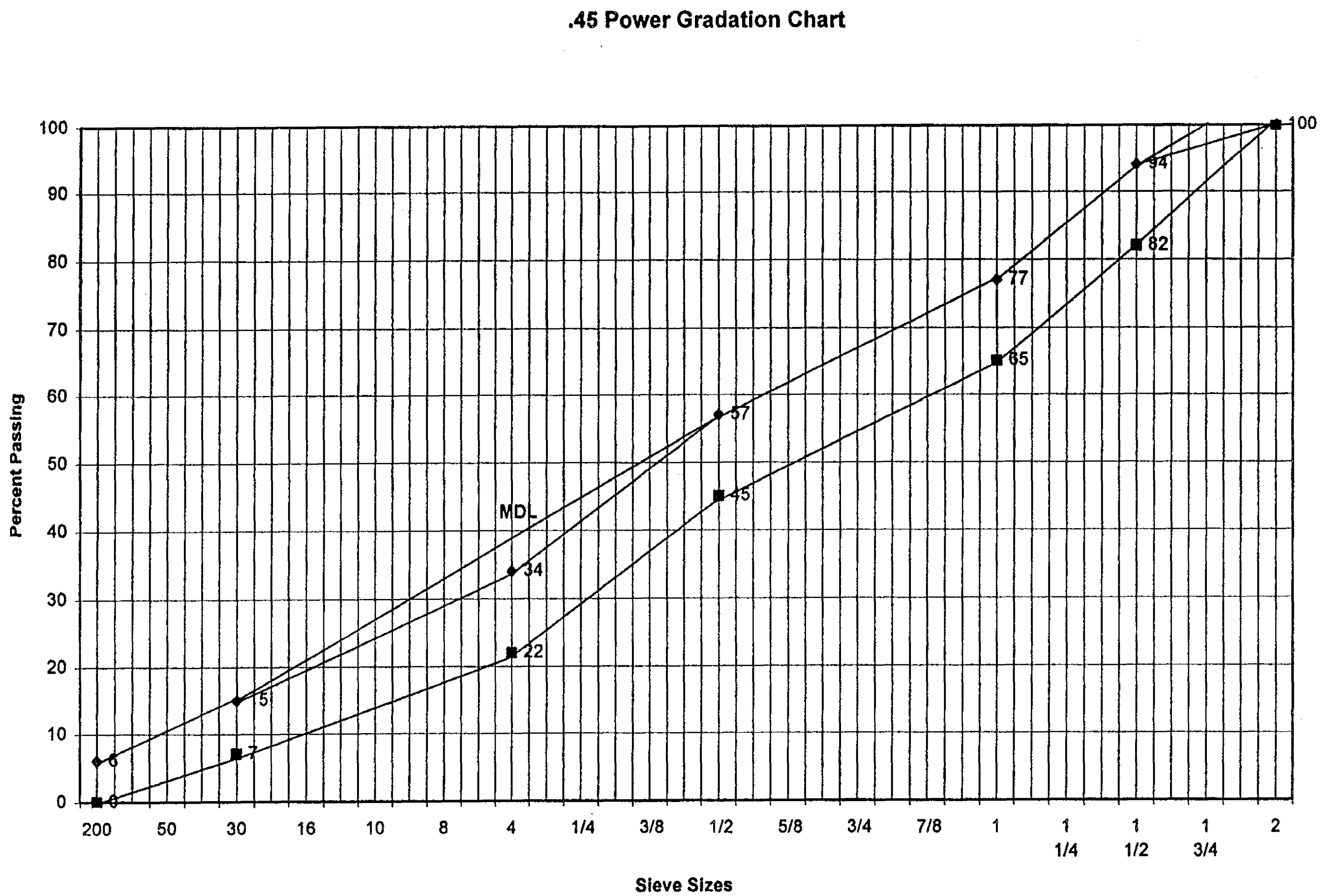
ATTACHMENT E

RESULTS OF TEXAS TRIAXIAL TEST

CRUSHED STONE FLEXIBLE BASE

PROPOSED DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)



Item 247 (Ty. A, Gr. 6) Gradation
Proposed for District 2 (Ft. Worth)

ATTACHMENT F

RESULTS OF TEXAS TRIAXIAL TEST

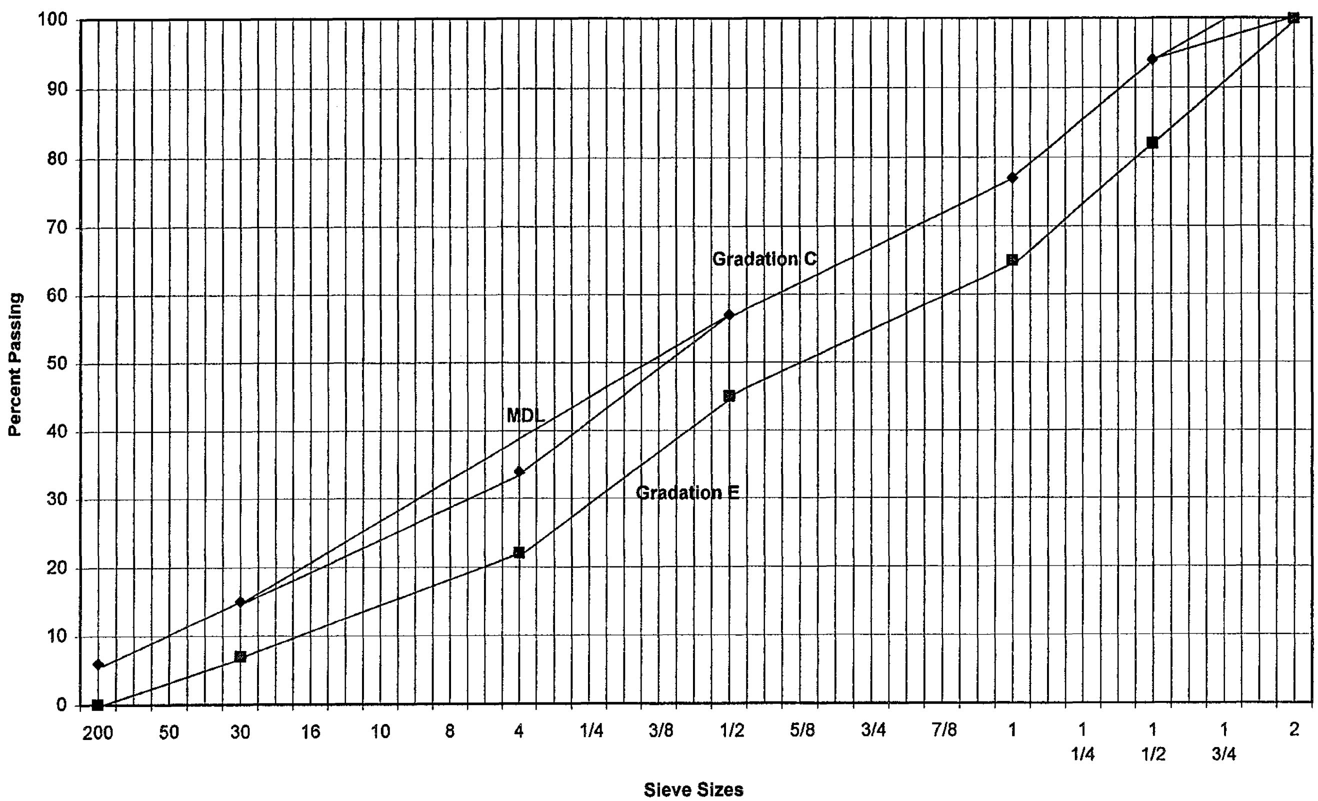
CRUSHED STONE FLEXIBLE BASE

PROPOSED DISTRICT ITEM 247, TY.A, GR. 6 GRADATION

PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931 (IN-HOUSE RESEARCH)

.45 Power Gradation Chart

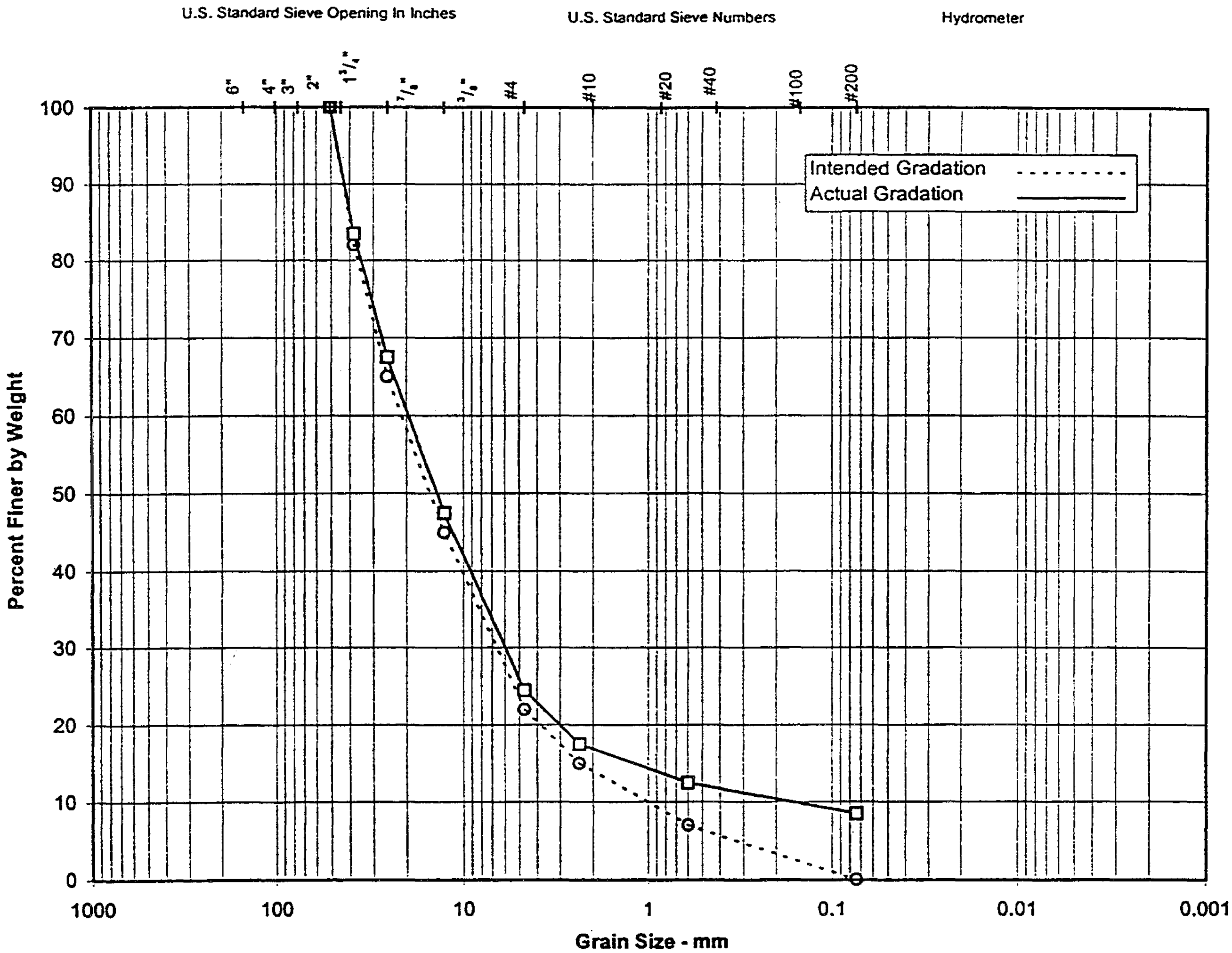


Pit A

Triaxial Class

Gradation	Class
C	1.8
E	2.1

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Pioneer Bridgeport Stockpile

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
-□-	GC	75.5	16.0	8.5	24	16	8
-○-	GP-GW	78.0	22.0	0.0	NP*	NP*	NP*
Material Type	Flex Base TYA GR6		**Material Source**		Pioneer Bridgeport Stockpile		

* Non Plastic.

