AMENDMENT OF SOLICITATION

City of New Braunfels
Purchasing
551 Landa Street
New Braunfels, Texas 78130

1. Solicitation No. and Title CSP 25-032	**2. Amendment No.** **1**	**3. Effective Date of this Action** **5/29/2025**

4. Name and Address of Offeror or Contractor	**5.** For Information Call: (No collect calls or Fax offers accepted) Purchasing: **Greg Gutierrez** Phone No.: **830-221-4398** Email:	**6.** Amount of Contract/Order is: Increased by: Decreased by: New Total: ☒ **Unchanged**

7. THIS BLOCK APPLIES TO AMENDMENTS OF SOLICITATIONS ONLY:

The above numbered solicitation is amended as set forth in Block 8 below.

☒ **The date and time specified for receipt of offers IS NOT extended.**

☐ **THE DATE AND TIME SPECIFIED FOR RECEIPT OF OFFERS IS CHANGED TO:**

Offerors must acknowledge receipt of this amendment prior to the date and time specified in the solicitation or as amended, by one of the following methods:

(i) By completing Blocks 4 and 9.a,b,c and returning this Addendum in the number of copies specified for the solicitation;
(ii) By acknowledging receipt of this Addendum on each copy of the bid submitted; or,
(iii) By separate letter, telegram, or fax referencing the solicitation and addendum.

If by virtue of this Addendum offeror desires to change an offer already submitted, such change may be made by letter, telegram, or fax, provided each such notice makes reference to the solicitation AND this Addendum, and is received prior to the date and time specified.

NOTICE: NON-RECEIPT OF YOUR OFFER AND THIS ADDENDUM AT THE DESIGNATED PLACE WITHIN THE DATE AND TIME SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER.

8. DESCRIPTION OF CHANGES -

1. Included Geotech Report.

Except as provided herein, all terms and conditions of the document referenced above remain unchanged and in full force and effect.

9a. SIGNATURE OF OFFEROR OR CONTRACTOR		**10. CITY OF NEW BRAUNFELS, TEXAS**
9b. PRINTED NAME AND TITLE	**9c.** DATE	**Greg Gutierrez** **Date** **Buyer**

RABA KISTNER

GEOTECHNICAL ENGINEERING PAVEMENT STUDY

FOR

WEST SAN ANTONIO STREET
PAVEMENT RECONSTRUCTION
NEW BRAUNFELS, TEXAS

RABA KISTNER
Raba Kistner, Inc.
1913 Post Road, Suite 645
New Braunfels, TX 78130
www.rkci.com

P 830.214.0544
F 830.214.0627
F-3257

Project No. ANA24-024-00
September 6, 2024

Mr. Alex Zertuche, P.E.
Senior Project Manager
Quiddity
2967 Oak Run Parkway
New Braunfels, Texas 78132

RE: Geotechnical Engineering Pavement Study
West San Antonio Street
Pavement Reconstruction
New Braunfels, Texas

Dear Mr. Zertuche:

RABA KISTNER Inc. (RKI) is pleased to submit the report of our Geotechnical Engineering Study for the above-referenced project. This study was performed in accordance with RKI Proposal No. PNA24-036-00, revised June 26, 2024. The purpose of this study was to drill borings within the proposed roadway, to perform laboratory testing to classify and characterize subsurface conditions, and to prepare an engineering report presenting pavement design and construction guidelines.

The following report contains our design recommendations and considerations based on our current understanding of the project information provided to our office. There may be alternatives for value engineering of the pavement systems, and RKI recommends that a meeting be held with the Owner and design team to evaluate these alternatives.

We appreciate the opportunity to be of service to you on this project. Should you have any questions about the information presented in this report, or if we may be of additional assistance with value engineering or on the materials testing-quality control program during construction, please call.

Very truly yours,

RABA KISTNER, INC.

Ryan DeWees

Ian Perez

TERRANCE IAN PEREZ
101225
LICENSED PROFESSIONAL ENGINEER

Ryan DeWees, E.I.T.
Graduate Engineer

Ian Perez, P.E.
Vice President

RD/TIP/mmd

Attachments

Copies Submitted: Above (1) – Email Only

GEOTECHNICAL ENGINEERING PAVEMENT STUDY

For

WEST SAN ANTONIO STREET
PAVEMENT RECONSTRUCTION
NEW BRAUNFELS, TEXAS

Prepared for

QUIDDITY
New Braunfels, Texas

Prepared by

RABA KISTNER, INC.
New Braunfels, Texas

PROJECT NO. ANA24-024-00

September 6, 2024

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The following figures are attached and complete this report:

ATTACHMENTS

ATTACHMENT B

INTRODUCTION

RABA KISTNER, Inc. (RKI) has completed the authorized subsurface exploration for the proposed West San Antonio Street reconstruction as illustrated on Figure 1. This report briefly describes the procedures utilized during this study and presents our findings along with our recommendations for pavement design and construction guidelines.

PROJECT DESCRIPTION

To be considered in this study is approximately 1,300 LF of West San Antonio Street extending from North Krueger Avenue to approximately 500 LF southwest of South Water Lane in New Braunfels, Texas. The proposed roadway is planned to be 30 to 38 ft in width. Texas Department of Transportation (TxDOT) design standards in general accordance with the *San Antonio District Pavement Design Standard Operating Procedure* dated September 1, 2022, will be used to design this roadway. We understand that the roadway has been designated as a major residential collector by the City of New Braunfels. Typical Roadway Sections and Grading with stationing information were provided in a document titled "CITYWIDE STREETS IMPROVEMENTS PROJECTS" sheets 5, 6, 12 and 45 through 49, dated May 2024, by the client via email on May 28, 2024. This document shows that the proposed reconstruction grades will be at or approximately 1 ft below the existing grades. Traffic data was also provided by the client via email on May 28, 2024, and was considered in the development of the recommended pavement sections provided herein.

RKCI previously performed a preliminary geotechnical engineering study at this site (Report No. ANA23-035-00). The recommendations from the previous report were reviewed and incorporated in this report, where applicable.

LIMITATIONS

This geotechnical report has been prepared in accordance with accepted Geotechnical Engineering practices in the region of South/Central Texas and for the use of Quiddity (CLIENT) and its representatives for design purposes. This report may not contain sufficient information for purposes of other parties or other uses. This report is not intended for use in determining construction means and methods. The attachments and report text should not be used separately.

The recommendations submitted in this report are based on the data obtained from the 1 current boring (Boring B-1), 3 previously drilled borings (Borings B-101 through B-103), 1 bulk sample collected for the current study at this site, the information from the previous preliminary report, and the information and documents (See *Project Description*) provided to us. This report may not reflect the actual variations of the subsurface conditions across the site. The nature and extent of variations across the site may not become evident until construction commences. The construction process itself may also alter subsurface conditions. If variations appear evident at the time of construction, it may be necessary to reevaluate our recommendations after performing on-site observations and tests to establish the engineering impact of the variations.

The scope of our Geotechnical Engineering Study does not include an environmental assessment of the air, soil, rock, or water conditions either on or adjacent to the site. No environmental opinions are presented in this report.

If final grade elevations are changed significantly from the proposed grades by more than plus or minus 1 ft, our office should be informed about these changes. If needed and/or if desired, we will reexamine our analyses and make supplemental recommendations.

BORINGS AND LABORATORY TESTS

Subsurface conditions at the site were evaluated by 1 current and 3 previous borings drilled at the locations shown on the Boring Location Map, Figure 1. These locations are approximate, and distances were measured using a recreational grade, hand-held, GPS Locator. The borings were drilled using a truck-mounted drilling rig to a depth of approximately 15 ft below the existing ground surface. During drilling operations, split-spoon samples with Standard Penetration Testing (SPT) were collected.

Each sample was visually classified in the laboratory by a member of our Geotechnical Engineering staff. The geotechnical engineering properties of the subsurface soil strata were evaluated by the natural moisture content, percent passing a No. 200 sieve, sulfate content, and Atterberg limits.

