San Antonio Street (Walnut Ave to Academy Ave)

Pavement Engineering Report

May 13, 2024 | Terracon Project No. 90231414

Prepared for:

City of New Braunfels
550 Landa Street
New Braunfels, Texas 78130

Terracon

6000 Northwest Parkway, Ste.100
San Antonio, TX 78249
P (210) 641-2112
Terracon.com

May 13, 2024

City of New Braunfels
550 Landa Street
New Braunfels, Texas 78130

Attn: Mr. Nathan Garza
P: 830-221-4082
E: ngarza@newbraunfels.gov

Re: Pavement Engineering Report
San Antonio Street (Walnut Ave to Academy Ave)
City of New Braunfels, Texas
Terracon Project No. 90231414

Dear Mr. Garza:

We have completed the scope of Pavement Engineering services for the above referenced project in general accordance with Terracon Proposal No. P90231414 dated September 9th, 2023. We appreciate the opportunity to work with you on this project and look forward to contributing to the ongoing success of this project with Materials Testing services during construction. Should there be any questions, please do not hesitate to contact our office.

Sincerely,

Terracon

Yash Menaria, P.E.
Senior Staff Engineer

Yatish A. Jakatimath, P.E.
Department Manager

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Attachments

Introduction

This report presents the results of our subsurface exploration and Pavement Engineering services performed for the proposed San Antonio Street from Walnut Ave to Academy Ave in the City of New Braunfels (CoNB) City of New Braunfels, Texas. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Pavement design and construction

The geotechnical engineering scope of services for this project included the advancement of six (6) test borings to depths 10 feet below existing site grades.

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	This report was developed based on the information provided by Mr. Nathan Garza and Mr. Scott McClelland with City of New Braunfels in the email received on August 29, 2023 ▪ San Antonio Street Maintenance Project Plans.pdf
Project Description	The project includes roadway reconstruction program of San Antonio Street from Walnut Ave to Academy Ave. Flexible pavement design options are being considered per City's request
Roadway Construction	Proposed plan is to reconstruct the existing roadway to match existing elevations.

Item	Description
Traffic Loads	The proposed reconstruction of San Antonio Street is to be designed based on City of New Braunfels specifications and classified to be designed as Minor Arterial.
Grading/Slopes	The roadway will be constructed at or near existing grades.

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at San Antonio Street from Walnut Ave to Academy Ave. (See Exhibit D) See **Site Location**
Existing Improvements	Existing asphalt roadway
Current Ground Cover	Asphalt pavement

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Layer Name	General Description
Asphalt Section	2 to 3 inches thick

Cement Treated Existing Material	5 to 6 inches thick
Base Material Section	2 to 3 inches thick
Lean Clay (CL)	Yellow to Reddish Yellow; stiff
Fat Clay (CH)	dark brown to brown; medium stiff to hard

Groundwater

Groundwater generally appears as either a permanent or temporary water source. Permanent groundwater is generally present year-round, which may or may not be influenced by seasonal and climatic changes. Temporary groundwater water is also referred to as a "perched" water source, which generally develops as a result of seasonal and climatic conditions.

The borings were advanced using dry drilling techniques to their full depths in an attempt to observe for the presence of subsurface water. Groundwater was not observed. Groundwater levels are influenced by seasonal and climatic conditions which generally result in fluctuations in the elevation of the groundwater level over time. Therefore, the contractor should check the groundwater conditions just before excavation activities.

Geotechnical Overview

The borings were drilled along San Antonio Street. The soil borings encountered Lean and Fat Clay below the existing site grades.

The following recommendations are based upon the data obtained from our field and laboratory programs, project information provided to us and on our experience with similar subsurface and site conditions.

The recommendations, comments and suggestions in this report are provided so project drawings, documents, and specifications can be prepared and to make certain the intent of our design recommendations are achieved. Details regarding excavation, dewatering, selection of equipment/machinery, trafficability, project site safety, shoring, and other similar construction techniques requiring "means and methods" to accomplish the work is the sole responsibility of the project contractor. The contractor is responsible for development of an excavation plan, which will meet all state and federal requirements with regard to trench safety. Our comments and opinions do not relieve the contractor's responsibility to establish and maintain all aspects of site safety.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Prior to construction, all pavement material and any otherwise unsuitable materials should be removed from the construction area. Wet or dry material should either be removed, or moisture conditioned and recompacted. Construction operations may encounter difficulties due to the wet or soft surface soils becoming a general hindrance to equipment due to rutting and pumping of the soil surface, especially during and soon after periods of wet weather. If the subgrade cannot be adequately compacted to minimum densities as described in the **Compaction Requirements** section of this report, one of the following measures may be required:

- removal and replacement with select fill;
- chemical treatment of the soil to dry and increase the stability of the subgrade; or
- drying by natural means if the schedule allows.

In our experience with similar soils in this area, chemical treatment (such as hydrated lime) may be an effective method to increase the supporting value of wet and weak subgrade. Chemical treatment is discussed in the **Pavement Section Materials** section of this report.

Proper site drainage should be maintained during the entire construction phase so ponding of surface runoff does not occur and cause construction delays and/or inhibit site access, particularly in cut areas. During construction, it is possible that the subgrade soils may become excessively wet as a result of inclement weather conditions. When the moisture content of these clay soils elevates above what is considered to be the optimum range of moisture for compaction operations, they can become difficult to handle and compact. If such conditions create a hindrance to compaction operations and/or site access, chemical treatment of these soils should be considered to improve their workability and expedite construction.

Fill Placement and Compaction Requirements

Structural/Select fill and general fill should meet the following compaction requirements.

Item	Description
Fill/Base Lift Thickness	All fill should be placed in thin, loose lifts of about 8 inches, with compacted thickness not exceeding 6 inches

Item	Description
Compaction of Soil	95 percent of the material's maximum dry density (Tex-114-E)
Moisture Content of Soil	The materials should be moisture conditioned between 0 and +4 percentage points of the optimum moisture content.
Flowable Fill	To be used where compaction of soil is not possible due to depths of the excavation such as around manholes/utilities. Width of flowable fill around manholes shall be minimum 18 inches.

Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Based upon the subsurface conditions determined from the field exploration, subgrade soils exposed during construction are anticipated to be relatively stable. Temporary dewatering may be required if large amounts of water is encountered during excavation.

Grading and Drainage

All grades must provide effective drainage away from the pavement and below grade structures during and after construction and should be maintained throughout the life of the structure. Water retained next to the structure can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential foundation movements.

Pavements

Based on the provided information, the proposed reconstruction of San Antonio Street can be classified as a City of New Braunfels "Minor Arterial". The pavement sections presented on this report are based on the indicated street classifications and on the pavement design guidelines included in the CONB Street Design Guide (March, 2021). If this information changes, Terracon should be contacted to review and revise our recommendations as appropriate.

Pavement Subgrade Preparations

Prior to construction, existing pavements should be removed. After the exposed subgrade should be proof rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a 15-ton roller or fully loaded dump truck. Wet, soft, low-density or dry material should either be removed, or moisture conditioned and recompacted to the moisture contents and densities described in section **Compaction Requirements** prior to placing fill. Trench proof-rolling can be done by robotic compaction equipment or hand tamping if less than 4 feet in depth.

Design Parameters

Flexible pavement design parameters for CoNB Minor Arterial Streets are presented below,

Minor Arterial Street

Design Parameters	Flexible
Initial ADT (vehicles)	11,500
Final ADT (vehicles)	25,000
Growth Rate	4.0%
% Truck	9.0%
# of Lanes	4.0
Directional Distribution	0.5
Lane Distribution	0.8
Initial Serviceability Index	4.2
Terminal Serviceability Index	2.5
Confidence %	95.0
Design Lane ESAL	4,000,000

Design Recommendations

The following table provides the pavement layer thickness option after discussion with the City of New Braunfels personnel for San Antonio Street classified as Minor Arterial Street.

Option 1: Hot Mix Asphalt over Flex Base

FLEXIBLE PAVEMENT SECTION – MINOR ARTERIAL STREET (INCHES)	
Layer	**Thickness**
Hot Mix Asphaltic Concrete (HMAC) Surface (Type D)	2.0
Underseal TxDOT SS 3085 (AC-15P, AC-20-5TR, AC-20XP, AC-10-2TR), Aggregate Item 302 Grade 4 Type PB	0.23 gal/sy.
Hot Mix Asphaltic Concrete (HMAC) Base (Type B) (2 lifts)	8.0
Prime Coat (MS-2 or CSS-1H) assuming no traffic to be allowed on prime coat	0.30 gal/sy.*
Flexible Base	6.0
Geogrid Tensar HX 5.5	---
Moisture Conditioned Subgrade	6.0

*If MC-30 or AE-P is used for prime coat, it could be placed at a rate of 0.20 gal/sy.

Option 2: Hot Mix Asphalt over Lime Treated Subgrade

FLEXIBLE PAVEMENT SECTION – MINOR ARTERIAL STREET (INCHES)	
Layer	**Thickness**
Hot Mix Asphaltic Concrete (HMAC) Surface (Type D)	2.0
Tack Coat PG Binders, CSS 1H, SS-1H (Temp>50F)	0.15 gal/sy.
Hot Mix Asphaltic Concrete (HMAC) Base (Type B) (2 lifts)	6.0
Prime Coat (MS-2 or CSS-1H) assuming no traffic to be allowed on prime coat	0.30 gal/sy.*
Lime Treated Subgrade (8.0% lime)	8.0
Moisture Conditioned Subgrade	6.0

*If MC-30 or AE-P is used for prime coat, it could be placed at a rate of 0.20 gal/sy.