Lab No.	02-96-364
Charge No.	70-72-797393170-807
County	Fort Worth District Laboratory
Control	7-931 (In-House Research)

NOTE: The stockpile was batched based on particle size using 1-3/4", 1-1/2", 1", 1/2", No. 4, No. 8, No. 30 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE97-003

FIGURE 1

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA GR6 Charge No.: 70-72-797393170-807

Material Source: Pioneer-Bridgeport Stockpile

Description: Light Gray Crushed Stone (LL= 24, PI= 8)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3

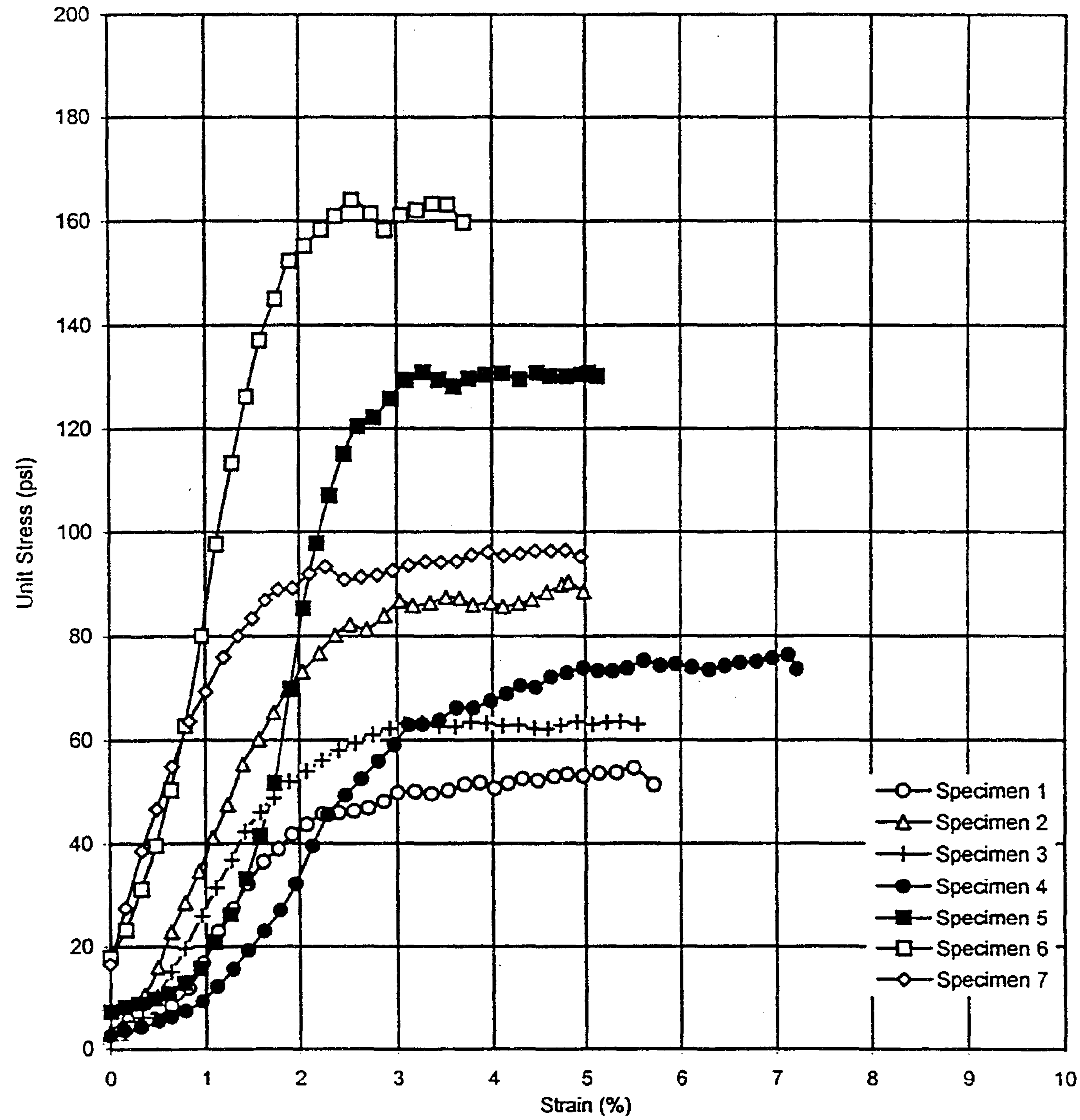
TEXAS TRIAXIAL CLASS 2.1

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	4.9	126.9	10	4.9	125.6	0	54.6	5.5	1.0
2	5.6	129.0	10	4.8	127.0	3	90.4	4.8	1.5
3	5.1	127.2	10	4.8	125.1	5	63.5	4.9	1.7
4	5.1	125.9	10	4.5	124.3	10	76.0	6.9	1.2
5	5.3	128.6	10	4.9	127.9	15	130.8	5.0	0.5
6	5.5	129.7	10	5.1	127.9	20	164.1	2.5	1.4
7	5.6	128.5	10	4.8	127.2	5	96.8	4.3	1.0

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E. Initial portion of the stress-strain curve was corrected for end effects.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research
Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807
Material Source: Pioneer-Bridgeport Stockpile
Description: Light Gray Crushed Stone (LL= 24, PI= 8)
All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	3	5	10	15	20	5

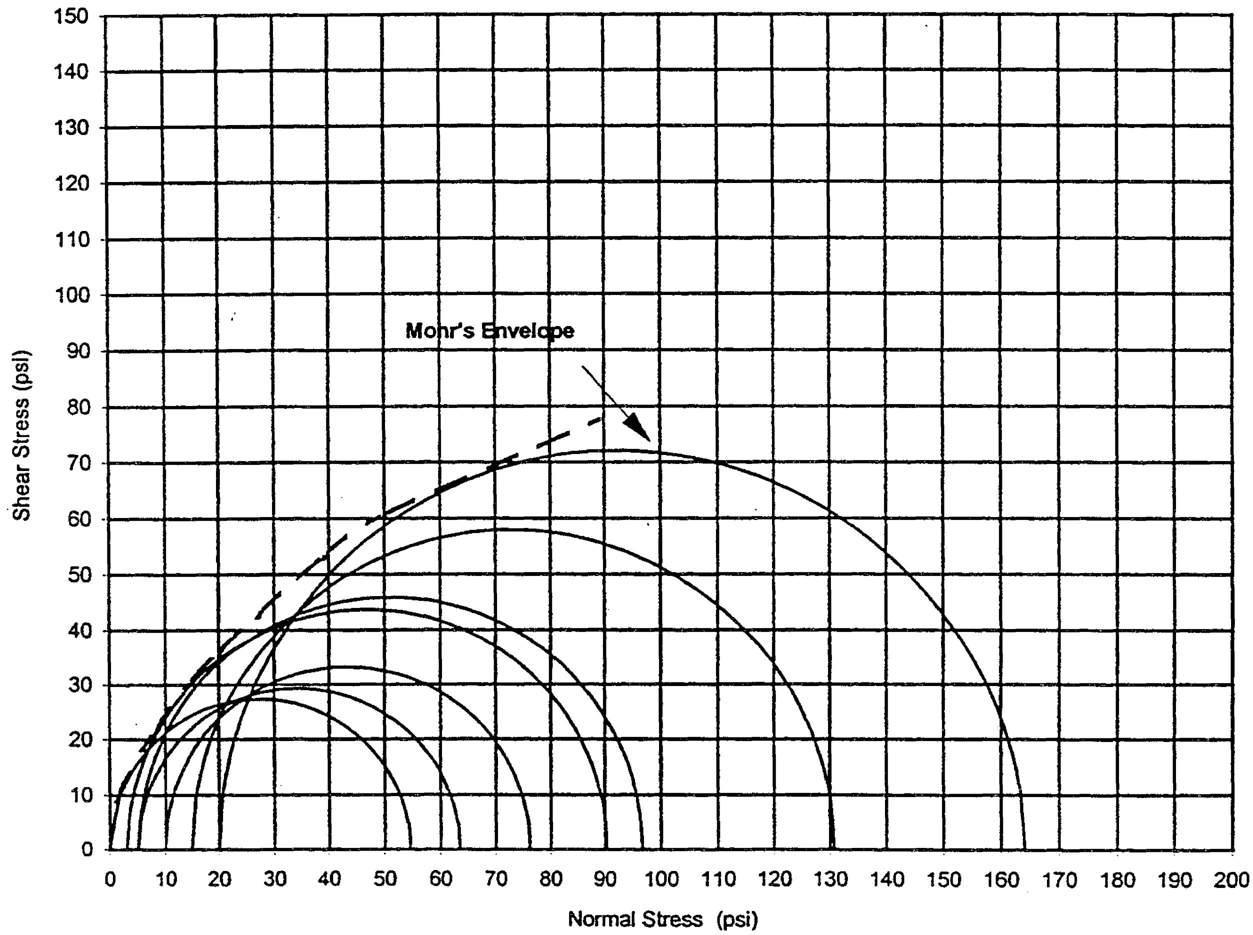
Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE97-003

FIGURE A-1

MOHR'S FAILURE ENVELOPE
CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research
Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807
Material Source: Pioneer-Bridgeport Stockpile
Description: Light Gray Crushed Stone (LL= 24, PI= 8)
All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



DE97-003

FIGURE A-2

TERRA-MAR, INC.

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE

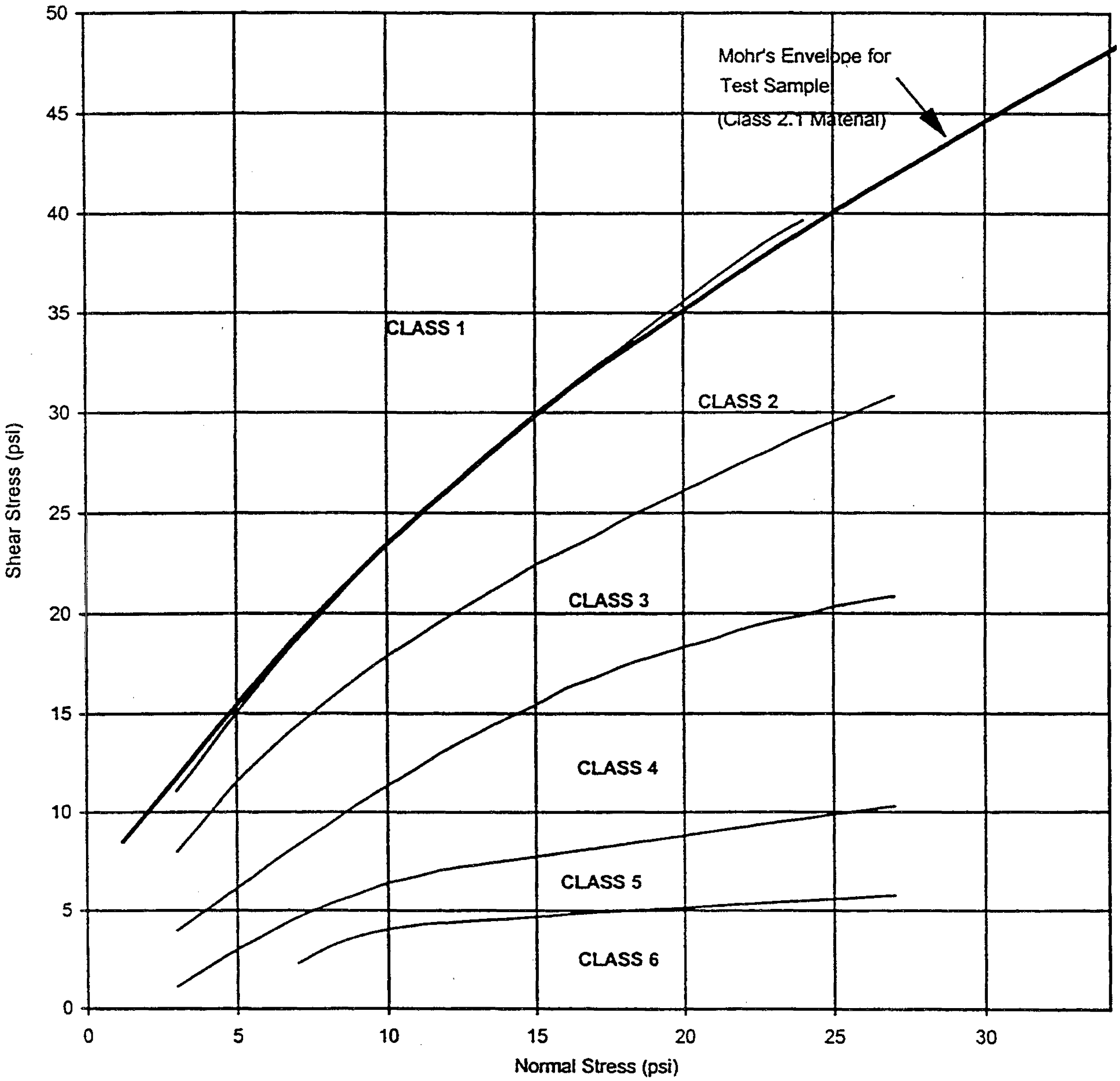
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Pioneer-Bridgeport Stockpile

Description: Light Gray Crushed Stone (LL= 24, PI= 8)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



DE97-003

FIGURE A-3

TERRA-MAR, INC.