The results of the laboratory tests for the current study are presented in graphical or numerical form on the boring log illustrated in Figure 2. A key to classification terms and symbols used on the log is presented in Figure 3. The results of the laboratory and field testing are also tabulated in Figure 4 for ease of reference.

Standard penetration test results are noted as “blows per ft” on the boring log and Figure 4, where “blows per ft” refers to the number of blows by a falling hammer required for 1 ft of penetration into the soil/weak rock (N-value).

In addition to the above listed testing and sampling, a sample of the predominant subgrade soil from an area near Boring B-1 was also collected for use in Texas Triaxial (TEX-117-E), pH-Lime series testing, and sulfate content testing. The results of the Texas Triaxial test results and classification chart are presented in Figures 5 and 6, respectively. The pH-Lime Series Curve can be found in Figure 7. The results of the sulfate testing are discussed in a subsequent section of this report.

A summary of the bulk sample testing results are presented in the following table:

Material Type, Location and Depth	Max Dry Density and Optimum Moisture	Raw Plasticity Index (PI)	Lime PI at 5% Lime
Brown Clay (Boring B-1, 0 – 2 ft)	91.2 pcf and 21.4%	41	14

The boring logs from the previous study (RKI Report No.: ANA23-035-00) are presented in Attachment B.

Samples will be retained in our laboratory for 30 days after submittal of this report. Other arrangements may be provided at the request of the Client.

SULFATE TESTING

Sulfate testing was performed on a portion of the bulk sample (collected from the vicinity of Boring B-1 of the current study). The results of the sulfate content tests are presented in the table below.

Sulfate Test Results			
Soil Type	Boring Number	Approximate Depth Below Existing Ground Surface (ft)	Sulfate Content (ppm)
Dark Brown Clay	B-1 Bulk Sample (current study)	0 – 2	180

The purpose of the sulfate testing was to determine the concentration of soluble sulfates in the subgrade soils, in order to investigate the potential for an adverse reaction to lime in sulfate-containing soils. The adverse reaction, referred to as sulfate-induced heave, has been known to cause cohesive subgrade soils to swell in short periods of time, resulting in pavement heaving and possible failure. Sulfates can also affect the durability of concrete where high sulfate concentrations are encountered.

On the basis of the laboratory test results presented above, the reported sulfate concentration value was generally determined to be negligible. Reported sulfate concentrations above 3,000 ppm are known to cause sulfate induced heaving when the soils are mixed with lime. If the option for lime is considered, a quality assurance program should be implemented to assist in reducing the risk of sulfate induced heaving.

Sulfate concentrations in soil can also be used to evaluate the need for the protection of concrete based on the general guidelines shown in the table below.

Sulfate Exposure Classes (1)	
Sulfate Ion Concentration, ppm or mg/kg	Exposure Class
$SO_4 > 10,000$	S3
$1,500 \leq SO_4 \leq 10,000$	S2
$150 \leq SO_4 \leq 1,500$	S1
< 150	S0

(1) ACI 318-19 (Table 19.3.1.1)

Based on sulfate content testing results presented in the *Sulfate Test Results* table, the sulfate content exposure class is generally S1 at this site. In general accordance with ACI 318, the sulfate contents encountered at this site require Type II cementitious materials to protect concrete in direct contact with the natural soils from sulfate attack. Type I or III cementitious materials may also be used with the condition that the C_3A contents are less than 8 percent.

GENERAL SITE CONDITIONS

GEOLOGY

A review of the *Geologic Atlas of Texas, San Antonio Sheet*, indicates that this site is naturally underlain with the soils/rock of the Pecan Gap Chalk. This formation mainly consists of chalk and chalky marl. Light yellow to yellowish brown in color. The Pecan Gap Chalk weathers to form moderately deep soil that typically consists of clays, marly clays, and marl grading to chalk at depth. Exogyra ponderosa fossils are common. Thin seams of bentonite and/or bentonitic clays are also often encountered in this formation. Because such seams are typically thin and random, they are often difficult to locate and identify with standard geotechnical sampling methods and sampling intervals. Key geotechnical engineering concerns for development supported on this formation are expansive, soil-related movement.

EXISTING PAVEMENT SECTIONS AND STRATIGRAPHY

The existing field measured pavement sections determined by auger drilling methods at the boring location from the current and previous study are summarized in the following table:

	Approximate Field Measured Thickness (in.)	
Boring No.	Asphalt	Base Material
B-1 (Current)	1-1/2	7-1/2
B-101 (Previous)	3	11
B-102 (Previous)	4	6
B-103 (Previous)	3	6

Below the existing pavement sections, the natural subsurface stratigraphy in can generally be described as dark brown high plasticity clay overlying tan clay underlain by grayish tan clay which extends to at least the boring termination depths. The estimated Potential Vertical Rise (PVR) along the alignment ranges from 2 to 3-3/4 in.

Each stratum presented on the boring logs has been designated by grouping materials that possess similar physical and engineering characteristics. The boring logs should be consulted for more specific stratigraphic information. Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials may be gradual or may occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by RKI in its analyses and should not be used as the basis of design or construction cost estimates without realizing there can be variation from that shown or described.

The boring logs and related information depict subsurface conditions only at the specific locations and times where sampling was conducted. The passage of time may result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

GROUNDWATER

Groundwater was not encountered during drilling, immediately upon completion of the drilling operations, or during the previously completed preliminary study. However, it is possible for groundwater to exist beneath this site at shallow depths on a transient basis, particularly following periods of precipitation. Fluctuations in groundwater levels occur due to variation in rainfall and surface water run-off. The construction process itself may also cause variations in the groundwater level.

SWELL/HEAVE POTENTIAL

As discussed in the previous section, the estimated PVR ranges from 2 to 3-3/4 in. along the alignment. The subgrade soils at this site are classified as plastic to highly plastic, and the potential exists for the soils to expand or heave when water is introduced, causing the pavement to become rough or uneven over time. Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also fuel consumption as well as vehicle maintenance costs. Pavement heave can be reduced through various measures but cannot be totally eliminated without full removal of the problematic soil. Measures available for reducing heave include:

- Soil Treatment with Lime or Other Chemicals;
- Removal and Replacement of Moderate to High PI Soils; and/or
- Drains or Barriers to Collect or Inhibit Moisture Infiltration.

Soil treatment with lime (or other chemicals) is typically used to reduce the swelling potential of the upper portion of the pavement subgrade containing plastic soils. Lime and water are mixed with the top 6 to 12 inches (or possibly more) of the subgrade and allowed to mellow or cure for a period of time. After mellowing, the soil-lime mixture is compacted to form a relatively strong soil matrix that can improve pavement performance and potentially reduce soil heave. However, the chemical reaction between the calcium-based additives and the sulfates and/or sulfide minerals in the soil can create a heaving problem on the pavement. If the soil soluble sulfate content exceeds 3,000 ppm, the use of lime to treat the soils will need to be reconsidered. Furthermore, in highly plastic soils, lime treatment of only the top portion of the expansive subgrade may not provide an acceptable reduction in PVR. For a more substantial reduction in PVR, removal and replacement or treatment of the high plasticity index (PI) soil may be the only method available to reduce the potential vertical rise of the pavement to an acceptable level. As stated previously though, it must be recognized that partial removal of expansive clay soil only reduces the potential (or risk) of the damage swell can cause to a pavement and does not completely eliminate this risk.

In addition, capturing water infiltration via French drains, pavement edge drains, or horizontal/vertical moisture barriers would reduce the potential for heave since one important component of the heaving mechanism, water, would be reduced.

It should be noted that the pavement sections recommended in subsequent sections of this report are structurally adequate for the given traffic levels and subgrade strength, but do not consider the long-term effects of pavement roughness due to heave, which can only be addressed by the measures discussed in this section.

PAVEMENT RECOMMENDATIONS

Recommendations for both flexible and rigid pavements are presented in this report. The Owner and/or design team may select either pavement type depending on the performance criteria established for the project. In general, flexible pavement systems have a lower initial construction cost as compared to rigid pavements. However, maintenance requirements over the life of the pavement are typically much greater for flexible pavements. This typically requires regularly scheduled observation and repair, as well as overlays and/or other pavement rehabilitation at approximately one-half to two-thirds of the design life. Rigid pavements are generally more "forgiving", and therefore tend to be more durable and require less maintenance after construction.