Option 3: Hot Mix Asphalt only

FLEXIBLE PAVEMENT SECTION – MINOR ARTERIAL STREET (INCHES)	
Layer	**Thickness**
Hot Mix Asphaltic Concrete (HMAC) Surface (Type D)	2.0
Tack Coat PG Binders, CSS 1H, SS-1H (Temp>50F)	0.15 gal/sy.
Hot Mix Asphaltic Concrete (HMAC) Base (Type B) (3 lifts)	14.0
Prime Coat (MS-2 or CSS-1H) assuming no traffic to be allowed on prime coat	0.30 gal/sy.*
Moisture Conditioned Subgrade	6.0

*If MC-30 or AE-P is used for prime coat, it could be placed at a rate of 0.20 gal/sy.

Other Construction Considerations

The pavement sections have been designed using generally recognized structural coefficients for the pavement materials. These structural coefficients reflect the relative strength of the pavement materials and their contribution to the structural integrity of the pavement. If the pavement does not drain properly, it is likely that ponded water will infiltrate the pavement materials resulting in a weakening of the materials as previously discussed. As a result, the structural coefficients of the pavement materials will be reduced, and the life and performance of the pavement will be shortened. The Asphalt Institute recommends a minimum of 2 percent slope for asphalt pavements. The importance of proper drainage cannot be overemphasized and should be thoroughly considered by the project team.

Proper perimeter drainage is very important and should be provided so infiltration of surface water from unpaved areas surrounding the pavement is minimized. Water can migrate through the untreated coarse aggregate base material (i.e. where used in flexible pavements) and into the subgrade.

Pavement Section Materials

Presented below are selection and preparation guidelines for various materials that may be used to construct the pavement sections. Submittals should be made for each pavement material. The submittals should be reviewed by the Geotechnical Engineer and appropriate members of the design team and should provide test information necessary to verify full compliance with the recommended or specified material properties.

- **Hot Mix Asphaltic Concrete Surface Course -** The asphaltic concrete surface course should be plant mixed, hot laid Type C or D surface. The asphaltic concrete base course should also be plant mixed, hot laid Type B. Each mix should meet the master specifications requirements of 2014 TxDOT

Standard Specifications SS 3076 and specific criteria for the job mix formula. The mix should be compacted between 92 and 97 percent of the maximum theoretical density as measured by TEX-227-F. The asphalt cement content by percent of total mixture weight should fall within a tolerance of ±0.3 percent asphalt cement from the specific mix. In addition, the mix should be designed so 75 to 85 percent of the voids in the mineral aggregate (VMA) are filled with asphalt cement. The grade of the asphalt cement should be PG 64-22 or higher performance grade. Aggregates known to be prone to stripping should not be used in the hot mix. If such aggregates are used measures should be taken to mitigate this concern. The mix should have at least 70 percent strength retention when tested in accordance with TEX-531-C.

Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method TEX-207-F. The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from project pavement specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required pavement specimens at their expense and in a manner and at locations selected by the Engineer.

- **Flexible Base Material -** Base material may be composed of crushed limestone base meeting all the requirements of 2014 TxDOT Item 247, Type A, Grade 1-2; including triaxial strength. The material should be compacted to at least 98.0 percent of the maximum dry density as determined in accordance with Tex-113-E at moisture contents ranging from -2 and +3 percentage points of the optimum moisture content.

- **Flowable Fill –** Refer to TxDOT Item 401

- **Geogrid –** Place Tensar HX5.5 grade as per CoNB guidelines.

- **Prime Coat –** Per Item 301, prepare the surface by sweeping or other approved methods. Lightly sprinkle the surface with water before applying bituminous material, when directed, to control dust and ensure absorption. Apply material within 15 F of the selected temperature but do not exceed maximum allowable temperature. When allowing traffic, spread blotter material (base course sweepings or native sand on applied prime coat). Type of material shall follow TxDOT Item 300.

- **Underseal –** Refer to TxDOT SS 3085

- **Lime Treated Subgrade -**The subgrade may be treated with hydrated lime in accordance with TxDOT Item 260 in order to improve its strength and improve its load carrying capacity. We recommend 8 percent hydrated lime will be required. This is equivalent to about 30 pounds of hydrated lime per square yard for a 6-inch treatment depth. The optimum lime content should result in a soil-lime mixture with a pH of at least 12.4 and should reduce the Plasticity Index to 20 or less.

  The lime should initially be blended with a mixing device such as a Pulvermixer, sufficient water added, and be allowed to cure for at least 48 hours. After curing, the lime-soil should be remixed to meet the in-place gradation requirements of Item 260 and compacted to at least 95 percent of the maximum dry density. The target lime content and optimum moisture content should be determined in accordance with Tex-113-E TxDOT procedure.

- **Moisture Conditioned Subgrade** - The subgrade should be scarified to a depth of 6 inches and then moisture conditioned between 0 and +4 percentage points of the optimum moisture content and then compacted to at least 95 percent of the maximum dry density determined as per Tex-114-E.

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

This report should be provided in its entirety to the key members of the design team, namely the Architect, Civil Engineer, and Structural. In addition, the MEP engineer, the Landscape Architect, and others should be provided a copy as there may be geotechnical recommendations included herein related to their services.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
B-1, B-2, B-3, B-4, B-5, B-6	10	San Antonio Street

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advance soil borings with a truck-mounted drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Five samples are obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling is typically performed using thin-wall tube and/or split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. The samples are placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. In addition, we observe and record groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

Our exploration team prepares field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory tests.