RESULTS OF TEXAS TRIAXIAL TEST

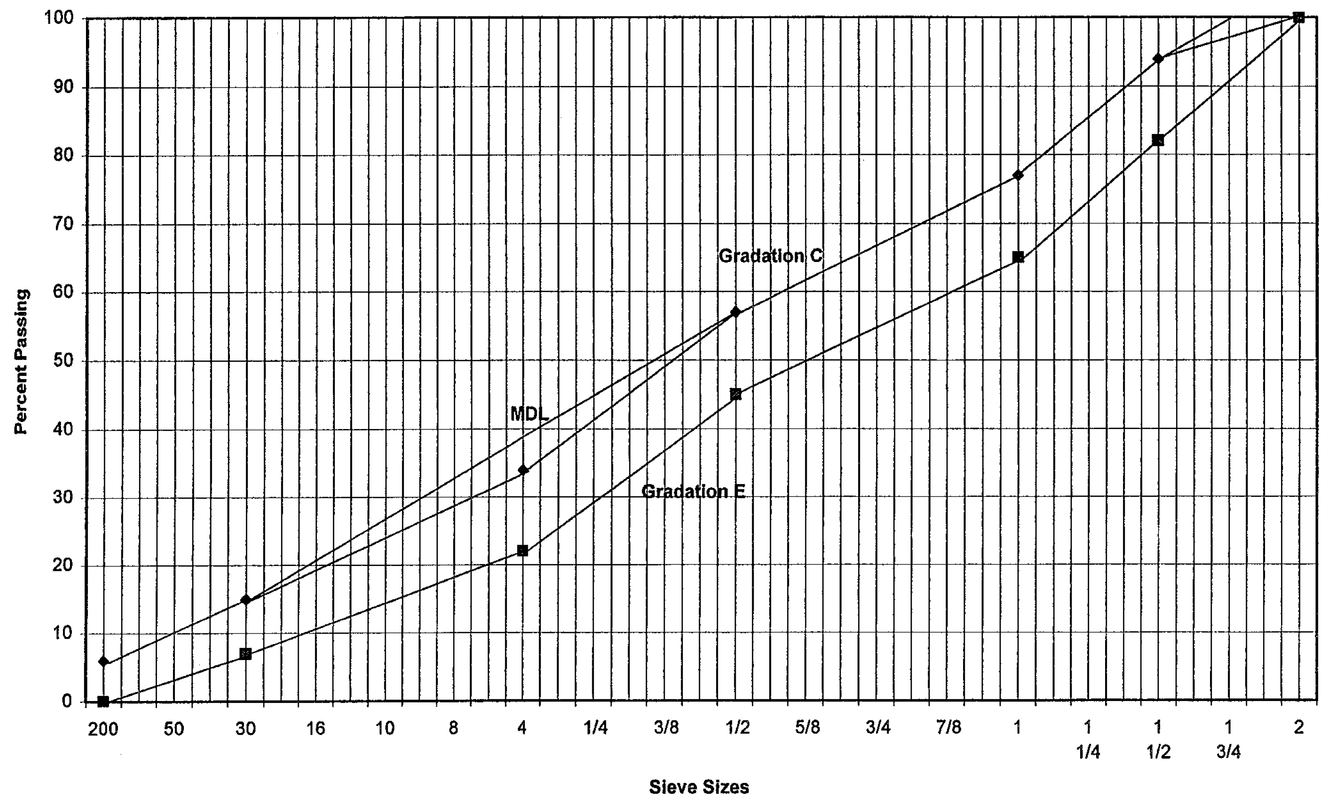
CRUSHED STONE FLEXIBLE BASE

PROPOSED DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

VULCAN GILBERT

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

.45 Power Gradation Chart

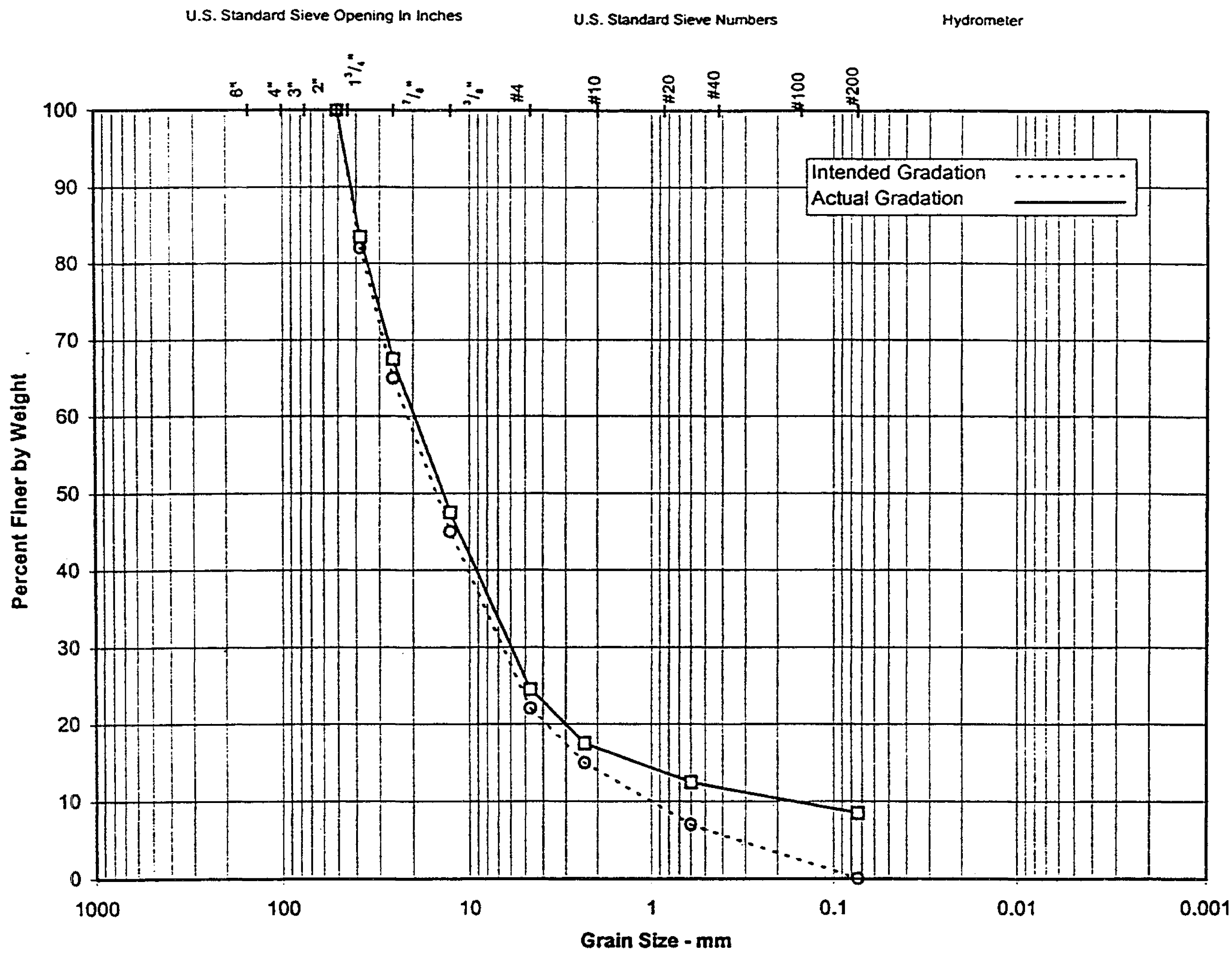


Pit B

Triaxial Class

Gradation	Class
C	2.9
E	2.3

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Vulcan Gilbert Pit - Pit B

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
–□–	GC	75.5	16.0	8.5	23	16	7
–○–	GP-GW	78.0	22.0	0.0	NP*	NP*	NP*
Material Type	Flex Base TYA GR6		Material Source		Vulcan Gilbert Pit - Pit B		

* Non Plastic.

Lab No.	02-96-364
Charge No.	70-72-797393170-807
County	Fort Worth District Laboratory
Control	7-931 (In-House Research)

NOTE: The stockpile was batched based on particle size using 1-3/4", 1-1/2", 1", 1/2", No. 4, No. 8, No. 30 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE97-004

FIGURE 1

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA GR6 Charge No.: 70-72-797393170-807

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 23, PI= 7)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 2.3

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	7.9	135.3	10	5.5	134.1	0	32.1	5.8	0.9
2	6.5	139.8	10	5.4	138.9	15	144.2	4.4	0.6
3	6.0	133.7	10	5.3	133.1	3	80.0	3.8	0.5
4	6.0	131.7	10	5.3	131.0	5	93.6	3.8	0.5
5	6.3	135.5	10	5.5	134.2	20	192.0	3.3	1.0
6	6.0	135.3	10	5.3	134.7	0	50.9	3.0	0.4
7	6.0	134.8	10	5.4	135.0	10	100.6	3.8	-0.2

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E. Initial portion of the stress-strain curve was corrected for end effects.