For either pavement type, drainage conditions will have a significant impact on long term performance, particularly where permeable base materials are utilized in the pavement section. Drainage considerations are discussed in more detail in a subsequent section of this report.

SUBGRADE CLASSIFICATION

In order to determine the Triaxial Classification for use in our pavement design, a sample of the subgrade soils collected from the vicinity of Boring B-1 (current study) was subjected to a Texas Triaxial test (TEX-117-E). The results of the Texas Triaxial test indicate the subgrade soils at this site have a classification of 4.2 (see Figures 5 and 6). This value was used in the Triaxial checks of the recommended pavement sections presented in a subsequent section of this report.

If clay soils are imported for the purpose of constructing the roadbed, then imported materials must be selected that have a Texas Triaxial classification value of 4.2 or lower. If higher classification clay fill materials are utilized, the pavement sections will have to be increased based on the quality (tested soil classification value) of the imported clays.

RECOMMENDED PAVEMENT SECTIONS

We understand that West San Antonio Street is to be designed using TxDOT design standards per guidance from the client and the City of New Braunfels. The subsequent pavement section options were designed using the provided data as summarized below.

Provided Traffic Information	Value (1)
AADT Beginning, 2040	2,400
AADT End, 2049	3,565
Percent Trucks (1)	4
Percent Growth (1)	2
Lane/Directional Distribution Factors	1.0/0.5
Resultant ESALs from above Traffic Parameters	**1,100,000**

(1) These values were determined using the traffic data provided by the client.

FPS Inputs (1)	
Initial Serviceability Index	4.5
Final Serviceability Index	2.5
ADT, Beginning (Vehicles/Day)	2,400
ADT, End 20 YR (Vehicles/Day)	3,565
18 kip ESAL 20 YR (1 DIR) (millions)	1.1
Percent Trucks	4
ATHWLD (lbs) (2)	12,000
Percent Tandem Axles (2)	50

(1) Default values were used for any inputs not specifically noted in the table.

(2) Estimated using TxDOT *Pavement Design Manual*, June 29, 2021, and our experience with similar roadways.

The assumptions presented above used to evaluate the anticipated traffic should be verified prior to implementing design or construction of the pavement sections presented below.

Flexible Pavements

The flexible pavement sections presented below were designed using the TxDOT program FPS 21. The recommended flexible pavement sections from the FPS 21 analysis are presented in the table below and in Figures 8, 9, and 10. Additionally, the Mechanistic and Triaxial checks are provided in the previously mentioned figures for the recommended pavement sections presented in the table below. Additional flexible pavement options may be provided upon request.

Flexible Pavement Option	Layer Description	Layer Thickness
Flexible Base – Option 1 See Figure 8	Asphalt Concrete Pavement Type C or D Flexible Base (1) Treated Subgrade **Combined Total**	3.5 in. 12.0 in. 6.0 in. **21.5 in.**
Flexible Base – Option 2 See Figure 9	Asphalt Concrete Pavement Type C or D Flexible Base (1) **Combined Total**	4.5 in. 12.0 in. **16.5 in.**
Full Depth Asphalt See Figure 10	Asphalt Concrete Pavement Type C or D Asphalt Concrete Pavement Type B Flexible Base (1) **Combined Total**	2.0 in. 5.0 in. 4.0 in. **11.0 in.**

(1) We recommend that geogrid be incorporated at the bottom of the flexible base layer in all options and at the midpoint of the Flexible Base Options.

The full-depth asphalt option results in a more rigid pavement section and should be carefully considered by the design team before including along the alignments. More rigid pavement sections have a higher likelihood of tensile cracking due to the potential for expansive soils heaving and creating isolated stress concentrations.

Geogrid provides lateral restraint to the flexible base by confining aggregate particles within the plane of the geogrid, thereby creating a reinforced, or mechanically stabilized layer. In our opinion, the incorporation of geogrid below the flexible base layer and at the midpoint of flexible base layers thicker than 10 in. will assist in reducing the potential for cracking due to soil related movements.

Rigid Pavements

The following input variables were utilized to design the recommended rigid pavements in accordance with the *TxDOT Pavement Design Manual*, Revised June 2021, Chapter 8, Section 4, Rigid Pavement Design Process for Concrete Pavement Contraction Design (CPCD) utilizing AASHTO 93 design procedure.

Rigid Pavement Input Values

Input Parameter	Input Value
28-day Concrete Modulus of Rupture, psi	620
28-day Concrete Elastic Modulus, psi	5,000,000
Effective Modulus of Base/Subgrade Reaction, pci	300
Serviceability Indices, Initial/Terminal	4.5/2.5
Load Transfer Coefficient	2.9
Drainage Coefficient	1.01
Overall Standard Deviation	0.39
Reliability, %	90
Design Traffic, 18-kip Equivalent Single Axle Load (ESAL)	1,100,000

CPCD (which is also referred to as Jointed Plain Concrete Pavement) is suggested for roadways with crosswalks, adjacent parking, or sidewalks and is recommended as the rigid pavement type for this City of New Braunfels Street.

Utilizing the TxDOT Pavement Design Manual, AASHTO design procedures, and the design inputs provided above the following rigid pavement options are recommended:

Rigid Pavement Option	Layer Description	Layer Thickness
Option 1	CPCD Pavement Hot Mix Asphalt Bond Breaker Cement Treated Base **Combined Total**	7.0 in. 1.0 in. 6.0 in. **14.0 in.**
Option 2	CPCD Pavement Hot Mix Asphalt, Type B Base (1) **Combined Total**	7.0 in. 4.0 in. **11.0 in.**

(1) Asphalt treated base may be used as an alternative.

Pavement Installation

In order to reduce the potential for isolated stress concentrations in the new pavement sections, we recommend benching the individual layers to offset the transition between new and existing pavement sections (where the reconstruction transitions to an existing alignment), as illustrated in Figure 11. Each bench should extend a minimum of 2 ft horizontally into each of the individual existing pavement layers. Optionally, geogrid should be considered at the top of the prepared subgrade extending the full width of the exposed subgrade area and the 2 ft (minimum) bench into the existing subgrade layer. The seams where the existing and new pavements meet should be sealed with an appropriate sealant conforming to 2024 TxDOT Standard Specifications, Item 300. Transitions between individual pavement layer thicknesses should be gradual.

PAVEMENT CONSTRUCTION CONSIDERATIONS

PAVEMENT SUBGRADE PREPARATION

Preparation for the right-of-way (for streets, sidewalks, utilities, etc.) should be performed in accordance with the 2024 TxDOT Standard Specifications, Item 100 – *Preparing Right of Way*. Exposed subgrades should be thoroughly proofrolled in order to locate any weak, compressible zones. A minimum of 5 passes of a fully loaded dump truck or a similar heavily-loaded piece of construction equipment should be used for planning purposes. Proofrolling operations should be observed by the Geotechnical Engineer or his representative to document subgrade condition and preparation. Weak or soft areas identified during proofrolling should be removed and replaced with a suitable, compacted backfill.

In areas where the clay subgrade will remain in place, the exposed subgrade should be moisture conditioned. This should be done after completion of the proofrolling operations and just prior to flexible base placement. Moisture conditioning is done by scarifying to a minimum depth of 8 in. and recompacting to a minimum of 95 percent of the maximum density determined from the Texas Department of Transportation Compaction Test (TxDOT, Tex-114-E). The moisture content of the subgrade should be maintained within the range of optimum moisture content to 3 percentage points above optimum until permanently covered.

If subgrade treatment is utilized, upon completion of fill grading using the clay subgrade, the final 6 in. of fill should be treated in accordance with the *Treatment of Subgrade* section of this report. If fill grading is not planned, then treatment of the stripped clay subgrade (see *Treatment of Subgrade* section) should be performed in conjunction with the scarifying, moisture conditioning, and recompaction described previously.