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

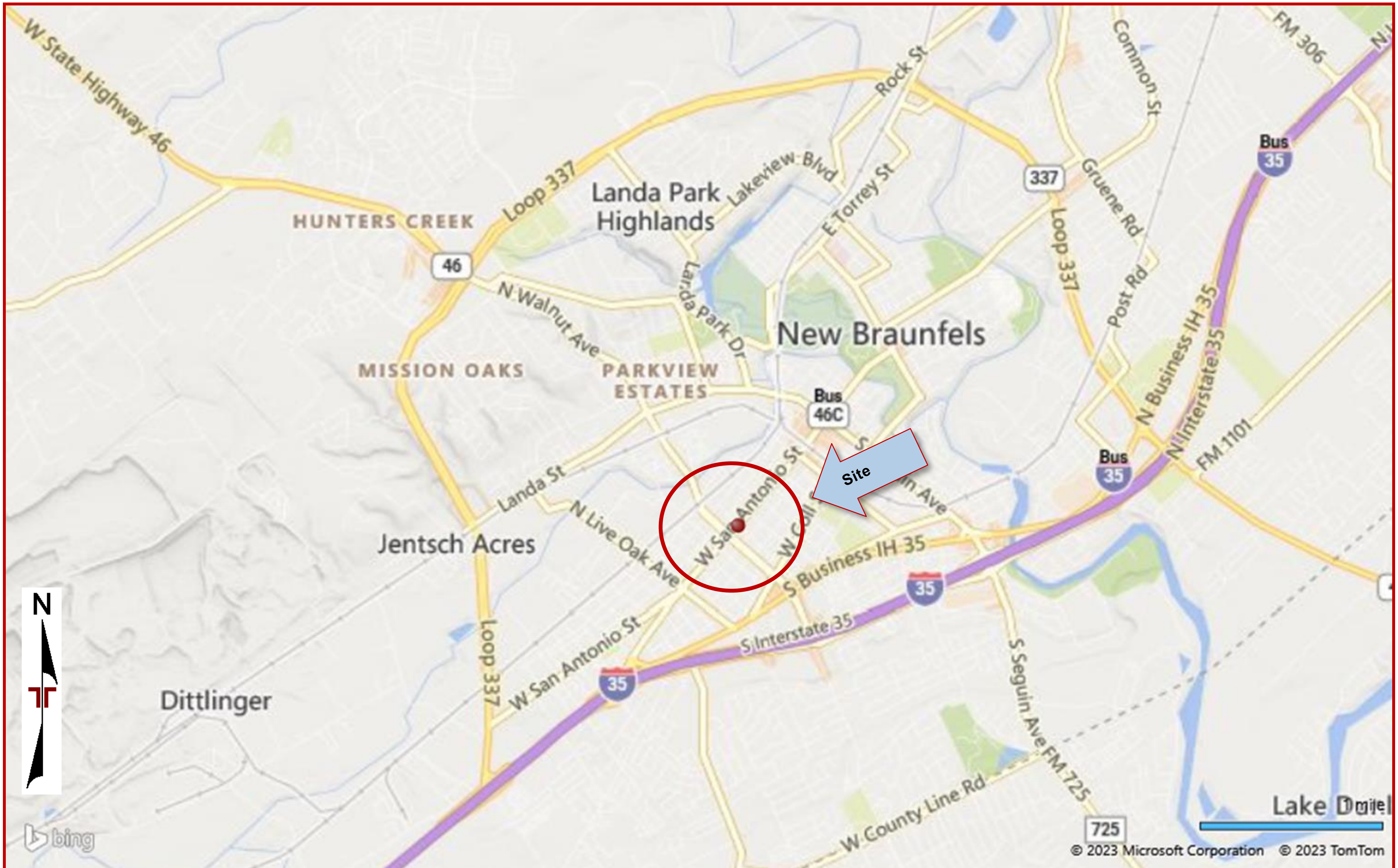


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

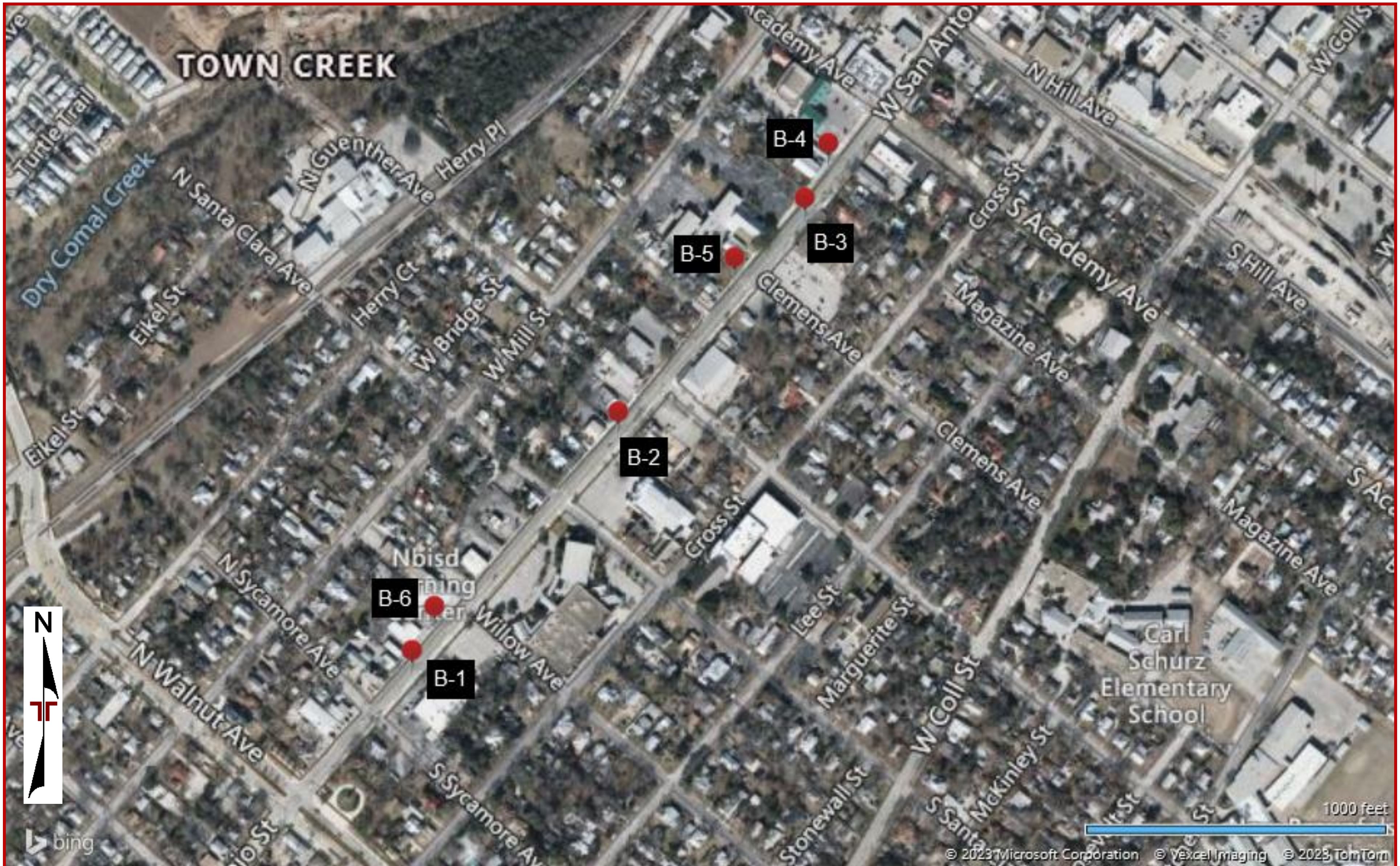


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Exploration and Laboratory Results

Contents:

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 29.6946° Longitude: -98.1326°

Depth (Ft.)	Description	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
0.5	**ASPHALT: 6.5 Inches thick**				
1.6	**UNTREATED BASE MATERIAL: 13 Inches thick**				
	FAT CLAY (CH), dark brown and light brown, stiff to very stiff	1.75 (HP)	20.8		58
	- with gravel between 2 to 3 feet	1.75 (HP)	30.3	66-21-45	
		2.25 (HP)	33.0	73-24-49	
8.0		3.25 (HP)	24.6		93
10.0	**LEAN CLAY (CL)**, light brown, very stiff	3.25 (HP)	20.9	46-17-29	
	Boring Terminated at 10 Feet				

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

Notes

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 29.6972° Longitude: -98.1300°

Model Layer	Graphic Log	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		0.3	**ASPHALT: 2.75 Inches thick**							
		0.8	**CEMENT TREATED MATERIAL: 8.5 Inches thick**							
		1.2	**UNTREATED BASE MATERIAL: 2.5 Inches thick**							
		3.0	**CLAYEY GRAVEL (GC)**, dark brown, medium dense				5-5-6 N=11	15.9	61-22-39	47
							4-5-7 N=12	26.1	65-24-41	75
		8.0	**FAT CLAY (CH)**, dark brown and light brown, stiff to hard	5			4.0 (HP)	16.9	54-17-37	
							4.5 (HP)	17.6		
		10.0	**LEAN CLAY (CL)**, light brown, stiff				2.0 (HP)	11.0	37-13-24	
			Boring Terminated at 10 Feet	10						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

Notes

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 29.6991° Longitude: -98.1281°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		0.2	**ASPHALT: 1.75 Inches thick**							
		0.9	**CEMENT TREATED MATERIAL: 9.5 Inches thick**							
		1.2	**UNTREATED BASE MATERIAL: 2.5 Inches thick**							
		3.0	**CLAYEY GRAVEL (GC)**, brown, medium dense				7-7-6 N=13	7.9		25
		8.0	**FAT CLAY (CH)**, brown and light brown, very stiff to hard - with gravel between 3 to 4 feet				6-7-8 N=15	22.4		77
				5			4.5 (HP)	25.3	67-19-48	
							4.5 (HP)	16.4		
		10.0	**LEAN CLAY (CL)**, light brown, hard				4.5 (HP)	17.2	37-15-22	
			Boring Terminated at 10 Feet	10						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 29.6996° Longitude: -98.1277°

Model Layer	Graphic Log	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		0.2	**ASPHALT: 2 Inches thick**							
		1.0	**CEMENT TREATED MATERIAL: 10 Inches thick**							
		1.2	**UNTREATED BASE MATERIAL: 2 Inches thick**							
			FAT CLAY (CH), brown and light brown, medium stiff to hard - with gravel between 1 to 3 feet				2-3-4 N=7	22.0	57-23-34	68
							4-6-7 N=13	24.3	67-22-45	89
		6.0		5			4.5 (HP)	15.7		
			LEAN CLAY (CL), light brown, very stiff to hard				4.0 (HP)	19.8	40-19-21	
		10.0		10			4.5 (HP)	15.2	42-16-26	
			Boring Terminated at 10 Feet							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

Notes

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 29.6986° Longitude: -98.1287°

Depth (Ft.)	Description
0.2	**ASPHALT: 2 Inches thick**
1.0	**CEMENT TREATED MATERIAL: 10 Inches thick**
1.2	**UNTREATED BASE MATERIAL: 2 Inches thick**
8.0	**FAT CLAY (CH)**, brown and light brown, stiff to hard - with gravel between 2 to 4 feet
10.0	**LEAN CLAY (CL)**, light brown, hard
	Boring Terminated at 10 Feet

Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
8-5-6 N=11	24.6	52-18-34	81
7-10-12 N=22	17.3	66-22-44	59
4.0 (HP)	22.4	60-21-39	
4.5 (HP)	17.9		
4.5 (HP)	20.6		

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

Notes

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Boring Log No. B-6

Location: See Exploration Plan

Latitude: 29.6960° Longitude: -98.1313°

Model Layer	Graphic Log	Depth (Ft.)	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
		0.2	**ASPHALT: 2 Inches thick**							
		1.0	**CEMENT TREATED MATERIAL: 9.5 Inches thick**							
		1.2	**UNTREATED BASE MATERIAL: 2.5 Inches thick**							
		3.0	**CLAYEY GRAVEL (GC)**, brown, loose				4-4-5 N=9	6.5		25
		8.0	**FAT CLAY (CH)**, brown and light brown, stiff to very stiff				4-6-7 N=13	25.4	67-21-46	86
			- with gravel between 3 to 4 feet	5			3.5 (HP)	27.6		
							3.5 (HP)	24.5	64-16-48	95
		10.0	**LEAN CLAY (CL)**, light brown, very stiff				3.5 (HP)	21.4	48-17-31	
			Boring Terminated at 10 Feet	10						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations

Notes

Advancement Method
F.A.