DE97-004

FIGURE 2

TERRA-MAR, INC.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE

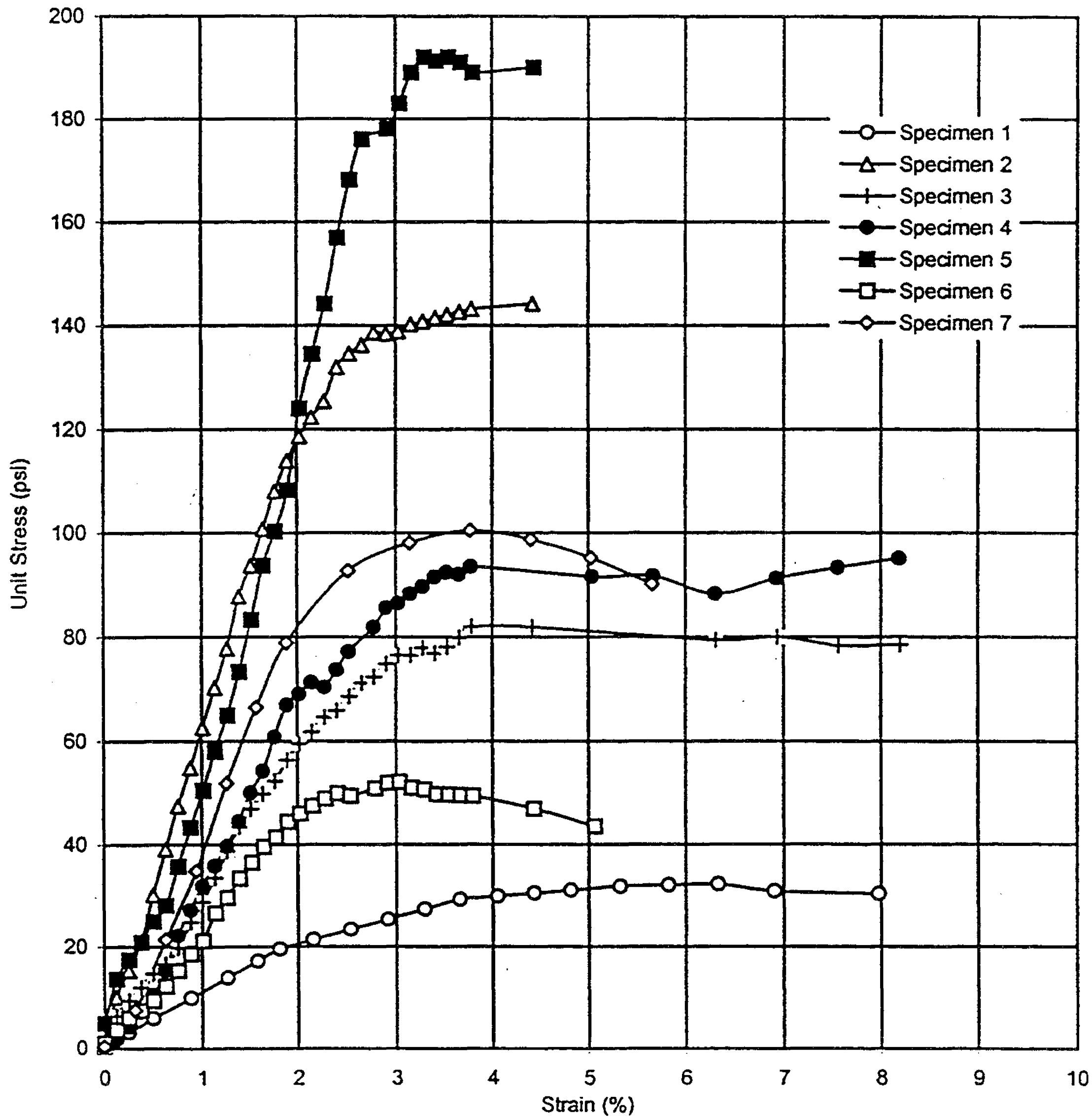
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 23, PI= 7)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3

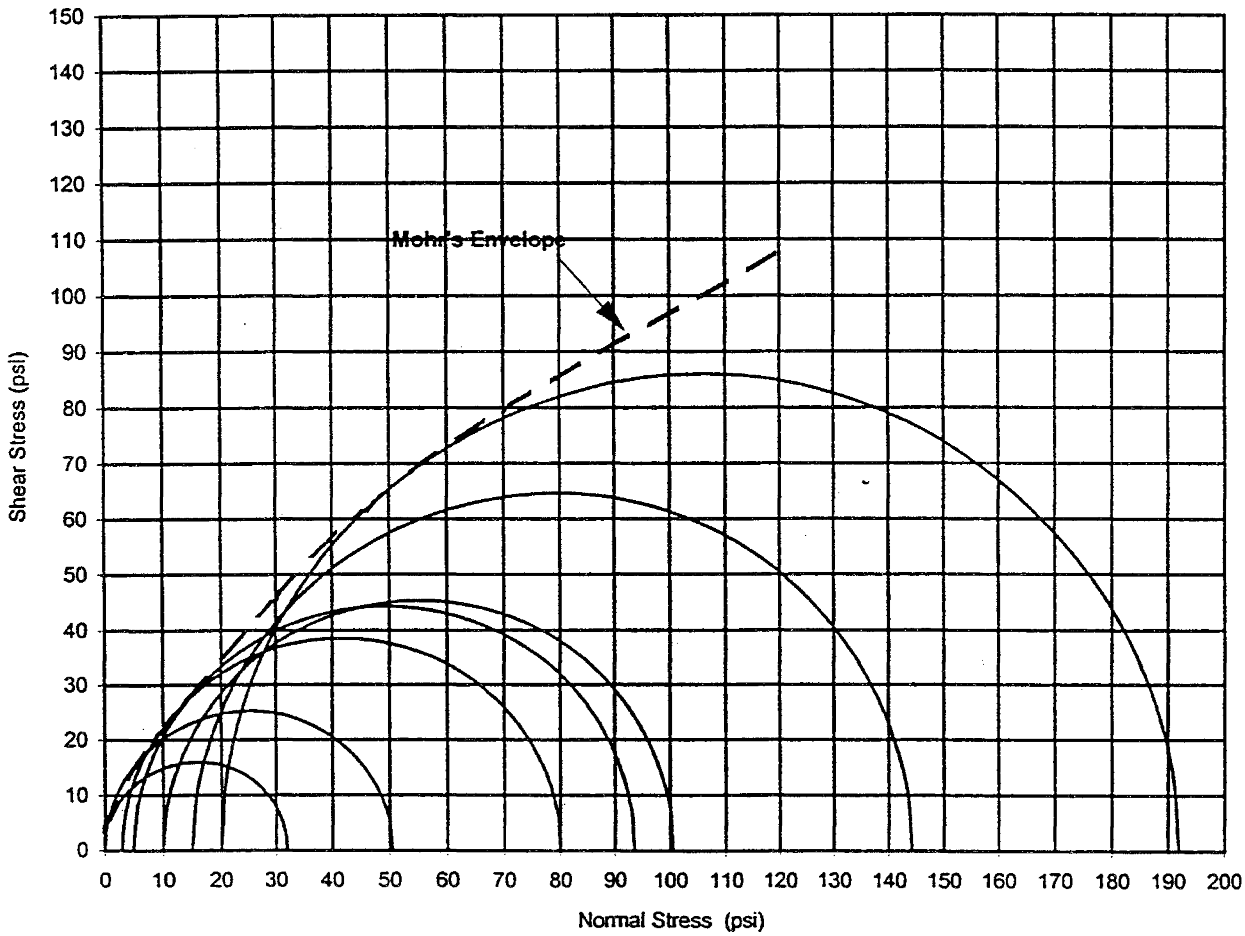


Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	15	3	5	20	0	10

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

MOHR'S FAILURE ENVELOPE
CRUSHED STONE FLEX BASE (GRADATION A)

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research
Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807
Material Source: Vulcan Gilbert Pit - Pit B
Description: Light Gray Crushed Stone (LL= 23, PI= 7)
All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in³



DE97-004

FIGURE A-2

TERRA-MAR, INC.

TEXAS TRIAXIAL CLASS EVALUATION

CRUSHED STONE FLEX BASE (GRADATION A)

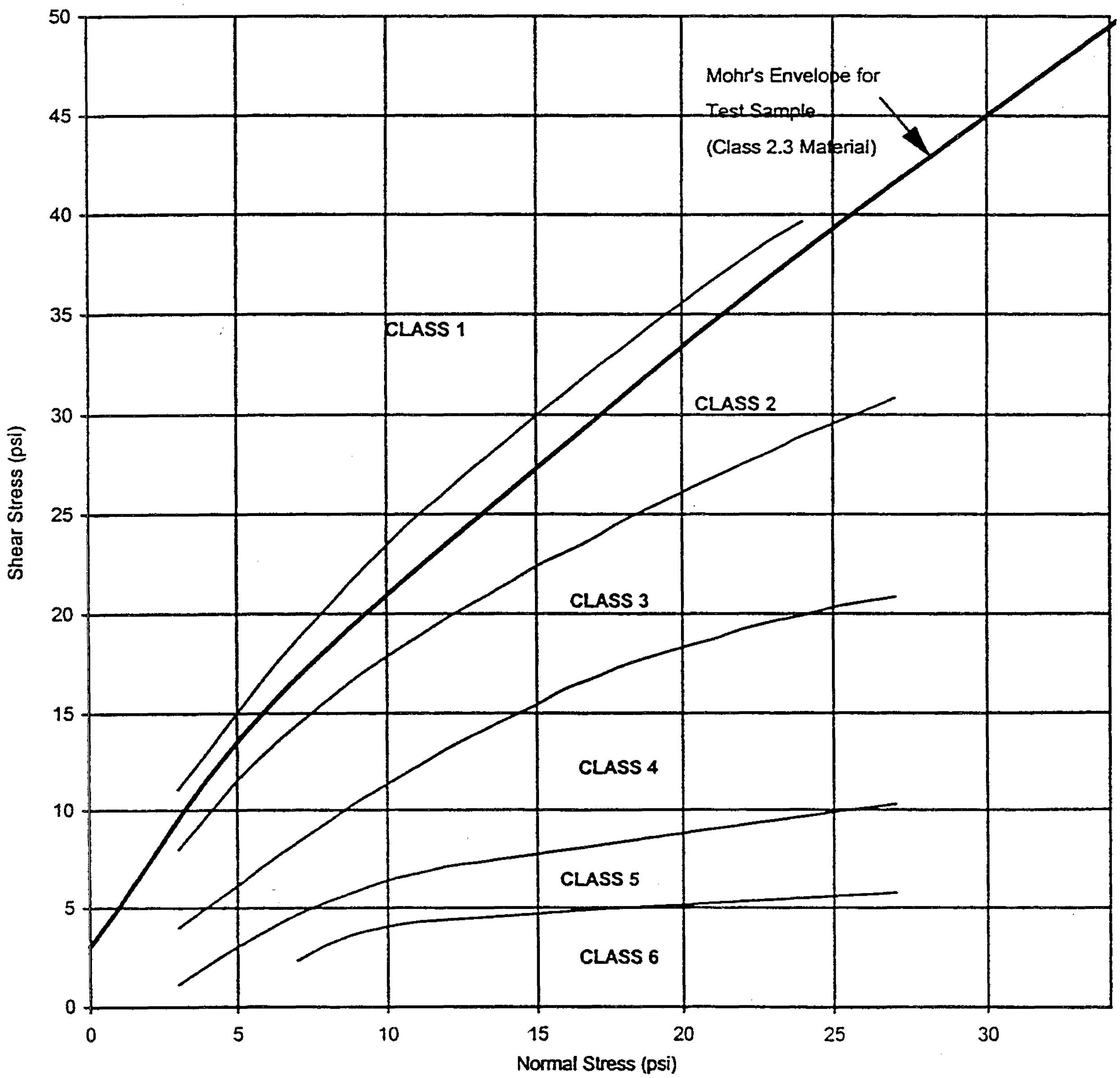
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Vulcan Gilbert Pit - Pit B

Description: Light Gray Crushed Stone (LL= 23, PI= 7)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



DE97-004

FIGURE A-3

TERRA-MAR, INC.