ON-SITE CLAY FILL

We recommend that the on-site soils be placed to conform to the 2024 TxDOT Standard Specifications, Item 132 – *Embankment*, Type B, and should be placed in compacted lifts not exceeding 6 in. in thickness and compacted to the requirements of Table 2 in Item 132 based on the maximum density and optimum moisture content as determined by TxDOT, Tex-114-E. The moisture content of the fill should be maintained to be at least equal to the optimum water content, but not exceed 3 percentage points above the optimum water content until permanently covered. Fill materials shall be free of roots and other organic or degradable material. We recommend that the maximum particle size not exceed 3 in. or one half the compacted lift thickness, whichever is smaller. If other import fill materials are utilized, RKI should be notified, as additional testing and thicker pavement sections may be required.

TREATMENT OF SUBGRADE

Lime or cement treatment of the subgrade soils, if utilized, should be in accordance with the 2024 TxDOT Standard Specifications, Item 260 or Item 275, respectively. A sufficient quantity of hydrated lime or cement should be mixed with the subgrade soils to reduce the soil plasticity index to 20 or less. The results of the pH-Lime Series testing show that a 5 percent lime mixture by soil dry unit weight will meet the above plasticity recommendations. For estimating purposes, the dosage rate for lime or cement treatment may be applied at 5 percent of the soil dry unit weight.

If cement treated flexible base is utilized as part of rigid pavement sections, it should conform to the 2024 TxDOT Standard Specifications, Item 276, and have a minimum 7-day compressive strength of 500 psi.

For construction purposes, we recommend that the optimum lime or cement content of the subgrade soils be determined by laboratory testing with representative samples of the subgrade materials being used for this project. Treated subgrade soils should be compacted to a minimum of 95 percent of the maximum density at a moisture content within the range of optimum moisture content to 3 percentage points above the optimum moisture content as determined by Tex-113-E.

The moisture content of finished cement-treated subgrade soils or flexible base, if any, should be maintained for a period of 24–48 hr. During this time, but no sooner than 24 hr., roll the finished course using a vibratory roller to induce microcracking. The vibratory roller must be in accordance with 2024 TxDOT Standard Specifications, Item 210, with a static weight equal to or more than 12 tons, and the vibratory drum must be no less than 20 in. wide. The roller must travel at a speed of 2 mph, vibrating at maximum amplitude, and make two–four passes with 100% coverage excluding the outside 1 ft. of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed. Notify the Engineer 24 hours before the microcracking begins. Cement treated subgrade soils may not produce a cracking pattern during initial vibratory rolling and additional passes of the vibratory roller should be completed at the engineer’s discretion.

We recommend that during site grading operations, additional laboratory testing be performed to determine the concentration of soluble sulfates in the subgrade soils. If present, the sulfate in the soil may react with calcium-based stabilizers such as lime or cement. The adverse reaction, referred to as sulfate-induced heave, has been known to cause cohesive subgrade soils to swell in short periods of time, resulting in pavement heaving and possible failure.

GEOGRID REINFORCEMENT

The geogrid reinforcement should be selected and placed in accordance with 2024 TxDOT Standard Specifications, Item 250, using a Type II TxDOT approved geogrid that conforms to DMS 6240. The geogrid should be placed at the bottom of the flexible (granular) base section in all flexible pavement cases. An alternative to the above geogrid should not be considered without approval from RKI. **In our opinion, incorporating geogrid into the flexible pavement sections will enhance overall pavement performance and reduce the potential for cracking and maintenance in asphalt pavements.**

FLEXIBLE BASE COURSE

The flexible base course should be crushed limestone conforming to the 2024 TxDOT Standard Specifications, Item 247 – *Flexible Base*, Type A, Grades 1-2. The base course should be placed in lifts with a maximum compacted thickness of 8 in. (10 inches loose) and compacted to a minimum of 95 percent of the maximum density determined by Tex-113-E at a moisture content within the range of 2 percentage points below to 2 percentage points above the optimum moisture content as determined by Tex-113-E.

ASPHALT TREATED BASE

Asphalt treated base materials should conform to the 2024 TxDOT Standard Specifications, Item 292. The asphalt treated base should be compacted uniformly to contain 3.8–8.5% in-place air voids, unless otherwise shown on the plans. The Engineer will determine in-place air voids from roadway cores taken in accordance with Section 292.4.11.3., "Placement Sampling." The Engineer will determine air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores must be pre-dried using a CoreDry or similar vacuum device to remove excess moisture.

PRIME COAT

A prime coat should be placed on top of the flexible base course (if used) and should be a MC-30, AE-P, EAP&T, or PCE conforming to the TxDOT Standard Specifications 2024, Item 310– *Prime Coat* or Item 314 – *Emulsified Asphalt Treatment* as well as TxDOT Item 300 – *Asphalts, Oils and Emulsions*. Prime coat application rates are typically between 0.1 to 0.3 gal/yd^2 and are generally dependent upon the absorption rate of the granular base and other environmental conditions at the time of placement. The prime coat layer should be placed on the prepared flexible base as soon as possible. This will facilitate plugging the capillary voids in the flexible base surface to reduce migration of moisture and providing a water resistant surface. The asphalt layer should be placed as soon as possible after the prime coat has been properly set/cured.

TACK COAT

A tack coat should be placed between asphaltic concrete base and/or surface lifts and should be SS-1H, CSS-1H, EAP&T, or a PG binder with a minimum high-temperature grade of PG 58 conforming to TxDOT Standard Specification 2024, Item 341, para 2.5 – *Tack Coat*.

ASPHALTIC CONCRETE SURFACE AND/OR BINDER[1] COURSES

The asphaltic concrete surface and/or binder courses should conform to the 2024 TxDOT Standard Specifications, Item 341 – *Dense Graded Hot-Mix Asphalt or Item 341 Paragraph 2.6.2 Warm Mix Asphalt (WMA)*, Types C or D for the surface and binder, and Type B for the base, if the full depth asphalt or option 2 rigid pavement section is selected for construction. The asphaltic concrete should be compacted to a minimum of 92 percent of the maximum theoretical specific gravity (Rice) of the mixture determined according to Test Method Tex-227-F. Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method Tex-207-F.

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[1] A binder course is defined as the hot mixed asphalt concrete (HMAC) layer placed directly beneath the HMAC surface or wearing course but is not an asphalt treated base layer.

The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from project roadway specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required roadway specimens at their expense and in a manner and at locations selected by the Engineer.

PORTLAND CEMENT CONCRETE

The Portland cement concrete should be in accordance with Class P concrete of the TxDOT 2024 Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Item 421, Hydraulic Cement Concrete. Requirements include concrete designed to meet a minimum average compressive strength of 3,200 psi at 7-days or a minimum average compressive strength of 4,000 psi at 28-days in accordance with TxDOT standard laboratory test procedure Tex-418-A. Liquid membrane-forming curing compound should be applied as soon as practical after broom finishing the concrete surface. The curing compound will help reduce the loss of water from the concrete. The reduction in the rapid loss in water will help reduce shrinkage cracking of the concrete.

CONCRETE PAVEMENT CONSTRUCTION CONTROL

Construction of Portland Cement Concrete Pavements should be controlled by the 2024 TxDOT Standard Specifications, Item 360 – *Concrete Pavement*. The surface of all concrete pavements should be textured or tined. Texturing using carpet dragging or tining should be in accordance with Item 360, Sections 3.5.1 and 3.5.2. Other texturing techniques may be utilized as described in ACI 330.1-03, Section 3, Subparagraph 9.

LOAD TRANSFER DEVICES

The TxDOT Pavement Design Manual requires the use of tied concrete shoulders, tied curb and gutters, or a widened lane, and the use of load transfer devices.