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite
Surface Capped with Asphalt

Drill Rig
CME 75

Hammer Type
Automatic

Driller
Ramco

Logged by
D. Pena

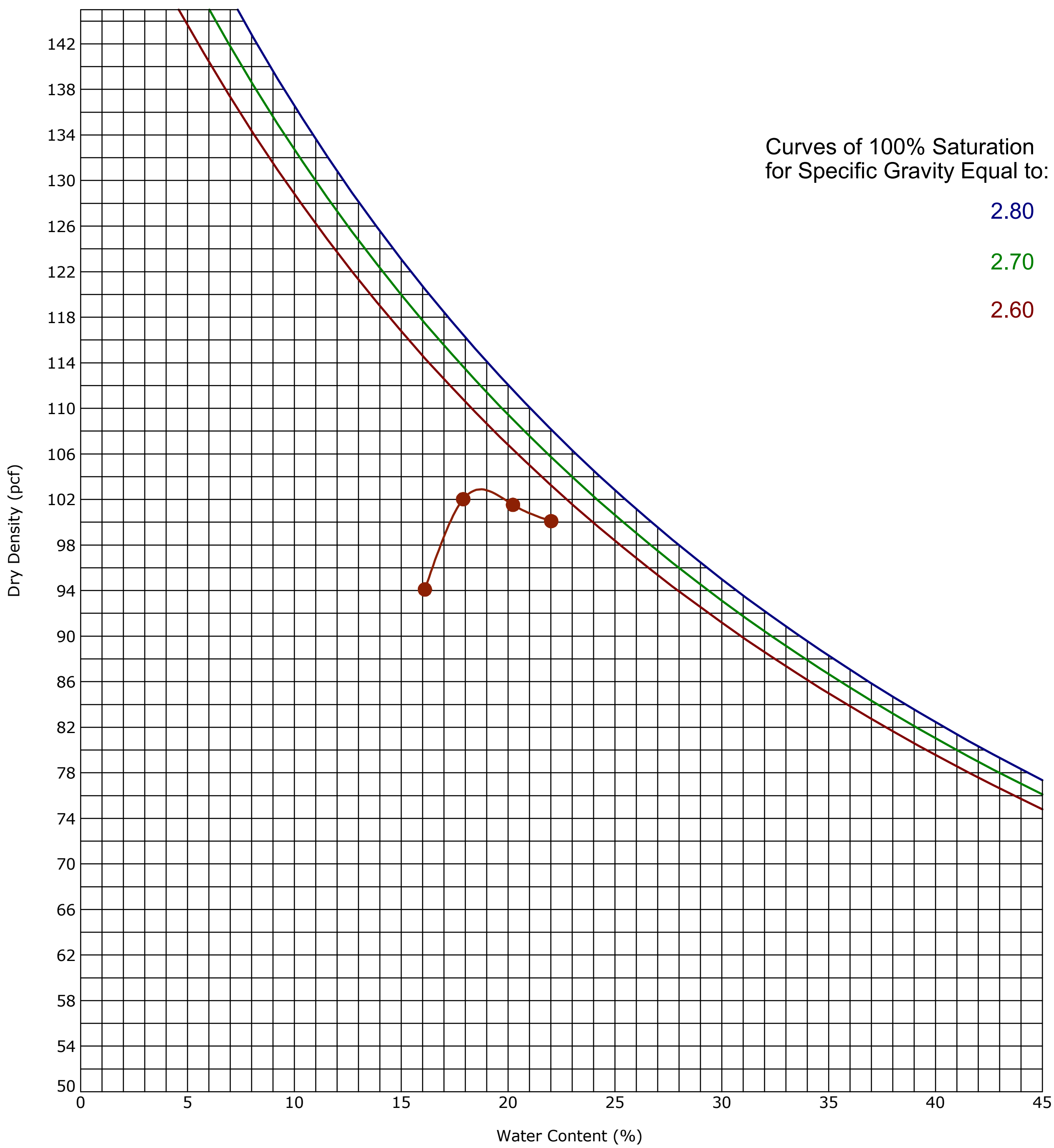
Boring Started

Boring Completed

Terracon
6000 Northwest Pkwy Ste 100
San Antonio, TX

Moisture-Density Relationship

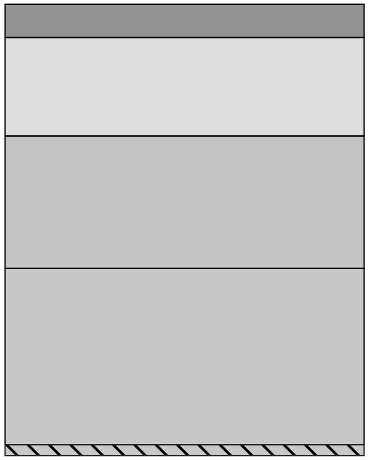
ASTM D698-Method A



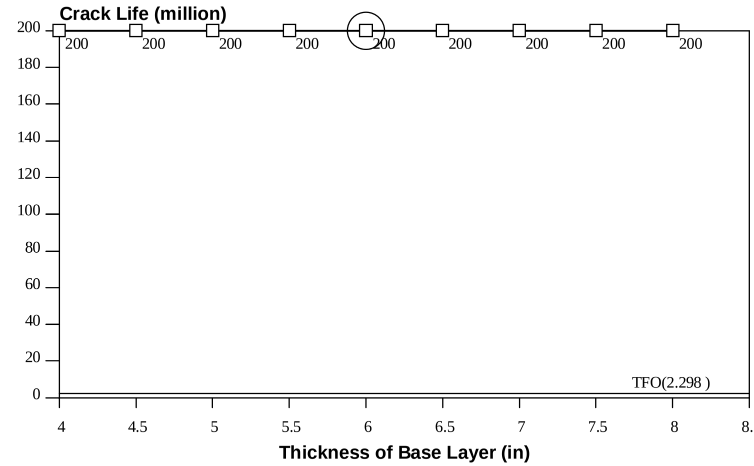
Boring ID	Depth (Ft)	Description of Materials
B-1 B-2 BULK	0 - 4	

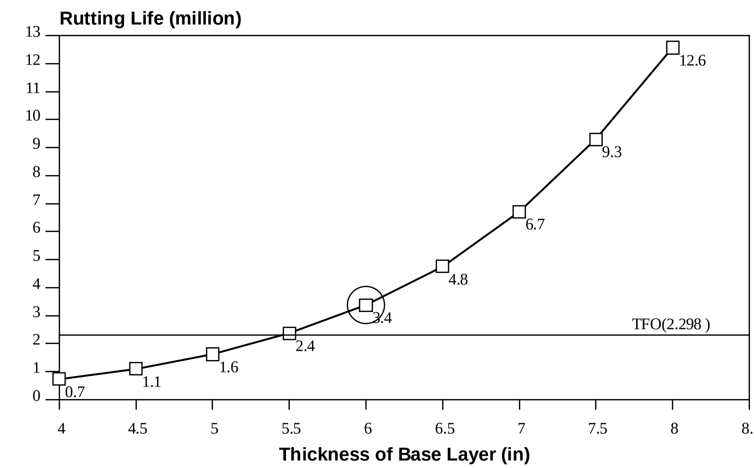
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)
	0.0				ASTM D698-Method A	102.2	18.8

HMA over Lime Treated Subgrade



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
2.00	500.00	0.35	DENSE-GRADED HMA Thin
6.00	500.00	0.35	DENSE-GRADED HMA Thick
8.00	30.00	0.35	STAB SUBB(Soil)
200.00	8.00	0.40	SUBGRADE





Fatigue Crack Model:

$$N_f = f_1 (\varepsilon_t)^{-f_2} (E_1)^{-f_3}$$

f_1 =7.96E-02

f_2 = 3.291

f_3 = .854

Rutting Model:

$$N_d = f_4 (\varepsilon_v)^{-f_5}$$

f_4 =1.37E-09

f_5 = 4.477

TFO(Traffic to 1st Overlay): 2.30 (million)

Crack Life: 200.00 (million) ε_τ = -8.49 ($\mu\varepsilon$)

Rut Life: 3.37 (million) ε_v = -365.00 ($\mu\varepsilon$)

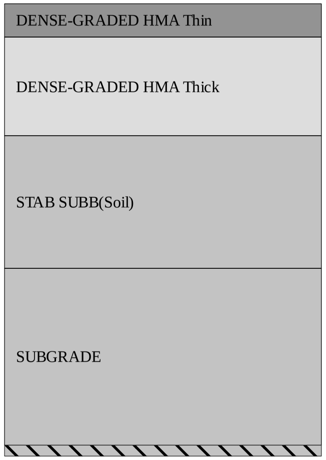
Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:4.00millions.
Also the start ADT:11500.0 and ending ADT:25000.0

Mechanistic Check Conclusion:

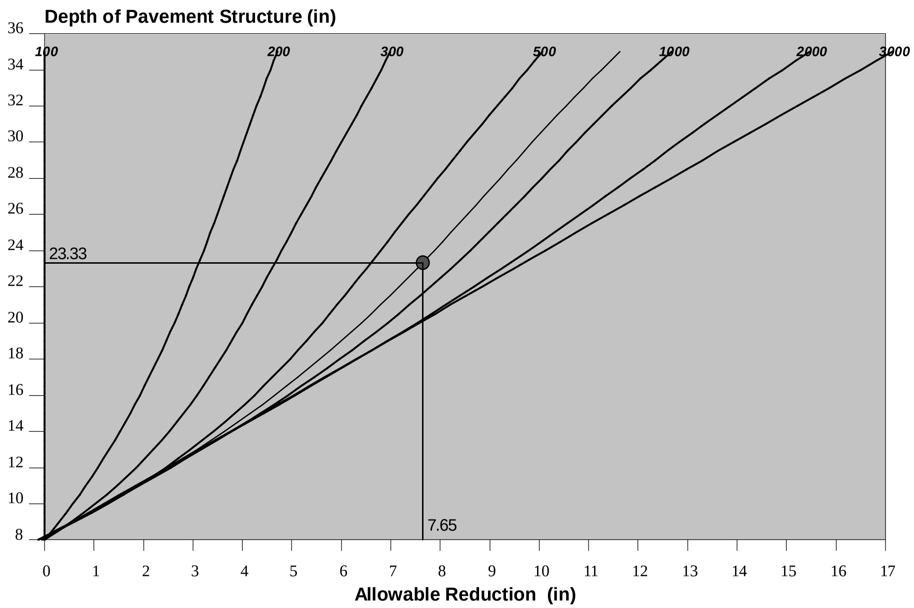
The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL
Design Type:User Defined Pavement Design			

HMA over Lime Treated Subgrade



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
2.00	500.00	0.35	DENSE-GRADED HMA Thin
6.00	500.00	0.35	DENSE-GRADED HMA Thick
8.00	30.00	0.35	STAB SUBB(Soil)
200.00	8.00	0.40	SUBGRADE
	800.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	11999.0 (lb)
Percentage of TandemAxles	49.0 (%)
Modified Cohesionmeter Value	800.0
Design Wheel Load	11999.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	5.60

TTC is based on Texas County Soil Database for (COMAL)

For soils type : clay of high plasticity, fat clay(CH)

RESULT:

Triaxial Thickness Required	23.3 (in)
The FPS Design Thickness	16.0 (in)
Allowable Thickness Reduction	7.6 (in)
Modified Triaxial Thickness	15.7 (in)

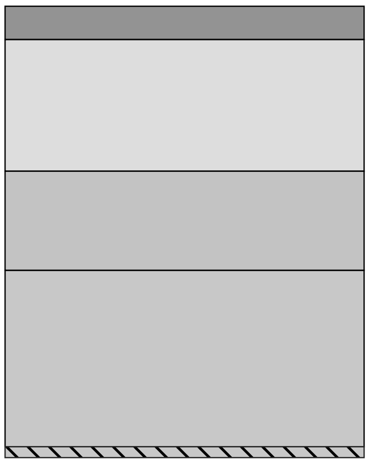
TRIAXIAL CHECK CONCLUSION:

The Design OK !