RESULTS OF TEXAS TRIAXIAL TEST

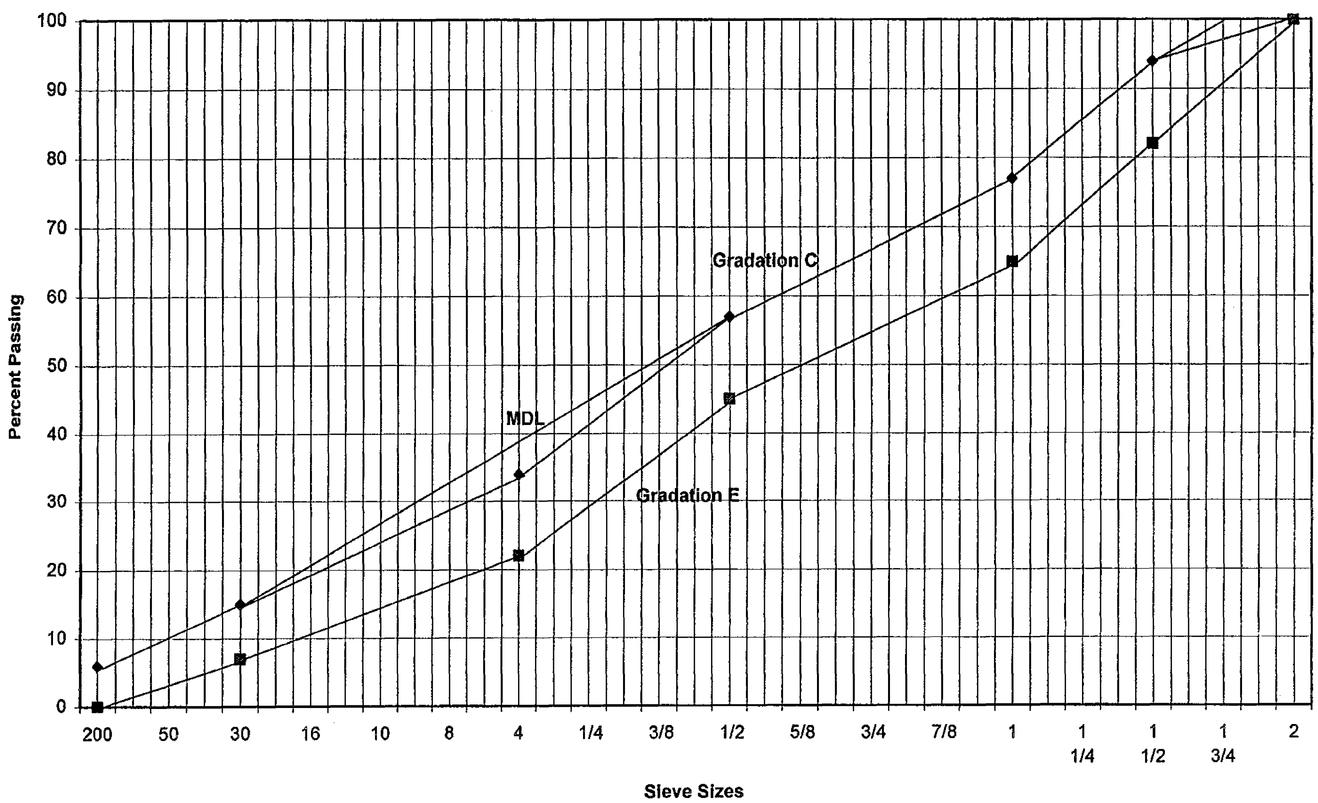
CRUSHED STONE FLEXIBLE BASE

PROPOSED DISTRICT ITEM 247,
TY.A, GR. 6 GRADATION

ARNOLD BLUM

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

.45 Power Gradation Chart

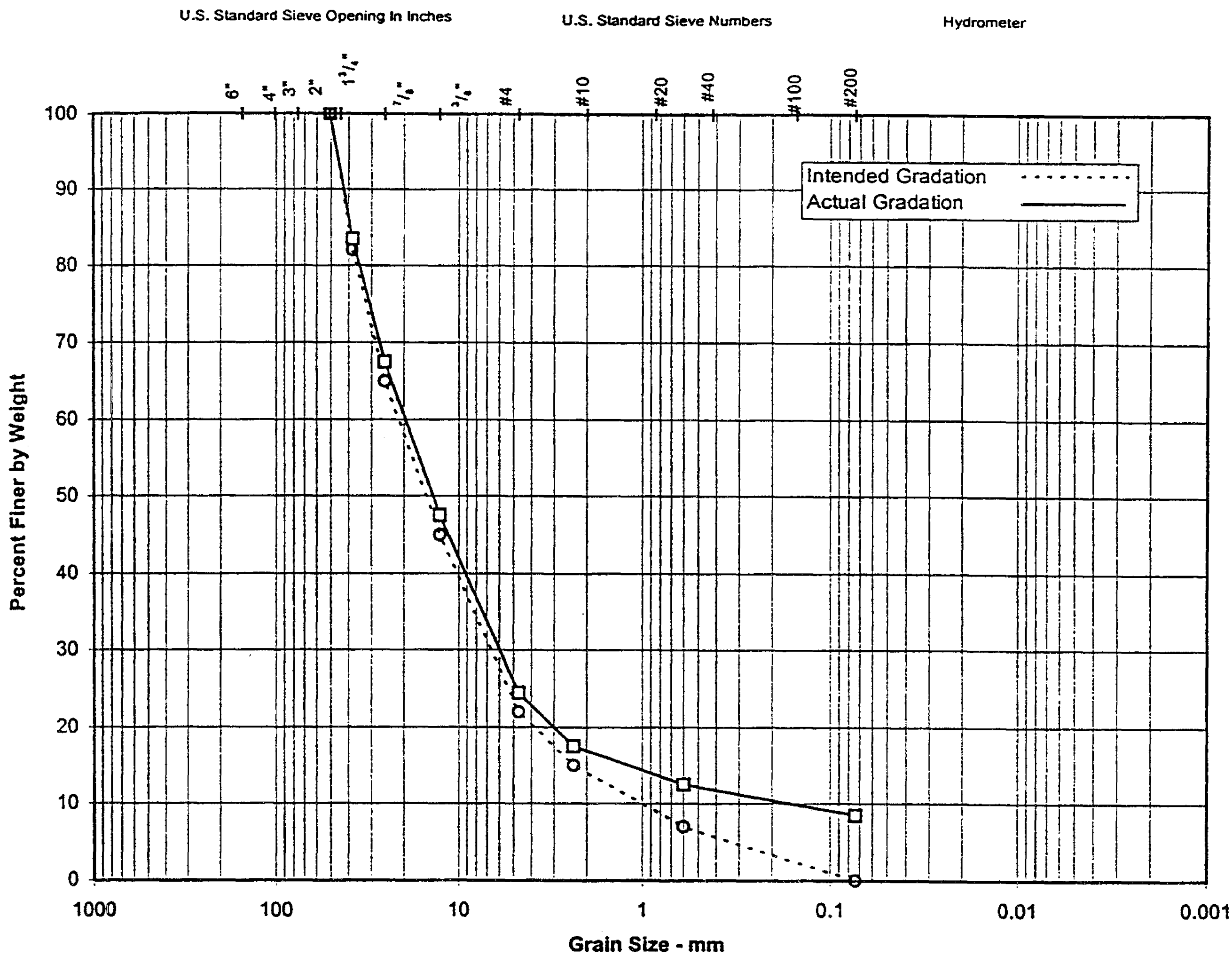


Triaxial Class

Pit C

Gradation	Class
C	2.4
E	2.5

GRAIN SIZE DISTRIBUTION TEST REPORT



Project: Arnold Crushed Stone - Blum Pit

Symbol	USCS	% Gravel Size	% Sand Size	% -#200	LL	PL	PI
-□-	GC	75.5	16.0	8.5	19	17	2
-○-	GP-GW	78.0	22.0	0.0	NP*	NP*	NP*
Material Type	Flex Base TYA GR6		Material Source		Arnold Crushed Stone		

* Non Plastic.

Lab No.	02-96-364
Charge No.	70-72-797393170-807
County	Fort Worth District Laboratory
Control	7-931 (In-House Research)

NOTE: The stockpile was batched based on particle size using 1-3/4", 1-1/2", 1", 1/2", No. 4, No. 8, No. 30 and No. 200 sieves. Bulk samples for both gradations were prepared by mixing particle sizes in proportions shown in the graph.

DE97-005

FIGURE 1

TABLE 1

TRIAXIAL TEST SUMMARY SHEET

CRUSHED STONE FLEX BASE

Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA GR6 Charge No.: 70-72-797393170-807

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 2)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3

TEXAS TRIAXIAL CLASS 2.5

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	7.8	118.9	10	7.7	118.3	0	33.1	2.0	0.5
2	6.8	117.8	10	8.0	117.5	3	55.3	2.4	0.3
3	8.0	118.6	10	8.2	117.4	5	80.6	3.9	1.0
4	8.0	119.1	10	7.9	117.9	7	93.4	2.8	1.0
5	7.9	119.3	10	8.1	119.0	10	123.4	2.9	0.2
6	7.8	118.6	10	8.1	117.7	15	128.7	3.9	0.8
7	6.8	118.1	10	8.0	117.6	0	38.0	2.0	0.4

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E.

DE97-005 FIGURE 2

TERRA-MAR, INC.

STRESS-STRAIN DIAGRAM
CRUSHED STONE FLEX BASE

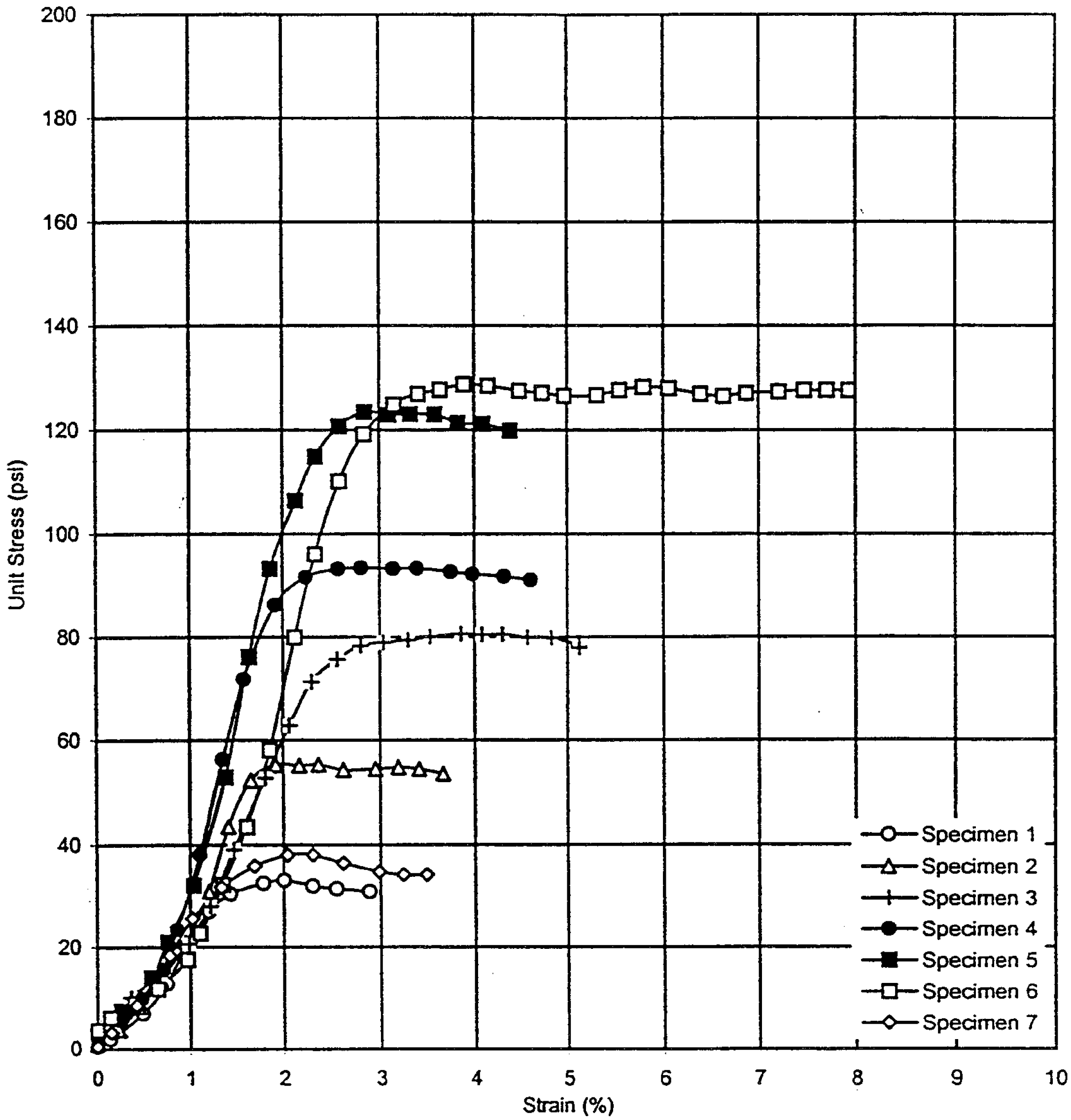
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 2)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	3	5	7	10	15	0

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

DE97-005 **FIGURE A-1**

TERRA-MAR, INC.