JOINT SPACING AND DETAILS

Typical joint types in CPCD include control (contraction) joints, isolation joints (sometimes called expansion joints), and construction joints. The recommended joint spacing is 30 times the thickness of the slab up to a maximum of 15 ft. The length of a slab or panel should not be more than 25% greater than its width. Isolation joints are used to separate concrete slabs from other structures or fixed objects within or abutting the paved area to offset the effects of expected differential horizontal and vertical movements. Such structures include, but are not limited to, buildings, light standard foundations, and drop inlets.

Isolation joints are also used at “T” intersections to accommodate differential movement along the different axes. Isolations joints are sometimes referred to as expansion joints. However, they are rarely needed to accommodate concrete expansion, so they are not typically recommended for use as regularly spaced joints.

We recommend a jointing layout plan be established and reviewed by all parties prior to construction. We also recommend avoiding jointing lines which create angles of less than 60 degrees, “T” joints, and interior corners.

Proper curing of the concrete pavement should be initiated immediately after finishing. All control joints should be formed or sawed to a depth of at least 1/3 the thickness of the concrete slab and should extend completely through monolithic curbs (if used). Sawing of control joints should begin as soon as the concrete will not ravel, preferably within 1 to 3 hours using an early entry saw or 4 to 8 hours with a conventional saw. Timing will be dictated by site conditions.

SUGGESTED PAVEMENT DETAILS

Suggested details that can be utilized for construction are:

- TxDOT CPCD-14, Concrete Pavement Details, Contraction Design, T-6 to 12 inches; and
- TxDOT JS-14, Concrete Paving Details, Joint Seals.

MISCELLANEOUS PAVEMENT RELATED CONSIDERATIONS

DRAINAGE CONSIDERATIONS

As with any soil-supported structure, the satisfactory performance of a pavement system is contingent on the provision of adequate surface and subsurface drainage. Insufficient drainage which allows saturation of the pavement subgrade and/or the supporting granular pavement materials will greatly reduce the performance and service life of the pavement systems.

Surface and subsurface drainage considerations crucial to the performance of pavements at this site include (but are not limited to) the following:

- Any known natural or man-made subsurface seepage at the site which may occur at sufficiently shallow depths as to influence moisture contents within the subgrade should be intercepted by drainage ditches or below grade French drains.
- Final site grading should eliminate isolated depressions adjacent to curbs, which may allow surface water to pond and infiltrate into the underlying soils. Curbs should be installed to a sufficient depth to reduce infiltration of water beneath the curbs and into the pavement base materials.
- Pavement surfaces should be maintained to help minimize surface ponding and to provide rapid sealing of any developing cracks. These measures will help reduce infiltration of surface water downward through the pavement section.

UTILITIES

Our experience indicates that significant settlement of backfill can occur in utility trenches, particularly when trenches are deep, when backfill materials are placed in thick lifts with insufficient compaction, and when water can access and infiltrate the trench backfill materials. The potential for water to access the backfill is increased where water can infiltrate flexible base materials due to insufficient penetration of curbs, and at sites where geological features can influence water migration into utility trenches (such as fractures within a rock mass or at contacts between rock and clay formations). It is our belief that another factor which can significantly impact settlement is the migration of fines within the backfill into the open voids in the underlying free-draining bedding material.

To reduce the potential for settlement in utility trenches, we recommend that consideration be given to the following:

- All backfill materials should be placed and compacted in controlled lifts appropriate for the type of backfill and the type of compaction equipment being utilized and all backfilling procedures should be tested and documented.
- Consideration should be given to wrapping free-draining bedding gravels with a geotextile fabric (similar to Mirafi 140N) to reduce the infiltration and loss of fines from backfill material into the interstitial voids in bedding materials.

Alternatively, consideration may be given to utilizing a low strength flowable fill in utility trenches located within the roadway alignments.

LONGITUDINAL CRACKING

It should be understood that asphalt pavement sections in expansive soil environments can develop longitudinal cracking along unprotected pavement edges. In the semi-arid climate of south central Texas this condition typically occurs along the unprotected edges of pavements where moisture fluctuation is allowed to occur over the lifetime of the pavements.

Pavements that do not have a protective barrier to reduce moisture fluctuation of the highly expansive clay subgrade between the exposed pavement edge and that beneath the pavement section tend to develop longitudinal cracks 1 to 4 ft from the edge of the pavement. Once these cracks develop, further degradation and weakening of the underlying granular base may occur due to water seepage through the cracks. The occurrence of these cracks can be more prevalent in the absence of lateral restraint and steep embankments. This problem can best be addressed by providing either a horizontal or vertical moisture barrier at the unprotected pavement edge.

A horizontal barrier is commonly in the form of a paved shoulder extending 8 feet or greater beyond the edge of the pavement. Other methods of shoulder treatment, such as using geofabrics beyond the edge of the roadway, are sometimes used in an effort to help reduce longitudinal cracking. Although this alternative does not eliminate the longitudinal cracking phenomenon, the location of the cracking is transferred to the shoulder rather than within the traffic lane.

Vertical barriers installed along the unprotected edges of roadway pavements are also effective in preventing non-uniform drying and shrinkage of the subgrade clays. These barriers are typically in the form of a vertical moisture barrier/membrane extending 6 feet or greater below the top of the subgrade at the pavement edge. Both types of barriers must be sealed at the edge of the pavement to prevent a crack that would facilitate the drying of the subgrade clays.

At a minimum, we recommend that the curbs are constructed such that the depth of the curb extends through the entire depth of the granular base material and into the subgrade to act as a protective barrier against the infiltration of water into the granular base.

In most cases, a longitudinal crack does not immediately compromise the structural integrity of the pavement system. However, if left unattended, infiltration of surface water runoff into the crack will result in isolated saturation of the underlying base. This will result in pumping of the flexible base, which could lead to rutting, cracking, and pot-holes. For this reason, we recommend that the owner of the facility immediately seal the cracks and develop a periodic sealing program.

PAVEMENT MAINTENANCE

Regular pavement maintenance is critical in maintaining pavement performance over a period of several years. All cracks that develop in asphalt pavements should be regularly sealed. Areas of moderate to severe fatigue cracking (also known as alligator cracking) should be sawcut and removed. The underlying base should be checked for contamination or loss of support and any insufficiencies fixed or removed and the entire area patched. Other typical maintenance techniques should be followed as required.

CURB AND GUTTER

It is good practice to construct curbs such that the depth of the curb extends through the entire depth of the granular base material to act as a protective barrier against the infiltration of water into the granular base. Pavements that do not have this protective barrier to moisture tend to develop longitudinal cracks 1 to 2 ft from the edge of the pavement. Once these cracks develop, further degradation and weakening of the underlying granular base may occur due to water seepage through the cracks.

CONSTRUCTION TRAFFIC

Construction traffic on prepared subgrade, granular base or asphalt treated base (black base) should be restricted as much as possible until the protective asphalt surface pavement is applied. Significant damage to the underlying layers resulting in weakening may occur if heavily loaded vehicles are allowed to use these areas.

CONSTRUCTION RELATED SERVICES

CONSTRUCTION MATERIALS TESTING AND OBSERVATION SERVICES

As presented in the attachment to this report, *Important Information About Your Geotechnical Engineering Report*, subsurface conditions can vary across a project site. The conditions described in this report are based on interpolations derived from a limited number of data points. Variations will be encountered during construction, and only the geotechnical design engineer will be able to determine if these conditions are different than those assumed for design.

Construction problems resulting from variations or anomalies in subsurface conditions are among the most prevalent on construction projects and often lead to delays, changes, cost overruns, and disputes. These variations and anomalies can best be addressed if the geotechnical engineer of record, RKI is retained to perform construction observation and testing services during the construction of the project. This is because:

- RKI has an intimate understanding of the geotechnical engineering report’s findings and recommendations. RKI understands how the report should be interpreted and can provide such interpretations on site, on the client’s behalf.
- RKI knows what subsurface conditions are anticipated at the site.