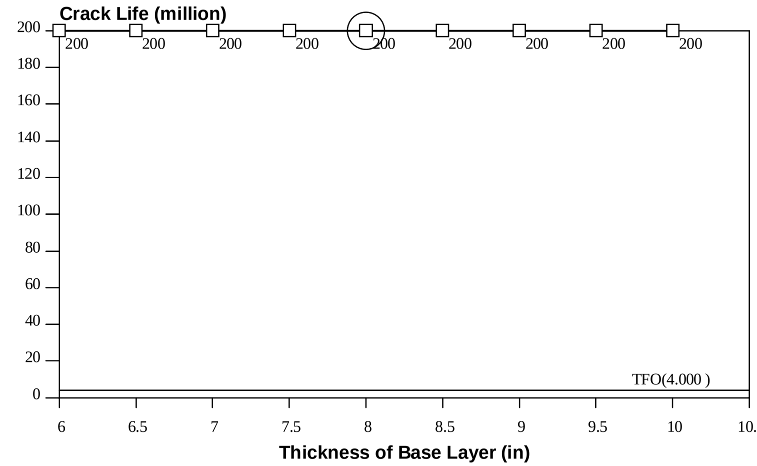
FPS 21 Triaxial Design Check Output	(FPS21-1.5Release:12-12-2018)		
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL

Design Type:User Defined Pavement Design

HMA over Flex Base



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
2.00	500.00	0.35	DENSE-GRADED HMA Thin
8.00	500.00	0.35	DENSE-GRADED HMA Thick
6.00	40.00	0.35	FLEXIBLE BASE
200.00	8.00	0.40	SUBGRADE



Fatigue Crack Model:

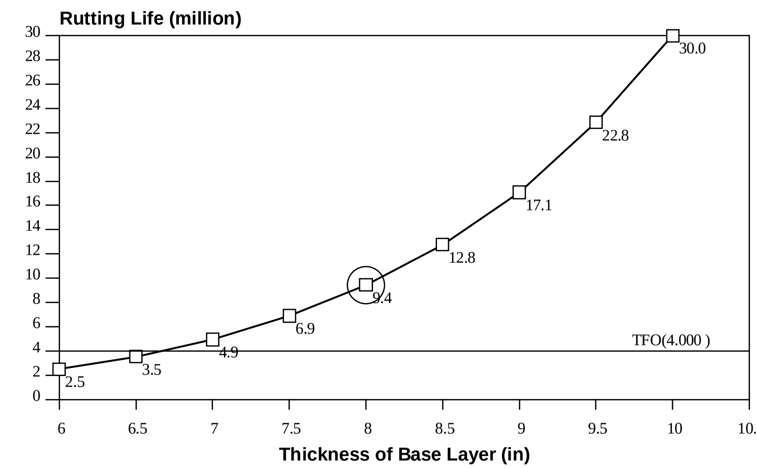
$$N_f = f_1 (\varepsilon_t)^{-f_2} (E_1)^{-f_3}$$

f_1 =7.96E-02
f_2 = 3.291
f_3 = .854

Rutting Model:

$$N_d = f_4 (\varepsilon_v)^{-f_5}$$

f_4 =1.37E-09
f_5 = 4.477



TFO(Traffic to 1st Overlay): 4.00 (million)

Crack Life: 200.00 (million) ε_τ = -4.64 (με)

Rut Life: 9.43 (million) ε_v = -290.00 (με)

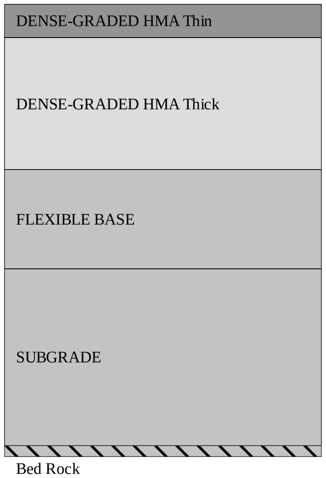
Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:4.00millions.
Also the start ADT:11500.0 and ending ADT:25000.0

Mechanistic Check Conclusion:

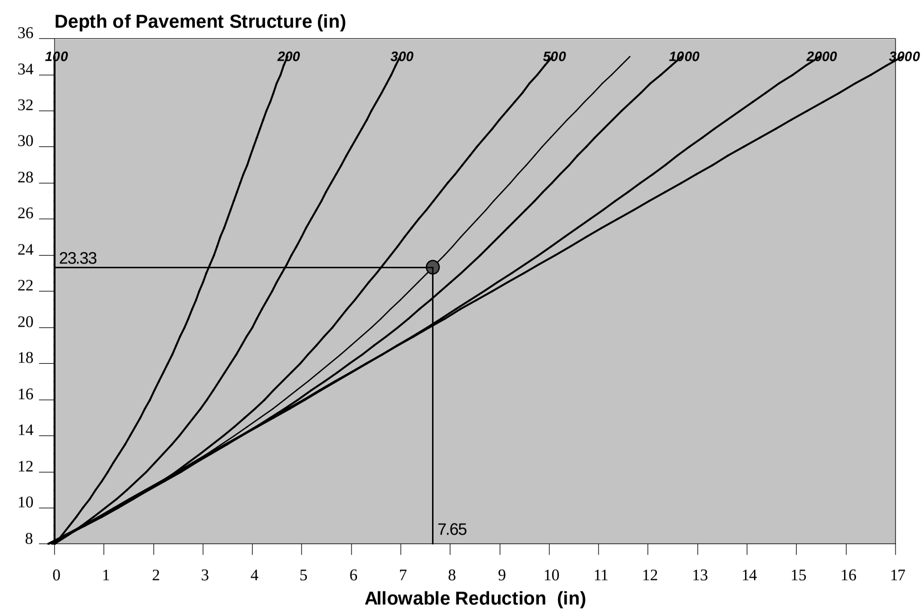
The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL
Design Type:User Defined Pavement Design			

HMA over Flex Base



Layer	Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
DENSE-GRADED HMA Thin	2.00	500.00	0.35	DENSE-GRADED HMA Thin
DENSE-GRADED HMA Thick	8.00	500.00	0.35	DENSE-GRADED HMA Thick
FLEXIBLE BASE	6.00	40.00	0.35	FLEXIBLE BASE
SUBGRADE	200.00	8.00	0.40	SUBGRADE
Bed Rock		800.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	11999.0 (lb)
Percentage of TandemAxles	49.0 (%)
Modified Cohesionmeter Value	800.0
Design Wheel Load	11999.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	5.60

TTC is based on Texas County Soil Database for (COMAL)

For soils type : clay of high plasticity, fat clay(CH)

RESULT:

Triaxial Thickness Required	23.3 (in)
The FPS Design Thickness	16.0 (in)
Allowable Thickness Reduction	7.6 (in)
Modified Triaxial Thickness	15.7 (in)

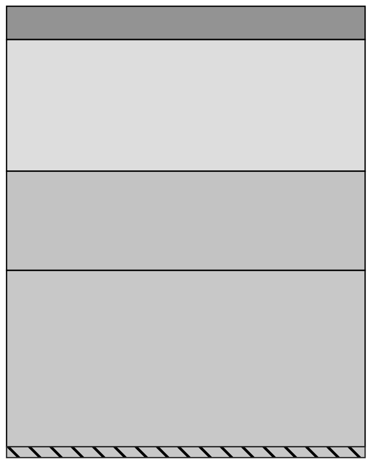
TRIAXIAL CHECK CONCLUSION:

The Design OK !