MOHR'S FAILURE ENVELOPE

CRUSHED STONE FLEX BASE

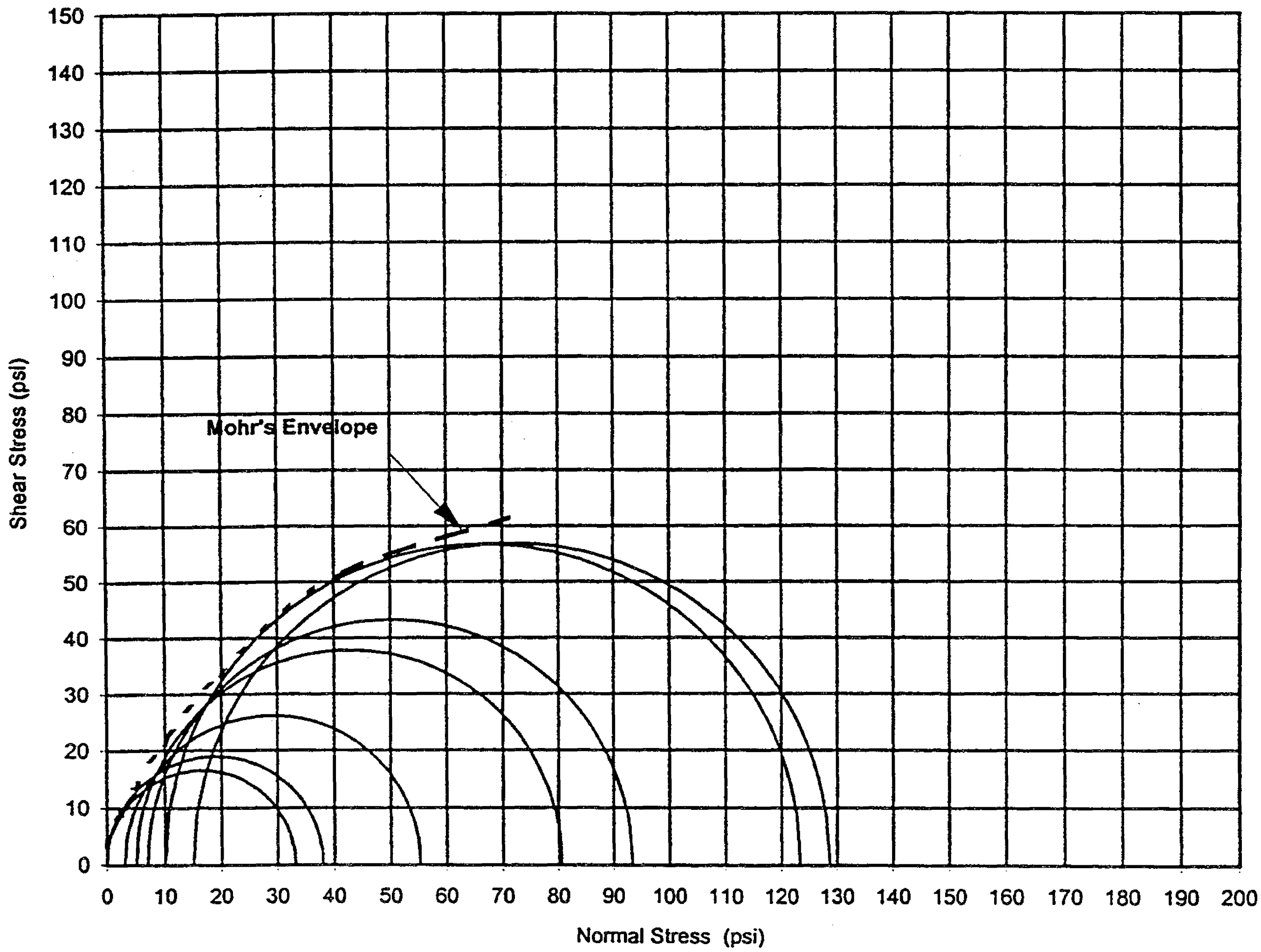
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 2)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



DE97-005

FIGURE A2

TERRA-MAR, INC.

TEXAS TRIAXIAL CLASS EVALUATION
CRUSHED STONE FLEX BASE

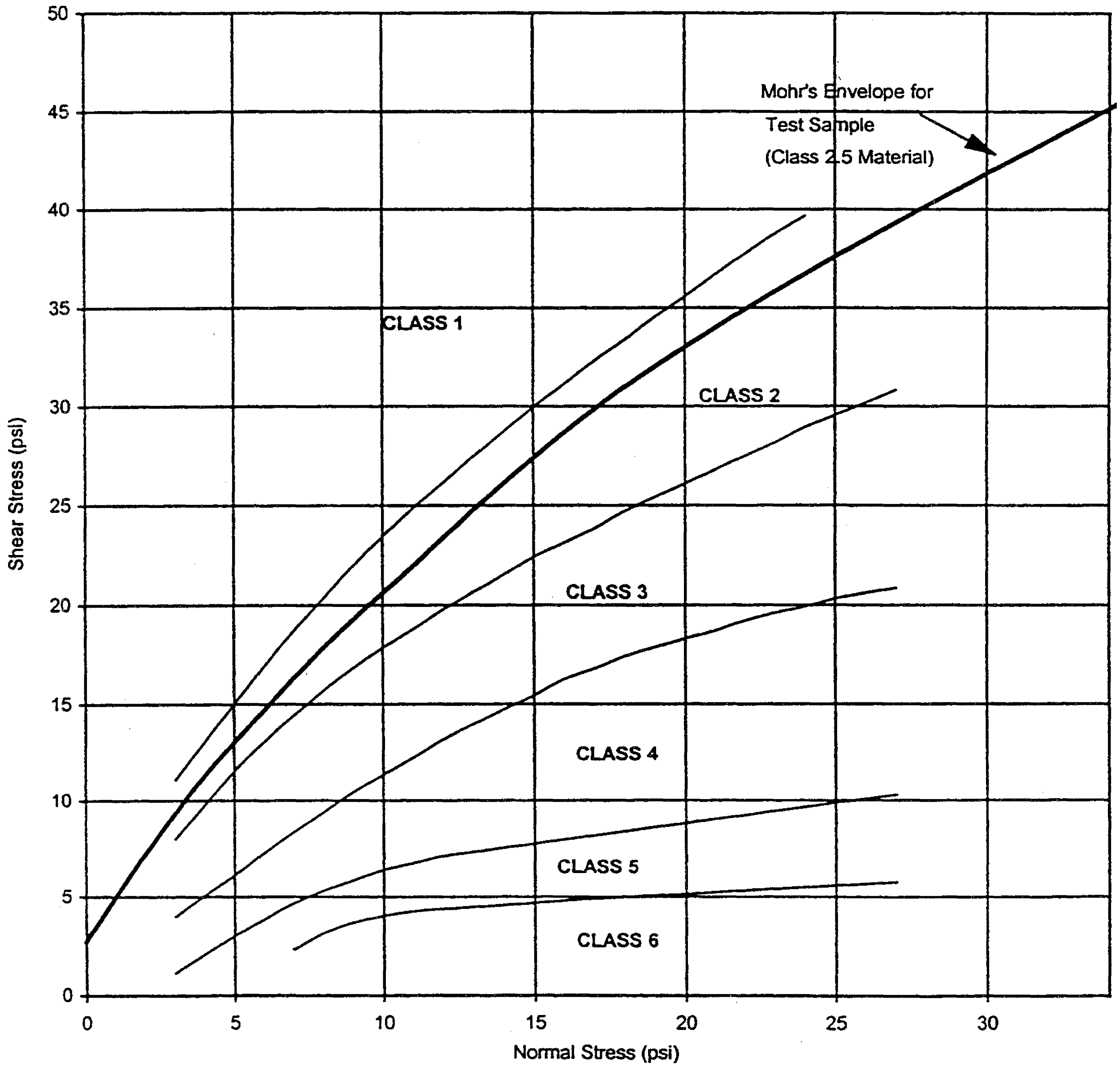
Lab No.: 02-96-364 County: Fort Worth District Lab Project: 7-3931; In-House Research

Material Type: Flex Base TYA, GR6 Charge No.: 70-72-797393170-807

Material Source: Arnold Crushed Stone - Blum Pit

Description: Tan Crushed Stone (LL= 19, PI= 2)

All Specimens Molded at a Compactive Effort of 13.3 ft-lb/in^3



DE97-005

FIGURE A-3

QUESTION – ANSWER PORTION OF MEETING WITH AGGREGATE PRODUCERS

CRUSHED STONE FLEXIBLE BASE

CURRENT AND PROPOSED DISTRICT ITEM 247, TY.A, GR. 6 GRADATION

PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931 (IN-HOUSE RESEARCH)

Question-Answer Portion of Meeting
with Aggregate Producers;
Research Project 7-3931

1. Using TxDOT Maximum Density Line? (Andrew)
   No. Using ASTM.

2. Do we have the compressive strength data? (Erv-Vulcan)
   Yes. Will show you later.

3. How does this compare with the other grades in Item 247? (Andrew)
   They straddle the MDL. Grades 1 & 2 are coarser. All grades 1-4 have other requirements which we usually do not consider.

4. What is the goal of the new specification in terms of performance? (Erv)
   To increase the triaxial strength of the base and narrow the gap between the high and low values. We expect the base to last longer.

5. Not having a problem, just a better product? (Neil Young) Western Rock
   Actually having structural problems from PMIS evaluation.

6. Any shrinkage limit or PI data? (Erv)
   Any differences in PI between the pits?
   - S.L. - No
   - P.I. - Yes
   - Diff. - No

7. What was the standard deviation on each of the sizes? (Erv)
   We did not run any statistical data.
   A. Slope will change when maximum aggregate size increases.
   B. ½" sieve will usually contain a ± 6% deviation. This is tight to try to stay within.

8. What is the ODOT gradation band? (Andrew)
   We did not get it.

9. Would it be better to just use the high side nos. but no minimum requirement? What would we likely get? (George)
   A coarse graded base. The producers would try to keep it as coarse as possible. It would depend on how much we would want to spend. We may need to keep a minimum to keep the base somewhat dense graded and remove the need for filter material between the subgrade and the base.

10. Have we looked at the gradations from the 1950's? (Andrew)
    No.

11. How much <200 material are we getting with the current gradation? (Neil)
    From the first graph, 18% - 28%.

12. What are the PI limits going to be? (Tommy - Pioneer)
    Will remain 4-12.
    Will it meet if the <200 is taken out? (Neil)
    Probably not. May need to remove the lower limit.

13. What density will we get? (Neil)
    We expect to get the same.

14. Which is more important in the flex base? Narrower band width or less fines? (George to Andrew)
    Less fines.

15. Has anyone produced Gr.1 or Gr.2? (George)
    Yes. Several have, but for other districts.

16. Is the Gr.1 & 2 cheaper or more expensive than the Gr.6?
    The Gr.1 & 2 are cheaper.

17. Are they meeting the triaxial requirements?
    Some are. Mainly the Gr.2.

18. If the cost were maintained at the current amount for Gr.6, what could be done to the gradation proposal? (Richard)
    Nothing. The use of larger aggregate size would probably not offset the cost of getting rid of the <200. This is the major problem.

19. How much would the cost be increased? (Andrew)
    Not a fair question without allowing the producers to go back and look at the needed changes at the plant.

20. Will there be any follow-up information coming out from this meeting?
    We will probably send out information sometime in the next 2-3 months.