- RKI is familiar with the goals of the owner and project design professionals, having worked with them in the development of the geotechnical workscope. This enables RKI to suggest remedial measures (when needed) which help meet the owner's and the design teams' requirements.
- RKI has a vested interest in client satisfaction, and thus assigns qualified personnel whose principal concern is client satisfaction. This concern is exhibited by the manner in which contractors' work is tested, evaluated and reported, and in selection of alternative approaches when such may become necessary.
- RKI cannot be held accountable for problems which result due to misinterpretation of our findings or recommendations when we are not on hand to provide the interpretation which is required.

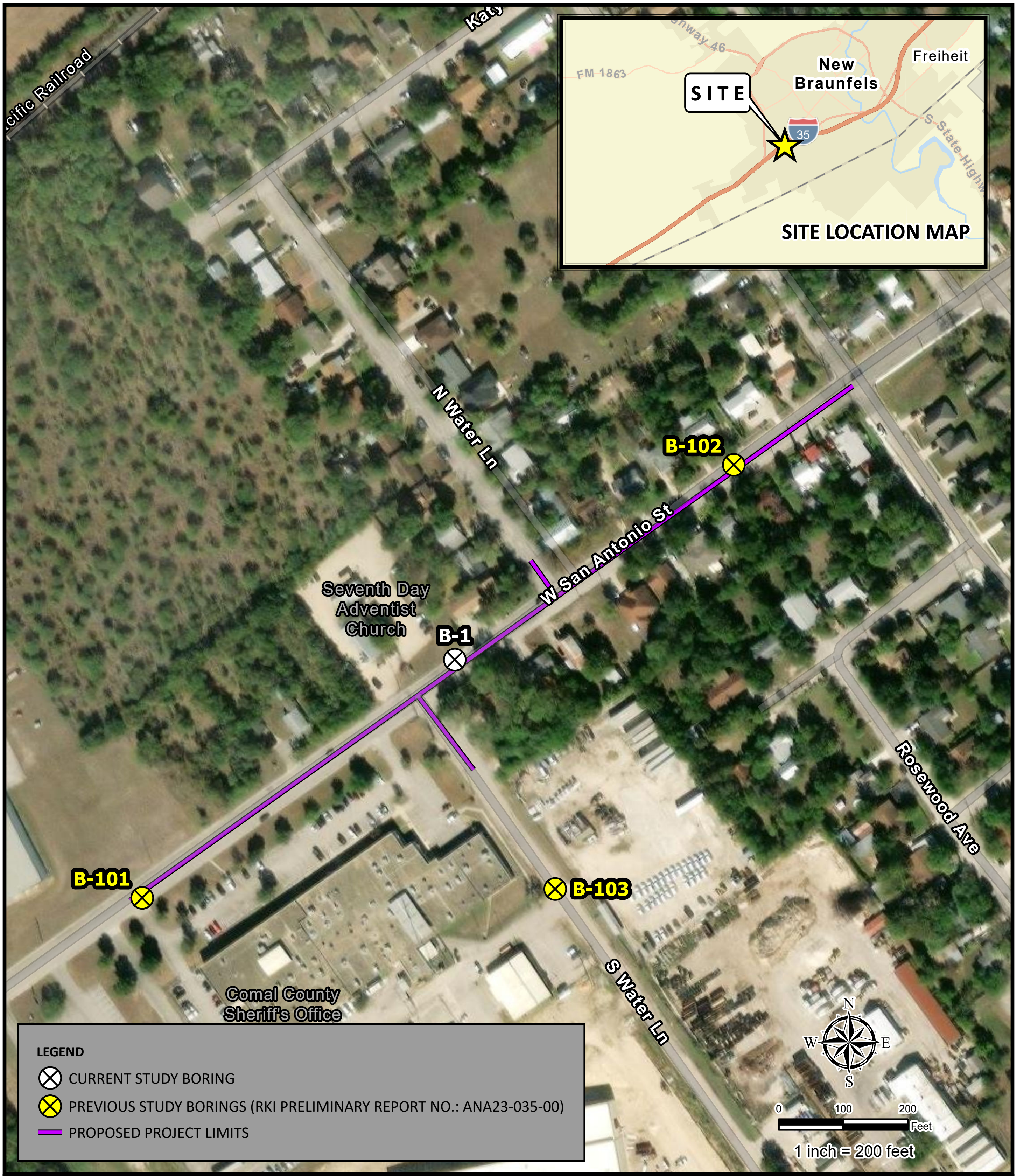
BUDGETING FOR CONSTRUCTION TESTING

Appropriate budgets need to be developed for the required construction testing and observation activities. At the appropriate time before construction, we advise that RKI and the project designers meet and jointly develop the testing budgets, as well as review the testing specifications as it pertains to this project.

Once the construction testing budget and scope of work are finalized, we encourage a preconstruction meeting with the selected contractor to review the scope of work to make sure it is consistent with the construction means and methods proposed by the contractor. RKI looks forward to the opportunity to provide continued support on this project, and would welcome the opportunity to meet with the Project Team to develop both a scope and budget for these services.

* * * * * * * * * * * * * * * * * *

ATTACHMENTS



RABA KISTNER

211 Trade Center, Suite 300
New Braunfels, Texas 78130

(830)214-0544 TEL
(830)214-0627 FAX
www.rkci.com

TBPE Firm Number 3257

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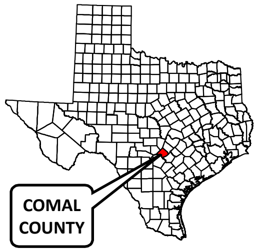
World Imagery: Maxar, Microsoft