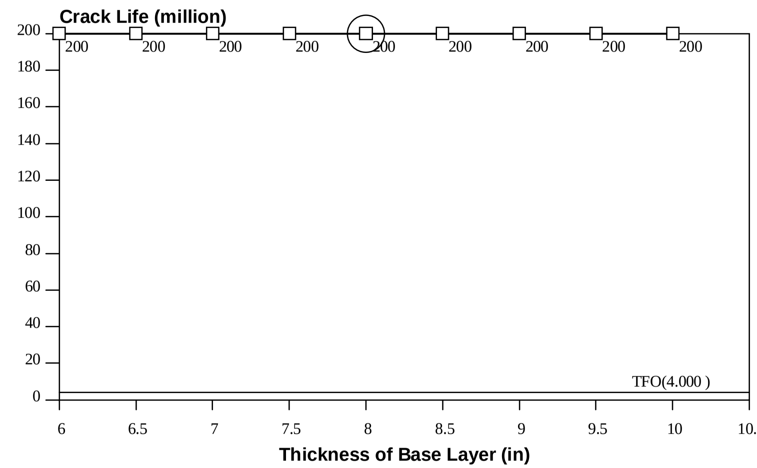
FPS 21 Triaxial Design Check Output	**(FPS21-1.5Release:12-12-2018)**		
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL

Design Type:User Defined Pavement Design

HMA only



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
2.00	500.00	0.35	DENSE-GRADED HMA Thin
8.00	500.00	0.35	DENSE-GRADED HMA Thick
6.00	500.00	0.35	DENSE-GRADED HMA Thick
200.00	8.00	0.40	SUBGRADE



Fatigue Crack Model:

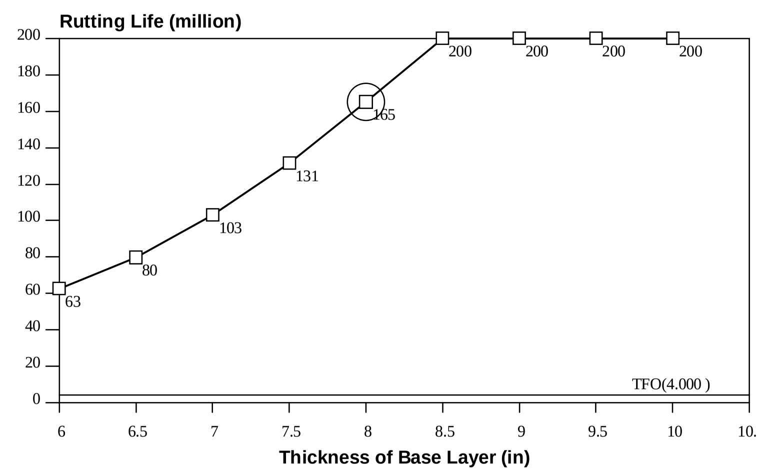
$$N_f = f_1 (\varepsilon_t)^{-f_2} (E_1)^{-f_3}$$

f_1 =7.96E-02
f_2 = 3.291
f_3 = .854

Rutting Model:

$$N_d = f_4 (\varepsilon_v)^{-f_5}$$

f_4 =1.37E-09
f_5 = 4.477



TFO(Traffic to 1st Overlay): 4.00 (million)

Crack Life: 200.00 (million) ε_τ = 4.98 ($\mu\varepsilon$)

Rut Life: 165.14 (million) ε_v = -153.00 ($\mu\varepsilon$)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:4.00millions.
Also the start ADT:11500.0 and ending ADT:25000.0

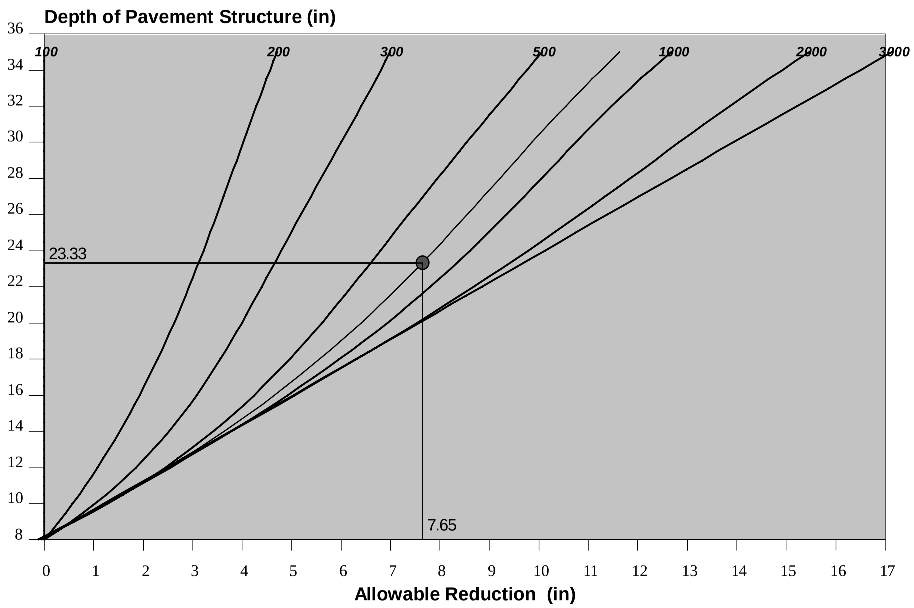
Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL
Design Type:User Defined Pavement Design			

HMA only

Layer	Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
DENSE-GRADED HMA Thin	2.00	500.00	0.35	DENSE-GRADED HMA Thin
DENSE-GRADED HMA Thick	8.00	500.00	0.35	DENSE-GRADED HMA Thick
DENSE-GRADED HMA Thick	6.00	500.00	0.35	DENSE-GRADED HMA Thick
SUBGRADE	200.00	8.00	0.40	SUBGRADE
Bed Rock		800.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	11999.0 (lb)
Percentage of TandemAxles	49.0 (%)
Modified Cohesionmeter Value	800.0
Design Wheel Load	11999.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	5.60

TTC is based on Texas County Soil Database for (COMAL)

For soils type : clay of high plasticity, fat clay(CH)

RESULT:

Triaxial Thickness Required	23.3 (in)
The FPS Design Thickness	16.0 (in)
Allowable Thickness Reduction	7.6 (in)
Modified Triaxial Thickness	15.7 (in)

TRIAXIAL CHECK CONCLUSION:

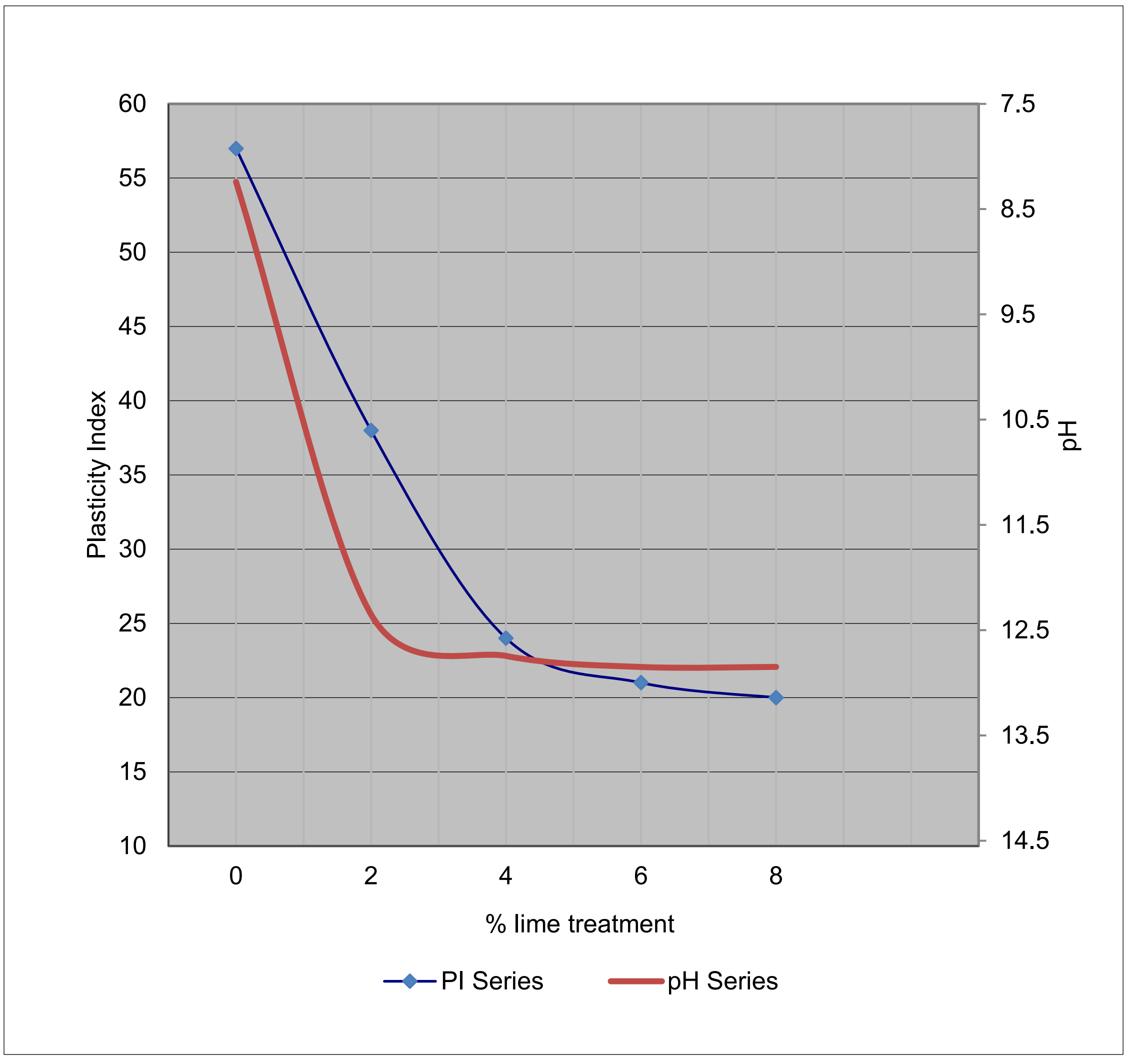
The Design OK !