21. Will we be looking at the construction methods as well?
    Need to have construction inspectors do a better job of enforcement. (This question was in reference to variations in Density over the thickness of the Flex Base material.)

RESULTS OF TEXAS TRIAXIAL TEST

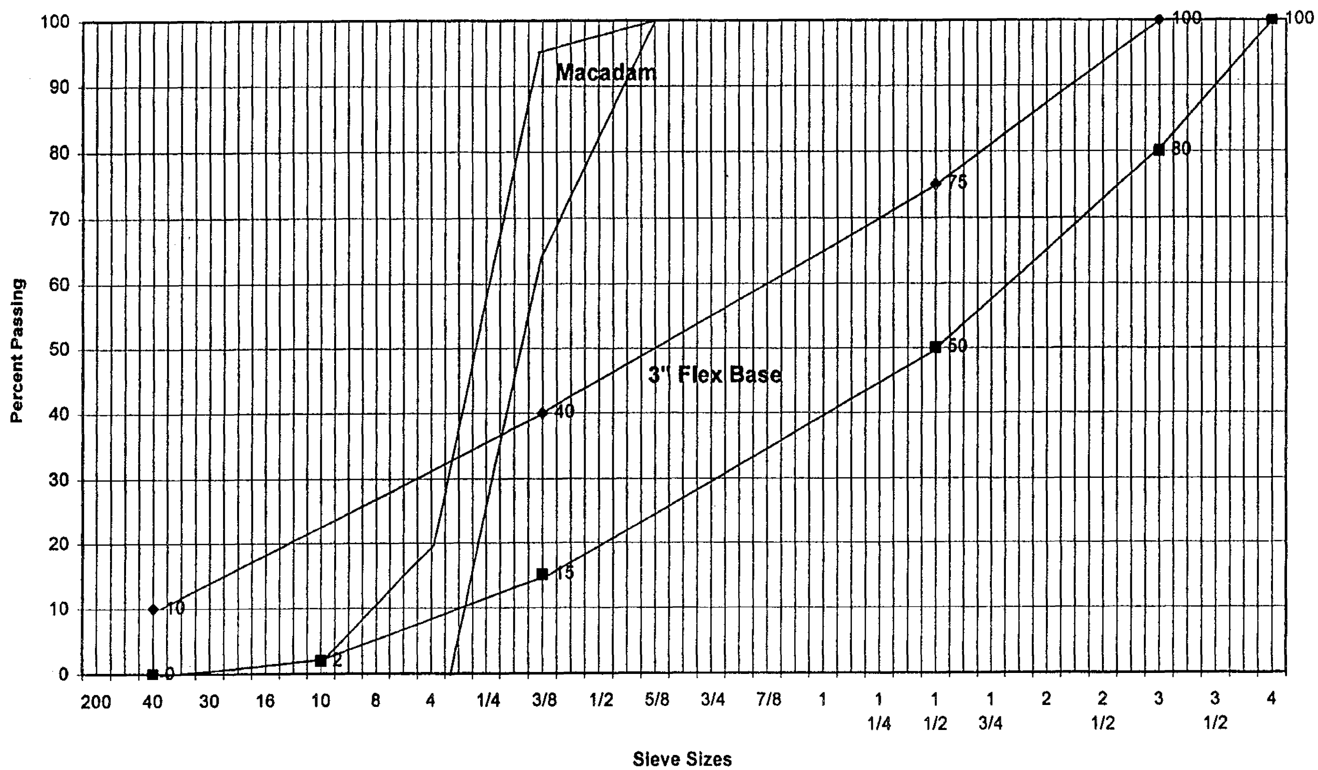
CRUSHED STONE FLEXIBLE BASE

ACTUAL CONSTRUCTION GRADATION

PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

.45 Power Gradation Chart



Sieve (mm)	% Passing
16.0	100
9.5	65-95
4.75	0-20
2.00	0- 5

Adding to, or enriching the fraction passing 0.425 mm (#40) is prohibited.

Sieve (mm)	% Passing	Sieve (")
102	100%	4
76	80-100	3
38	50- 75	1.5
9.5	15- 40	3/8
0.425	0- 10	#40

TRIAXIAL TEST SUMMARY SHEET

Texas Triaxial - TEX-117-E

Project: Big Stone Flexible Base Testing **Work Order:** 02-99-934 **TMI No.:** FE96-032-01

Location: Pioneer, Bridgeport, Texas

Client: Texas Department of Transportation, Fort Worth District Laboratory

Material Use and Source: Roadway Flexible Base, Bulk Sample

Optimum Moisture: 138.1 pcf Liquid Limit: NP

Maximum Dry Density: 6.4 % Plasticity Index: NP

Specimen No.	When Molded		Capillary Moisture Time, days	After Capillarity		Applied Lateral Pressure (psi)	*Ultimate Compressive		Volumetric Swell (%)
	w (%)	γ_d (pcf)		w (%)	γ_d (pcf)		Strength (psi)	Strain (%)	
1	5.4	137.3	2	4.8	134.6	0	56.2	2.7	2.0
2	4.5	137.6	1	5.2	137.5	0	82.7	2.8	0.1
3	7.7	131.9	1	4.8	128.5	3	125.1	4.9	2.7
4	5.5	132.9	1	4.8	131.0	5	100.6	6.0	1.4
5	6.4	135.0	1	4.3	133.1	10	219.7	6.2	1.4
6	4.5	138.0	1	3.7	135.3	15	253.4	4.2	2.0
7	4.5	139.8	1	5.3	136.2	20	322.1	3.4	2.6

Gradation Specifications & Results		
Sieve Size	Specified % Passing	Actual % Passing
4"	<100	100
3"	80 - 100	99
1-1/2"	50 - 75	70
3/8"	15 - 40	54**
#40	0 -10	9

Texas Triaxial Class
1.0

* Ultimate compressive strength was recorded as peak stress at failure or stress corresponding to 7.5% strain, whichever occurred first, as per Tex-117-E.

** Does not meet project specifications.

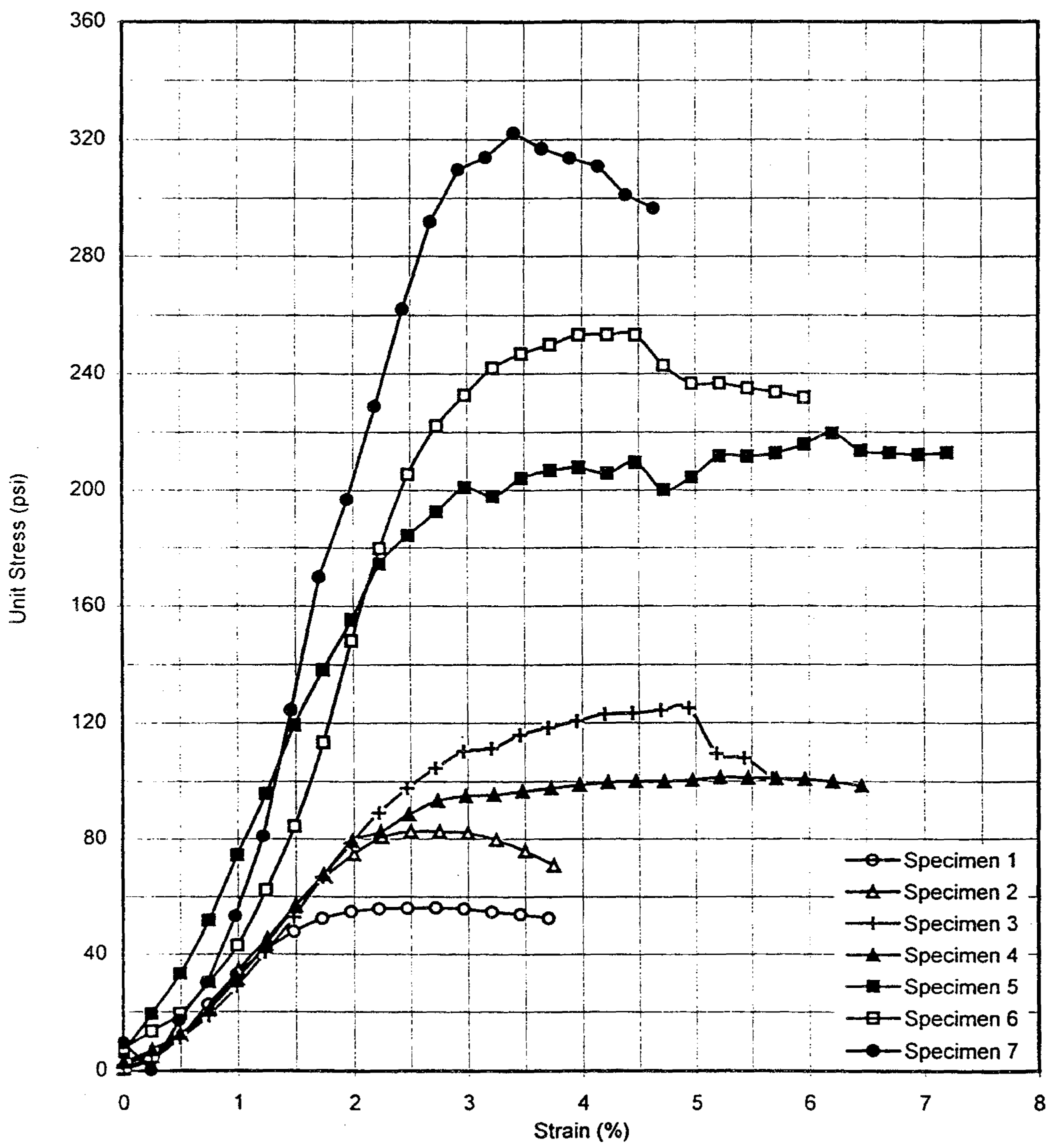
Note: Tested in accordance with Tex-117-E, Part II-D

FIGURE 1

STRESS-STRAIN DIAGRAM

Texas Triaxial Test - TEX-117-E

Project: Big Stone Flexible Base Testing **Work Order**: 02-99-934 **TMI No.**: FE96-032-01
Location: Pioneer, Bridgeport, Texas
Client: Texas Department of Transportation, Fort Worth District Laboratory
Material Use and Source: Roadway Flexible Base, Bulk Sample



Specimen No.	1	2	3	4	5	6	7
Lateral Pressure (psi)	0	0	3	5	10	15	20

Note: A compressive stress was recorded at zero strain due to (1) weight of porous stone & bell housing, and (2) compressive stress induced by applying lateral pressure while restraining the specimen to read zero strain prior to shearing the specimen.

FIGURE 2

TERRA-MAR, INC.