BORING LOCATION MAP

West San Antonio Street
Pavement Reconstruction
New Braunfels, Texas



PROJECT No.:	ANA24-024-00
ISSUE DATE:	7/17/2024
DRAWN BY:	BM
CHECKED BY:	RD
REVIEWED BY:	TIP

FIGURE

1

NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

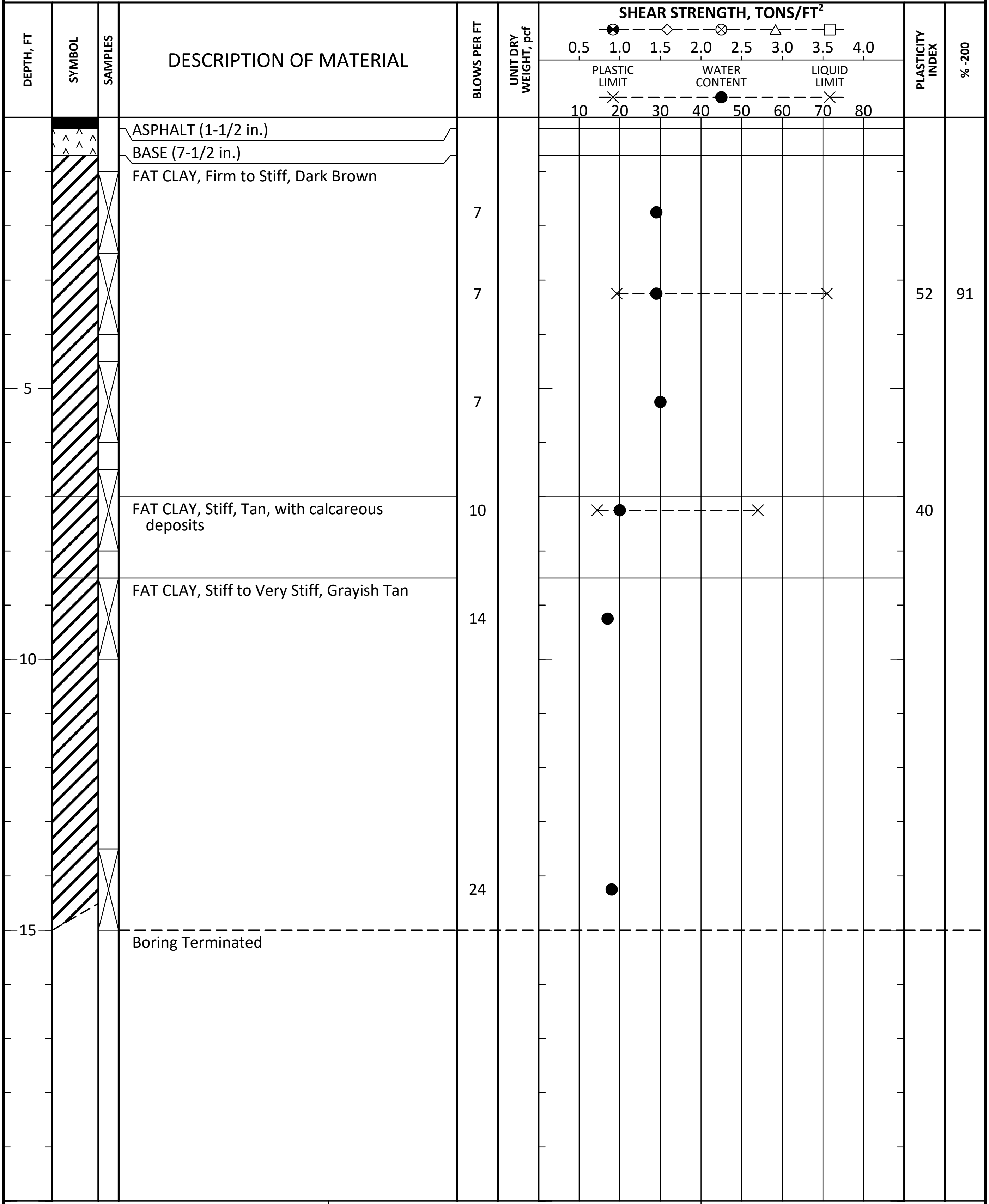
LOG OF BORING NO. B-1

West San Antonio Street
Pavement Reconstruction
New Braunfels, Texas

TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.68116; W 98.15071



DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	ASPHALT (1-1/2 in.)				
	BASE (7-1/2 in.)				
	FAT CLAY, Firm to Stiff, Dark Brown	7			
		7		52	91
5		7			
	FAT CLAY, Stiff, Tan, with calcareous deposits	10		40	
	FAT CLAY, Stiff to Very Stiff, Grayish Tan	14			
10					
		24			
15	Boring Terminated				

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 15.0 ft
DATE DRILLED: 7/23/2024
DEPTH TO WATER: Dry
DATE MEASURED: 7/23/2024
PROJ. No.: ANA24-024-00
FIGURE: 2

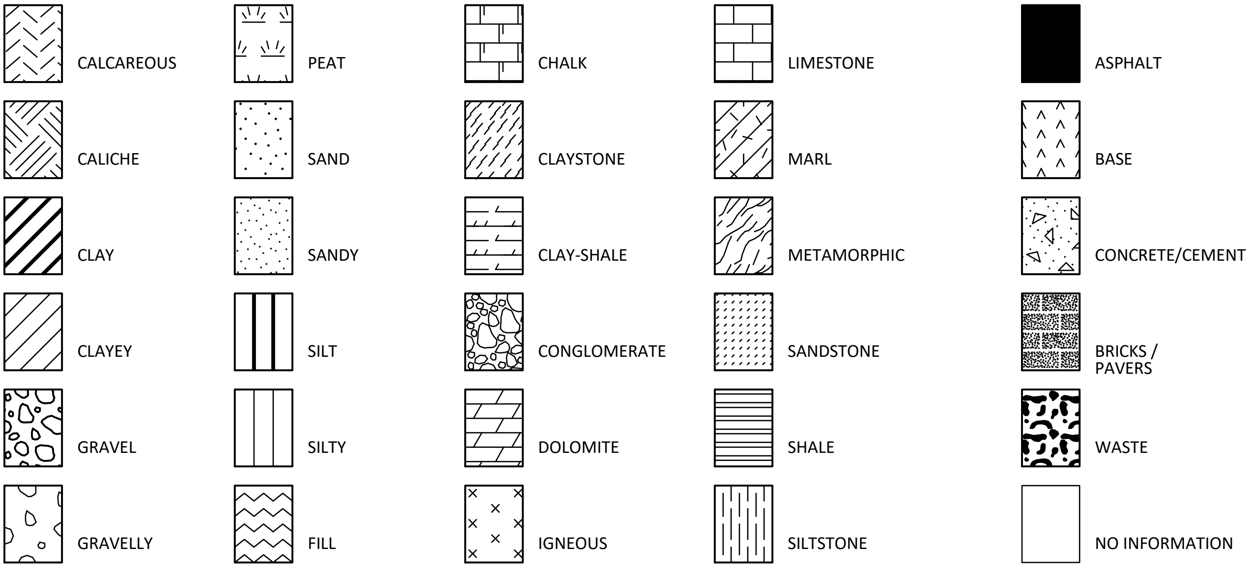
KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

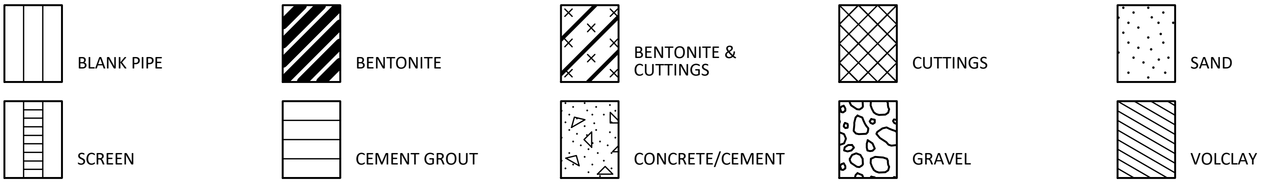
SOIL TERMS

ROCK TERMS

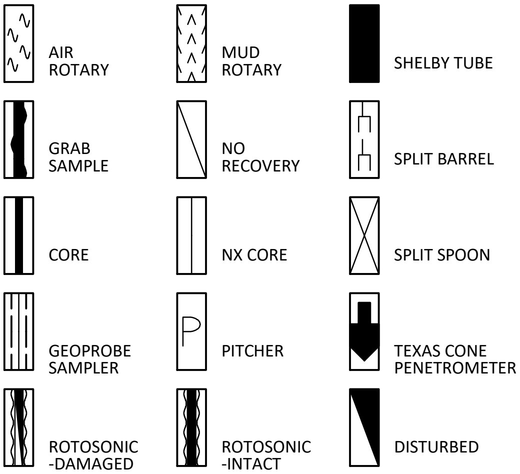
OTHER



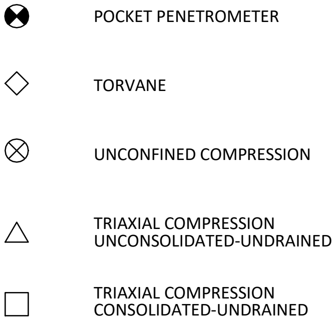
WELL CONSTRUCTION AND PLUGGING MATERIALS



SAMPLE TYPES



STRENGTH TEST TYPES



NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

PROJECT NO. ANA24-024-00

RABAKISTNER

FIGURE 3a

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-06 and D2488-00, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2005.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Depth measurements may be presented in a manner that implies greater precision in depth measurement, i.e 6.71 meters. The reader should understand and interpret this information only within the stated half-foot tolerance on depth measurements.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0 - 2	Very Soft	0 - 0.125
2 - 4	Soft	0.125 - 0.25
4 - 8	Firm	0.25 - 0.5
8 - 15	Stiff	0.5 - 1.0
15 - 30	Very Stiff	1.0 - 2.0
> 30	Hard	> 2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0 - 5	None
5 - 10	Low
10 - 20	Moderate
20 - 40	Plastic
> 40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
NR = Not Recorded/No Recovery
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace Deposits
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Mc = Catahoula Formation
EI = Laredo Formation
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kew = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

SAMPLING METHODS

RELATIVELY UNDISTURBED SAMPLING

Cohesive soil samples are to be collected using three-inch thin-walled tubes in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587) and granular soil samples are to be collected using two-inch split-barrel samplers in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). Cohesive soil samples may be extruded on-site when appropriate handling and storage techniques maintain sample integrity and moisture content.