FPS 21 Triaxial Design Check Output	(FPS21-1.5Release:12-12-2018)		
Highway	SAT St NB	Problem	2
C-S-J	NA - 1 - 1	Date	5/9/2024
District	San Antonio	County	COMAL

Design Type:User Defined Pavement Design

Project Name:	Walnut to Academy
Project #	90231414
Soil Type	Bore Bulk Sample

Lime Series Results		
% Lime	**pH Series**	**Plasticity Index (PI)**
0	8.2	57
2	12.3	38
4	12.7	24
6	12.8	21
8	12.8	20

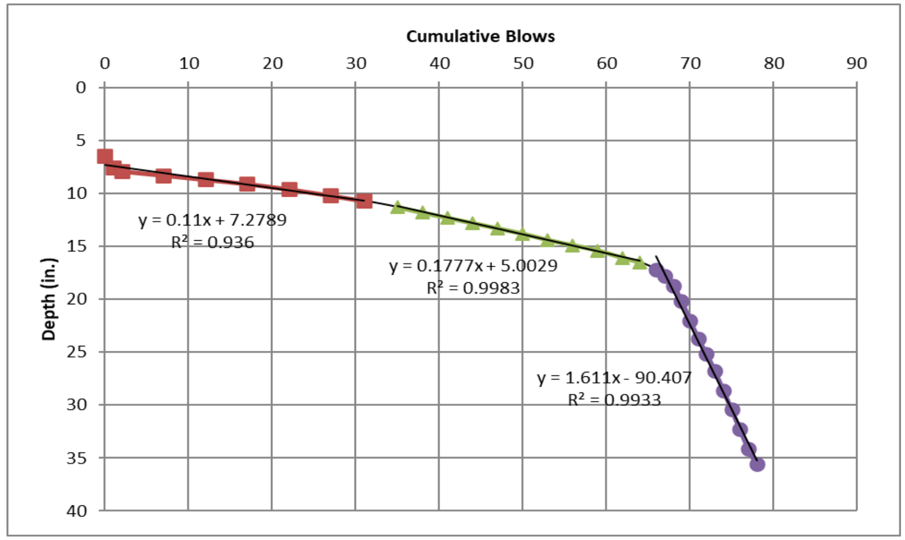


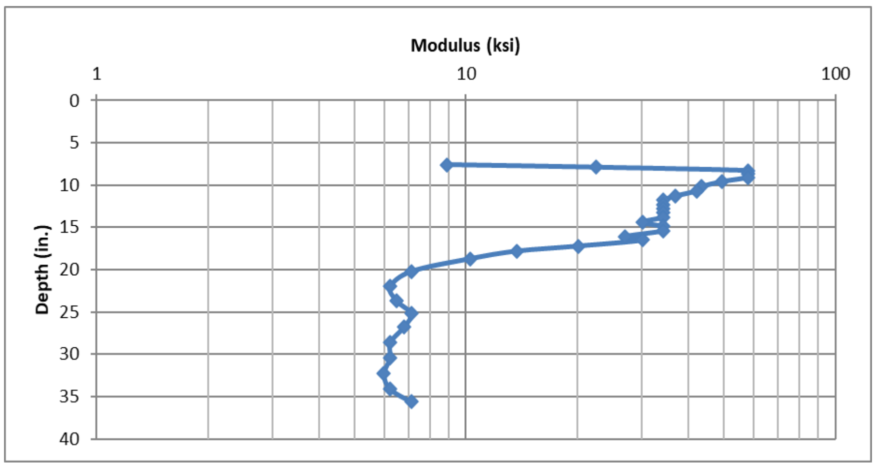
DYNAMIC CONE PENETROMETER TESTING

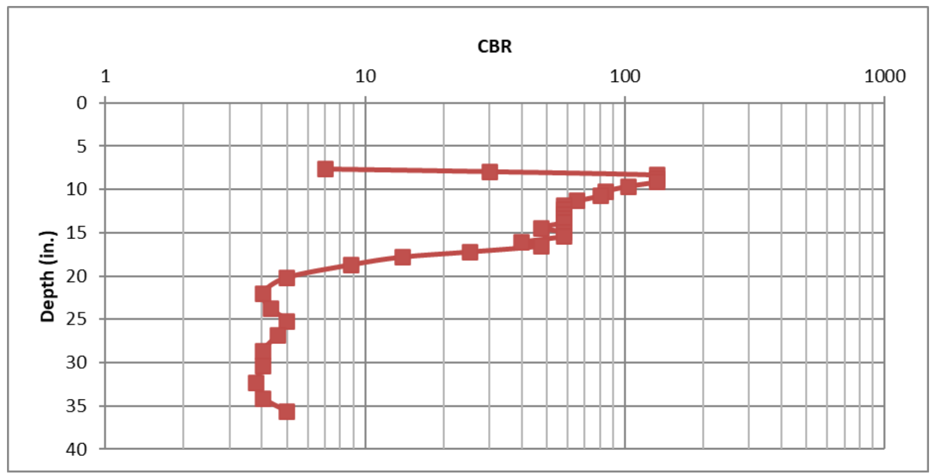
CSJ	NA	Location/Site Number	B-1
District	San Antonio	Drilling Depth [in.]	6.5
County	Comal	Note	
Roadway	San Antonio Street		
Test Date	12/1/2023		

	Inches			
Surface Zero	1.7			
	Slope	Intercept	CBR	E (Ksi)
Layer #1	0.1100		92.39	46.19
Layer #2	0.1777		53.99	32.75
Layer #3	1.6100		4.57	6.75

Site Photo





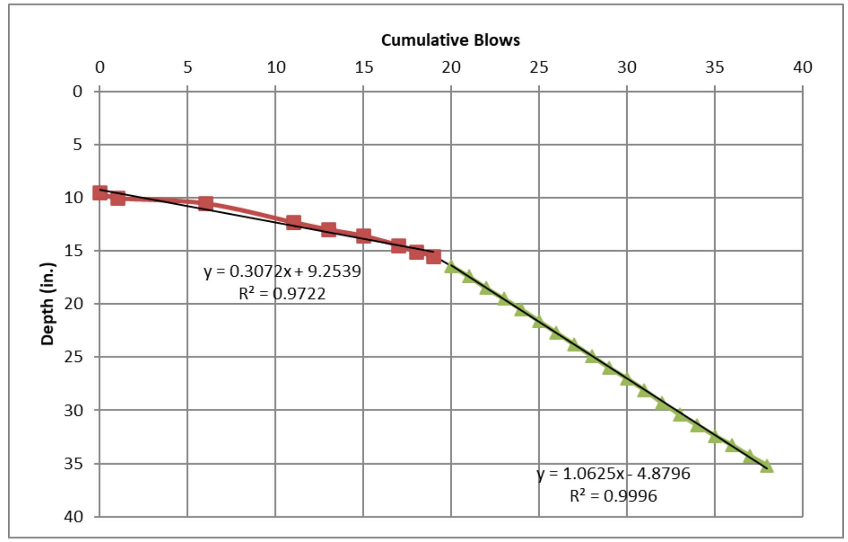


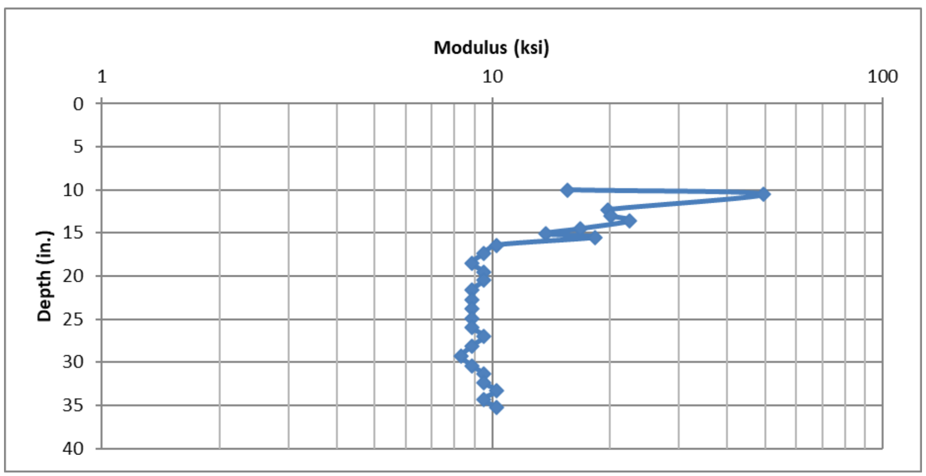
DYNAMIC CONE PENETROMETER TESTING

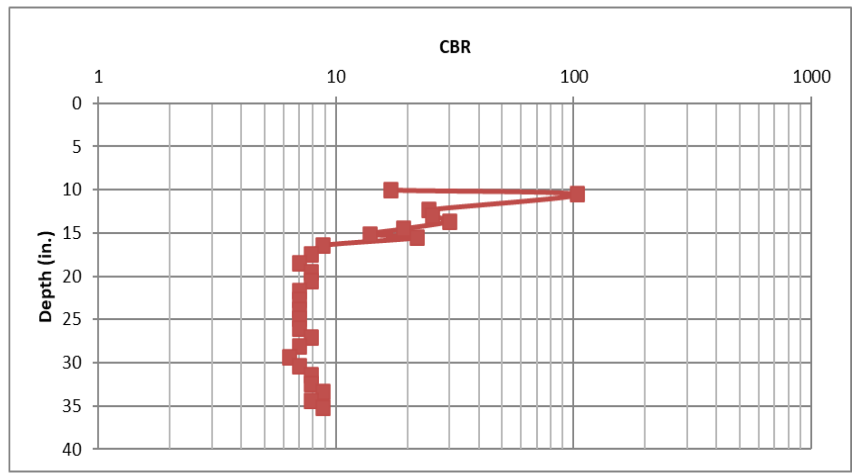
CSJ	NA	**Location/Site Number**	B-3
District	San Antonio	**Drilling Depth [in.]**	9.5
County	Comal	**Note**	
Roadway	San Antonio Street		
Test Date	12/1/2023		

		Inches		
Surface Zero		1.4		
	Slope	**Intercept**	**CBR**	**E (Ksi)**
Layer #1	0.3072		**29.25**	**22.12**
Layer #2	1.0625		**7.29**	**9.09**
Layer #3				