MOHR'S FAILURE ENVELOPE

Texas Triaxial Test - TEX-117-E

Project: Big Stone Flexible Base Testing **Work Order**: 02-99-934
TMI Project No: FE96-032-01
Location: Pioneer, Bridgeport, Texas
Client: Texas Department of Transportation, Fort Worth District Laboratory
Material Use and Source: Roadway Flexible Base, Bulk Sample

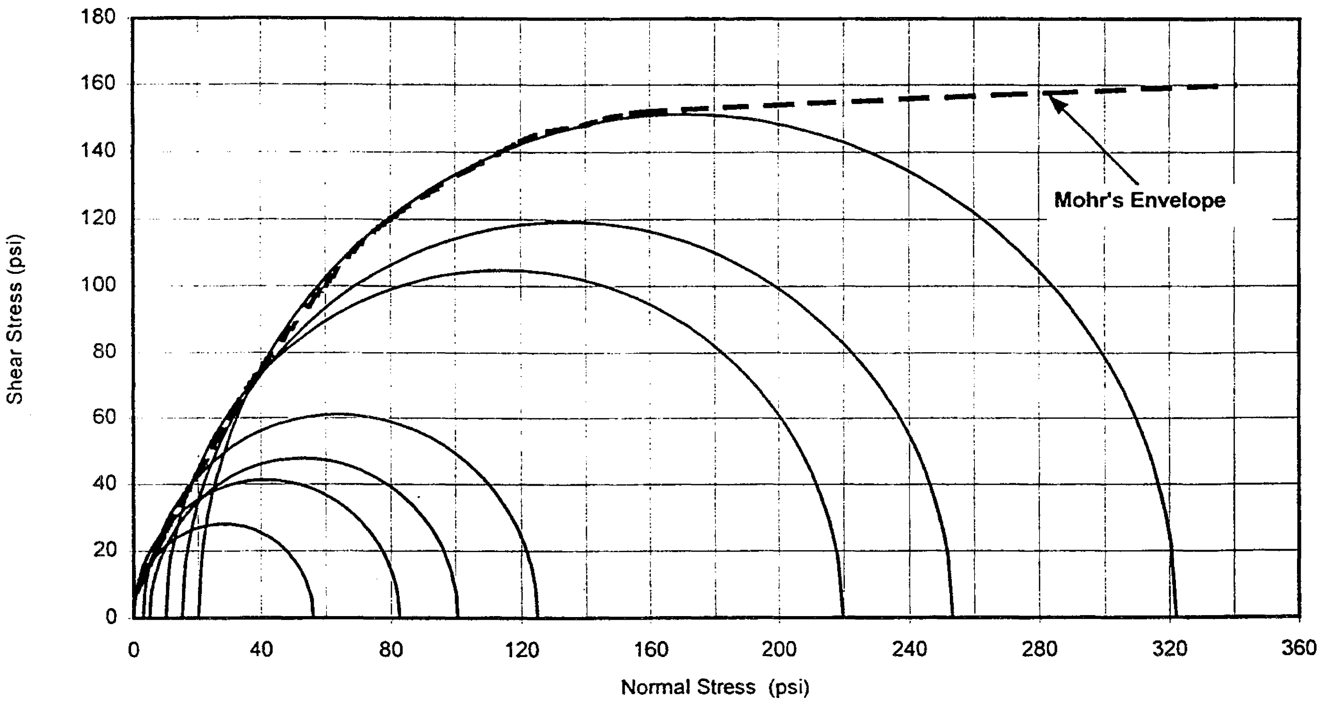


FIGURE 3

TEXAS TRIAXIAL CLASS EVALUATION

Texas Triaxial Test - TEX-117-E

Project: Big Stone Flexible Base Testing **Work Order**: 02-99-934 **TMI No.**: FE96-032-01

Location: Pioneer, Bridgeport, Texas

Client: Texas Department of Transportation, Fort Worth District Laboratory

Material Use and Source: Roadway Flexible Base, Bulk Sample

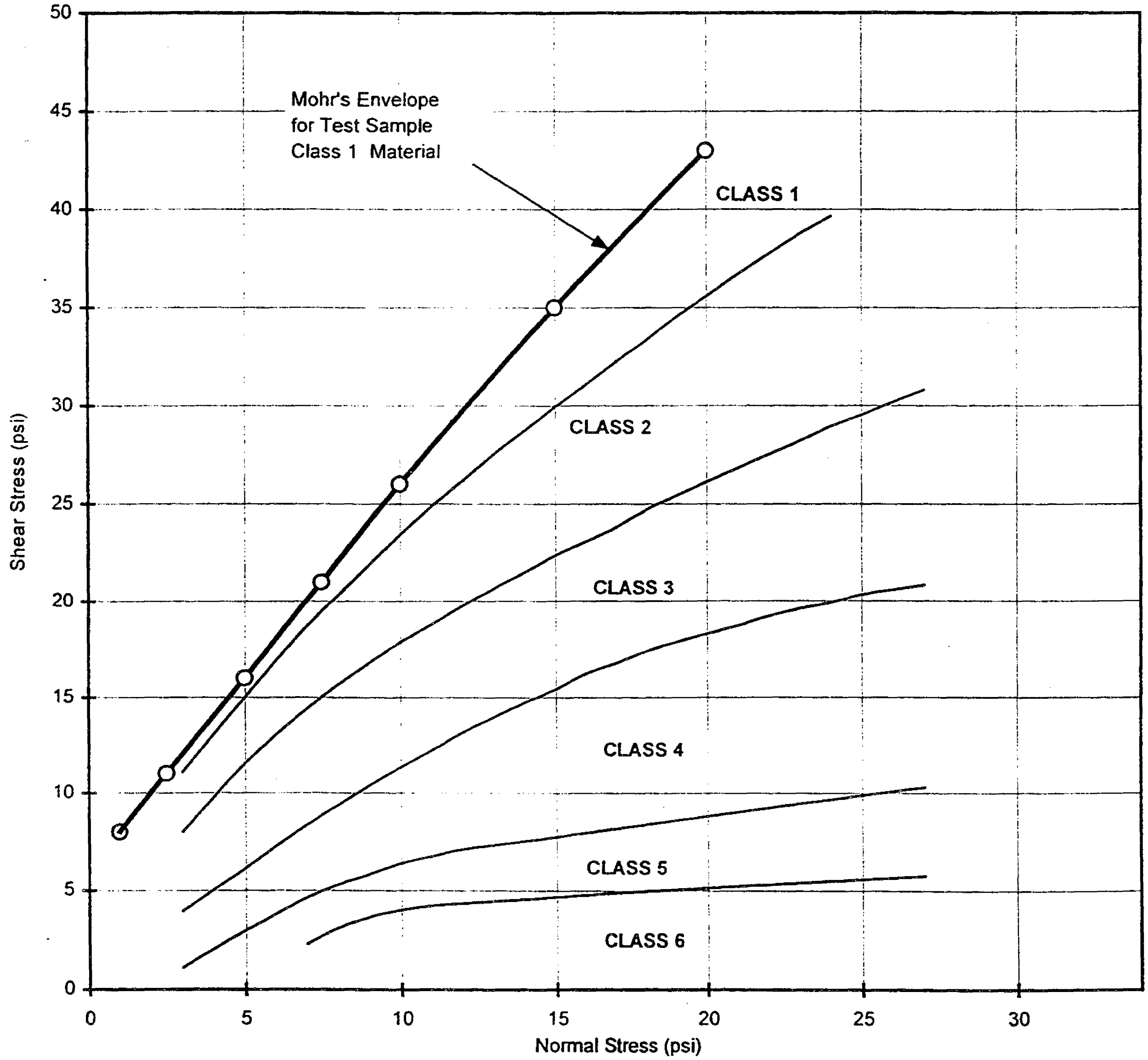


FIGURE 4

GRAIN SIZE DISTRIBUTION TEST REPORT

Test Method - TEX-110-E

Project: Big Stone Flexible Base Testing **Work Order:** 02-99-934 **TMI No.:** FE96-032-01
Location: Pioneer, Bridgeport, Texas
Client: Texas Department of Transportation, Fort Worth District Laboratory
Material Use and Source: Roadway Flexible Base, Bulk Sample

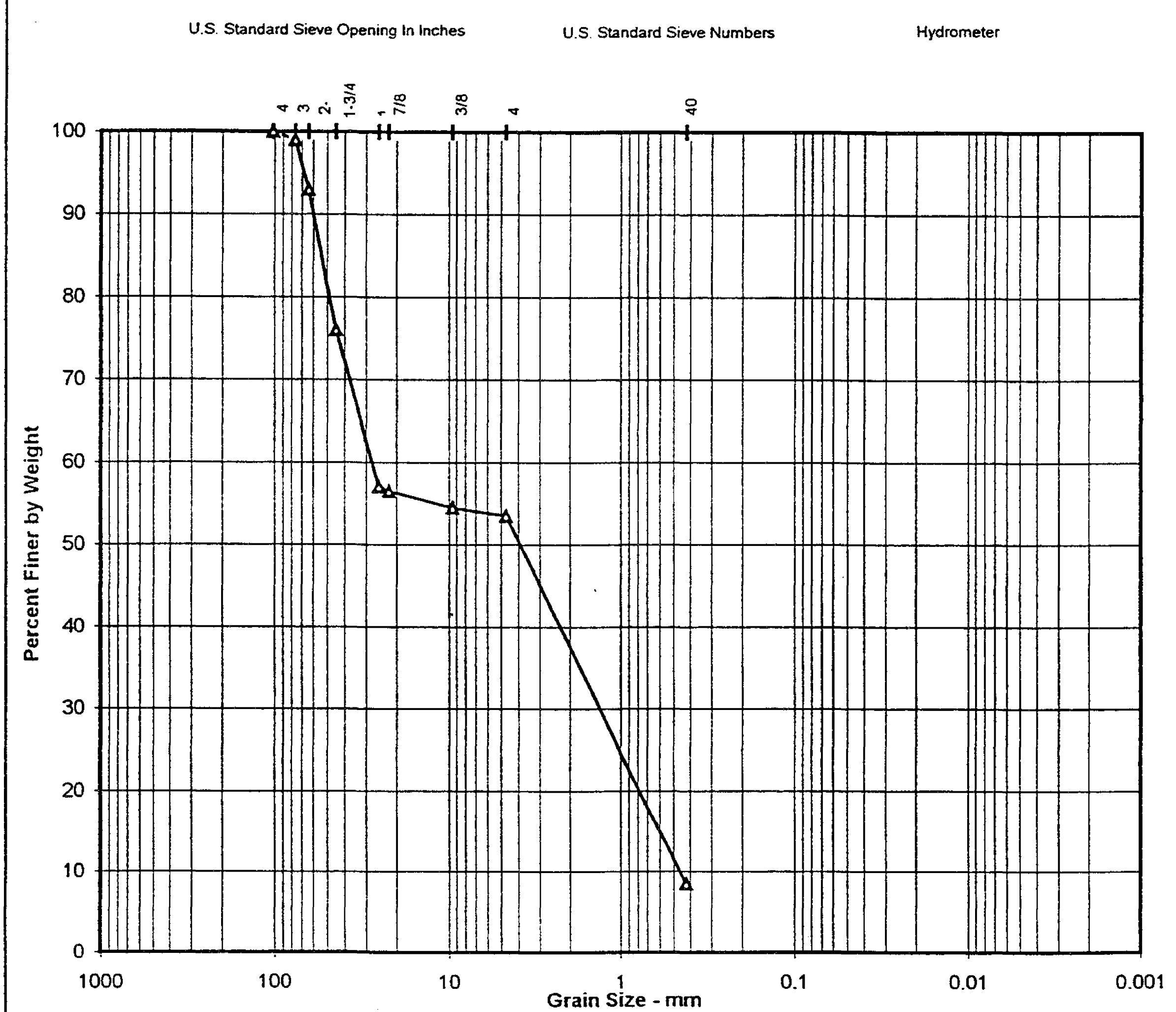


FIGURE 5

RESULTS OF STIFFNESS GAUGE TEST

CRUSHED STONE FLEXIBLE BASE

ACTUAL CONSTRUCTION GRADATION

PIONEER-BRIDGEPORT

RESEARCH PROJECT 7-3931
(IN-HOUSE RESEARCH)

station	stif 1	stif 2	stif 3	stif 4
1920	19.6	16.46	19.58	8.82
1880	14.91	10.99	12.66	12.77
1840	16.43	10.17	14.5	9.49
1800	12.3	11.82	10.29	12.73
1760	10.3	19.5	14.9	8.97
1720	10.17	11.31	15.31	10.4
1680	23.4	12.95	18.87	5.15
1640	12.24	11.25	21.02	11.9
1600	9.54	14.45	12.8	8.86
1560	9.5	12.88	10.3	10
1520	16.44	16.6	16.8	20.63
1480	14.08	16.79	19.6	18.66
1440	16.27	19.58	16.53	19.45
1400	12.8	23.19	21.03	15.2
	4.183034	14.34179	0.291668	
4080	17.5	22.55	17.58	
4160	18.39	38.98	25.12	
4240	32.98	29.08	26.56	
4310	38.18	19.64	27.72	
	7.580258	26.19	0.289433