Site Photo





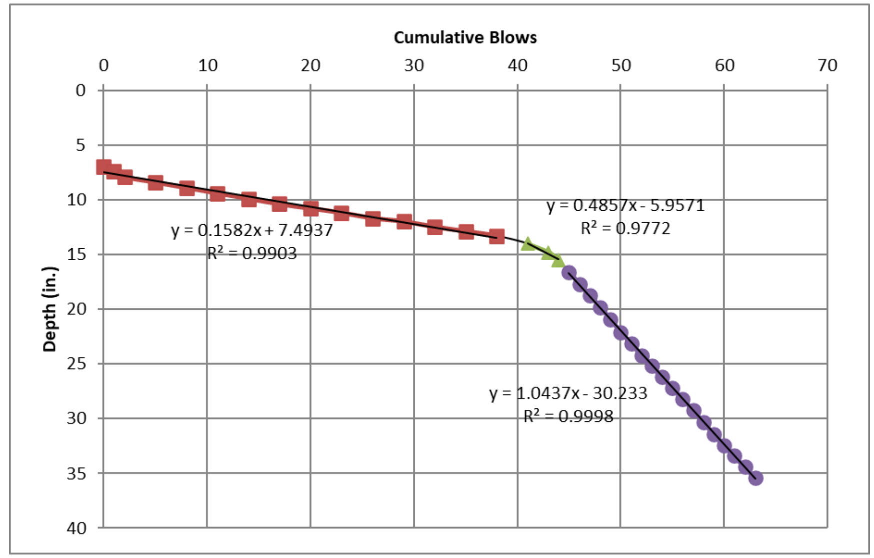


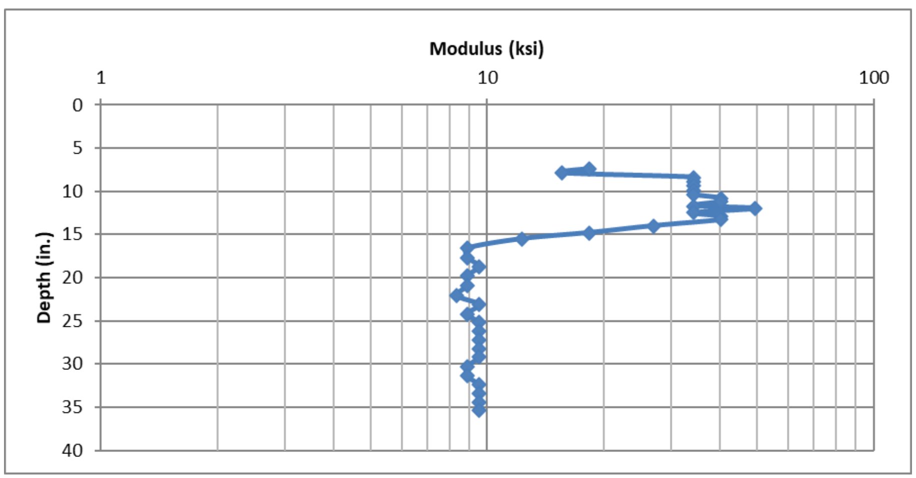
DYNAMIC CONE PENETROMETER TESTING

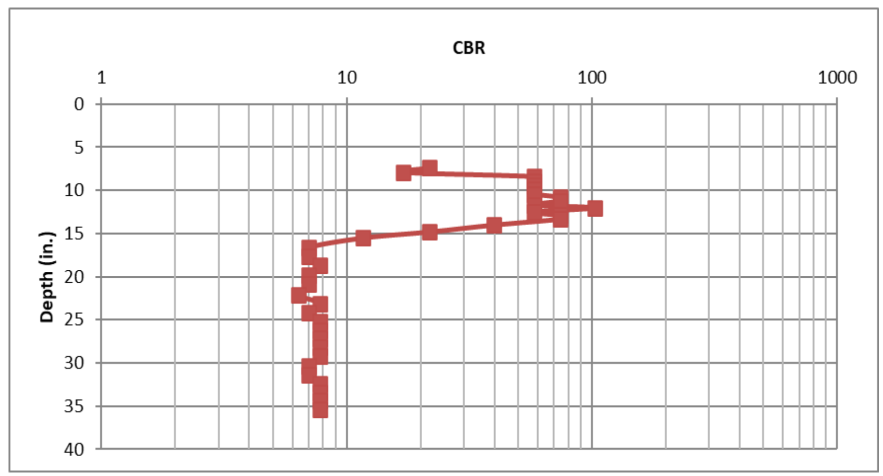
CSJ	NA	Location/Site Number	B-4
District	San Antonio	Drilling Depth [in.]	7.0
County	Comal	Note	
Roadway	San Antonio Street		
Test Date	12/1/2023		

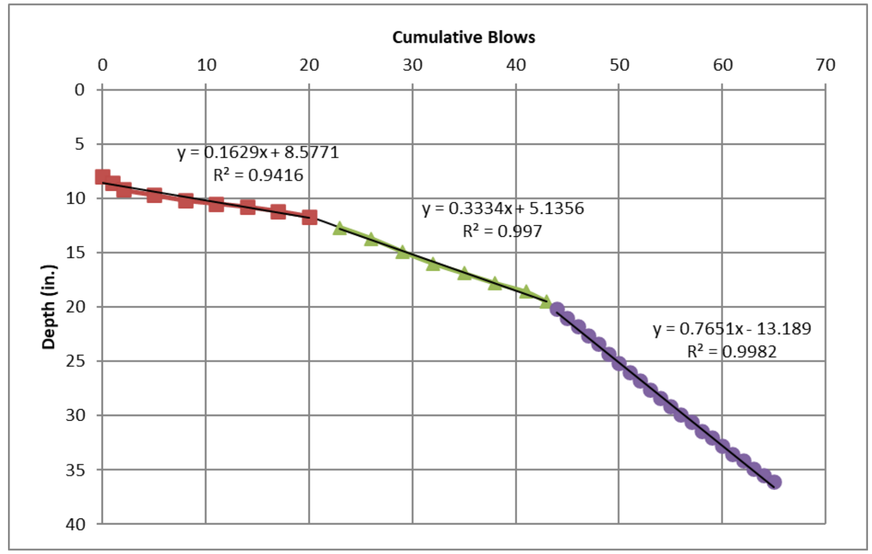
	Slope	Intercept	CBR	E (Ksi)
Surface Zero		Inches 2.1		
Layer #1	0.1582		61.50	35.60
Layer #2	0.4850		17.54	15.95
Layer #3	1.0437		7.43	9.21

Site Photo







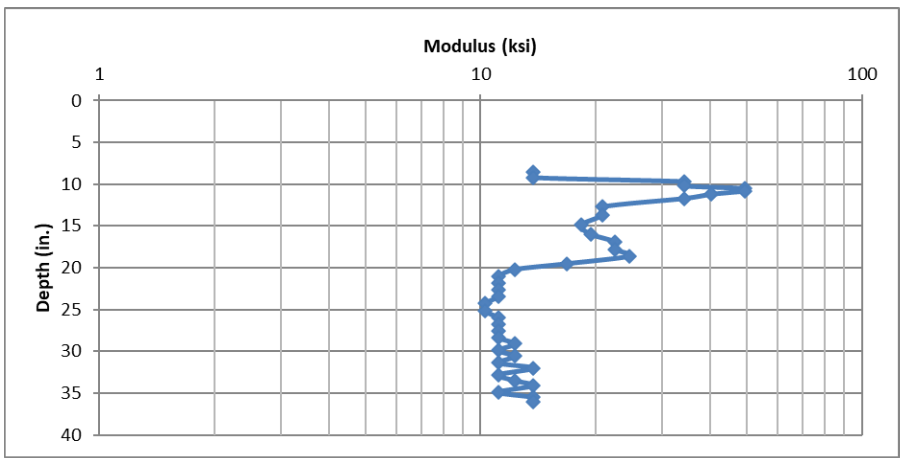


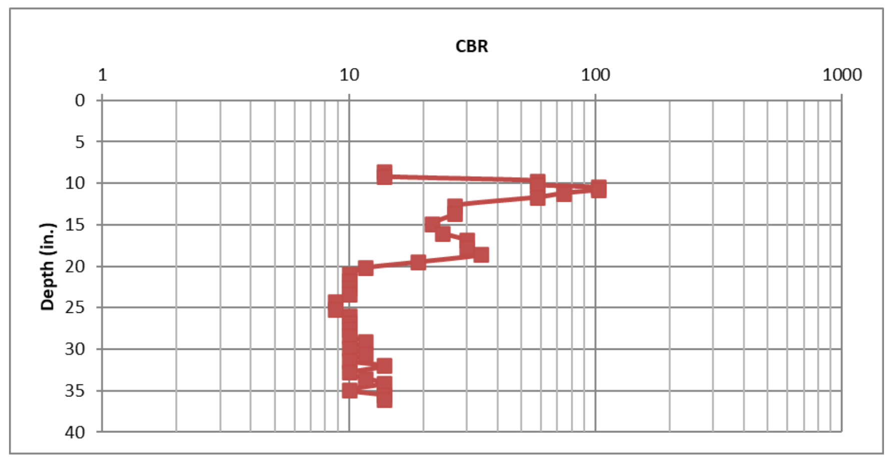
DYNAMIC CONE PENETROMETER TESTING

CSJ	NA	Location/Site Number	B-6
District	San Antonio	Drilling Depth [in.]	8.0
County	Comal	Note	
Roadway	San Antonio Street		
Test Date	12/1/2023		

	Slope	Intercept	CBR	E (Ksi)
Surface Zero		Inches 1.2		
Layer #1	0.1629		59.51	34.86
Layer #2	0.3334		26.68	20.86
Layer #3	0.7651		10.52	11.50

Site Photo





Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.