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-in.-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: West San Antonio Street
Pavement Reconstruction
New Braunfels, Texas

FILE NAME: ANA24-024-00 CONB WEST SAN ANTONIO STREET RECONSTRUCTION.GPJ 8/28/2024

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-1	1.0 to 2.5	7	29								
	2.5 to 4.0	7	29	71	19	52	CH		91		
	4.5 to 6.0	7	30								
	6.5 to 8.0	10	20	54	14	40	CH				
	8.5 to 10.0	14	17								
	13.5 to 15.0	24	18								

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. ANA24-024-00

RABA KISTNER

TEXAS DEPARTMENT OF TRANSPORTATION

TRIAXIAL COMPRESSION TESTS
Tex-117-E

Refresh Workbook

TX117 - File Version: 10/04/19 07:09:14

SAMPLE ID:	B-1	SAMPLED DATE:	
TEST NUMBER:	TEX-117-E	LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	NA
COUNTY:	COMAL	SPEC YEAR:	2014
SAMPLED BY:	RYAN BOATRIGHT	SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:	CH	GRADE:	
MATERIAL NAME:	DARK BROWN FAT CLAY		
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

Moisture-Density Data

Maximum Dry Density (pcf):	91.2
Optimum Moisture Content (%):	21.4
Hygroscopic Moisture Content (%):	6.2

Mass of Mold (universal), (lb):	10.91
Volume of Mold per Linear Inch (universal) (in^3/in):	0.0166
Check here if multiple molds are used:	☐
Mass of Material per Specimen (lb):	12.862
Mass of Water per Specimen (lb):	1.841

Performed By Tex-117-E:	Automated : Part I (Classification)

Triaxial Test Data Sheet

Specimen Data									
Specimen Number:	1	2	3	4	5	6	7	8	9
Cell No.:									
Wet Mass Spec. & Mold, (lb):	25.559	25.627	25.625	25.625	25.555	25.645	25.671	25.674	25.598
Mass of Mold (universal), (lb):	10.910	10.910	10.910	10.910	10.910	10.910	10.910	10.910	10.910
Vol. of Mold (universal) (in^3/in):	0.0166	0.0166	0.0166	0.0166	0.0166	0.0166	0.0166	0.0166	0.0166
Wet Mass Specimen, (lb):	14.649	14.717	14.715	14.715	14.645	14.735	14.761	14.764	14.688
Initial Height of Specimen, in.:									
New Height of Specimen, in.:	8.088	7.997	8.119	8.219	8.057	8.196	8.084	8.164	8.136
Average Diameter, in.:	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Circumference, in. (manual):									
Circumference, in. (auto):	18.850	18.850	18.850	18.850	18.850	18.850	18.850	18.850	18.850
Area, in.^2:	28.27	28.27	28.27	28.27	28.27	28.27	28.27	28.27	28.27
Avg. Cross Sectional Area, in^2:	29.15	29.32	29.09	30.57	30.57	30.57	30.56	30.58	30.57

Dry-Back Data									
Wet Mass of Pan & Specimen, (lb)	17.674	17.742	17.777	17.805	17.688	17.795	17.890	17.874	17.755
Dry Mass of Pan & Specimen, (lb):	15.371	15.361	15.489	15.506	15.439	15.499	15.574	15.553	15.497
Mass of Pan, (lb):	3.032	3.013	3.062	3.071	3.062	3.035	3.107	3.082	3.047
Dry Mass of Material, (lb):	12.339	12.348	12.427	12.435	12.377	12.464	12.467	12.471	12.450
Mass of Water, (lb):	2.303	2.381	2.288	2.299	2.249	2.296	2.316	2.321	2.258
Moisture Content, (%):	18.7	19.3	18.4	18.5	18.2	18.4	18.6	18.6	18.1
Wet Density, (pcf).:	109.1	110.9	109.2	107.9	109.5	108.3	110.0	108.9	108.8
Dry Density, (pcf):	91.9	92.9	92.2	91.0	92.7	91.5	92.8	91.8	92.1

Strength Data									
Lateral Pressure, psi.:	0	0	0	3	3	3	15	15	15
Evaluated Lateral Pressure, psi.:	0	0	0	3	3	3	15	15	15
Calibration Factor:	-4662376.89	-4662376.89	-4662376.89	-4662376.89	-4662376.89	-4662376.89	-4662376.89	-4662376.89	-4662376.89
Excitation:	10.0281067	10.0281067	10.0281067	10.0281067	10.0281067	10.0281067	10.0281067	10.0281067	10.0281067
Zero:	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05	-7.6731E-05
Dead Load, lbs.:	8.300	8.300	8.300	8.300	8.300	8.300	8.300	8.300	8.300
Piston Correction, lbs.:	-0.0702	-0.0750	-0.0715	0.6063	0.5979	0.6009	2.9484	2.9617	2.9756
Max. Load Reading, div.:	-0.0016	-0.0018	-0.0019	-0.0026	-0.0029	-0.0028	-0.0041	-0.0038	-0.0039
Max Load, lbs.:	704.2	806.9	847.0	1165.8	1324.1	1271.9	1892.6	1739.6	1802.1
Deformation at Max Load, in.:	0.24	0.29	0.23	0.62	0.61	0.62	0.61	0.61	0.61
Uncorrected Stress, psi.:	25.2	28.8	30.2	41.5	47.1	45.3	67.2	61.8	64.0
% Strain , in./in.:	3.00	3.58	2.79	7.52	7.52	7.52	7.49	7.53	7.51
I-Strain, in./in.:	0.9700	0.9642	0.9721	0.9248	0.9248	0.9248	0.9251	0.9247	0.9249
Corrected Stress, psi.:	24.4	27.8	29.4	38.4	43.6	41.9	62.2	57.2	59.2

Classification:	**4.2**
Internal Angle of Friction:	**23.0**
Cohesion, psi:	**8.5**
Correlation Factor:	**0.9482**

15 psi

Test results may be omitted by typing 'VOID' in the '<u>Laterial Pressure, psi</u>' cell.

SCA Data (Imported)									
Total Energy (lb-ft) Lift 1:	653.94	645.35	648.20	633.55	661.51	649.63	587.09	659.32	643.05
Total Energy (lb-ft) Lift 2:	647.44	647.26	650.04	652.04	655.87	634.82	560.37	653.59	634.59
Total Energy (lb-ft) Lift 3:	641.80	651.95	616.75	649.37	662.71	659.28	635.73	658.19	644.16
Total Energy (lb-ft) Lift 4:	633.72	660.33	651.68	659.52	658.05	650.66	644.01	650.47	652.78
Energy/Lift (lb-ft) Lift 1:	8.72	8.60	8.64	8.45	8.82	8.66	7.83	8.79	8.57
Energy/Lift (lb-ft) Lift 2:	8.63	8.63	8.67	8.69	8.74	8.46	7.47	8.71	8.46
Energy/Lift (lb-ft) Lift 3:	8.56	8.69	8.22	8.66	8.84	8.79	8.48	8.78	8.59
Energy/Lift (lb-ft) Lift 4:	8.45	8.80	8.69	8.79	8.77	8.68	8.59	8.67	8.70
Avg. Drop Ht. (lb-ft) Lift 1:	12.15	12.14	12.14	12.14	12.13	12.13	12.13	12.13	12.14
Avg. Drop Ht. (lb-ft) Lift 2:	12.14	12.13	12.12	12.13	12.03	12.12	12.14	12.13	12.13
Avg. Drop Ht. (lb-ft) Lift 3:	12.13	12.13	12.12	12.12	12.12	12.13	12.12	12.12	12.13
Avg. Drop Ht. (lb-ft) Lift 4:	12.12	12.13	12.13	12.13	12.12	12.13	12.12	12.11	12.13
No. of Blows (lb-ft) Lift 1:	75	75	75	75	75	75	75	75	75
No. of Blows (lb-ft) Lift 2:	75	75	75	75	75	75	75	75	75
No. of Blows (lb-ft) Lift 3:	75	75	75	75	75	75	75	75	75
No. of Blows (lb-ft) Lift 4:	75	75	75	75	75	75	75	75	75

Remarks:

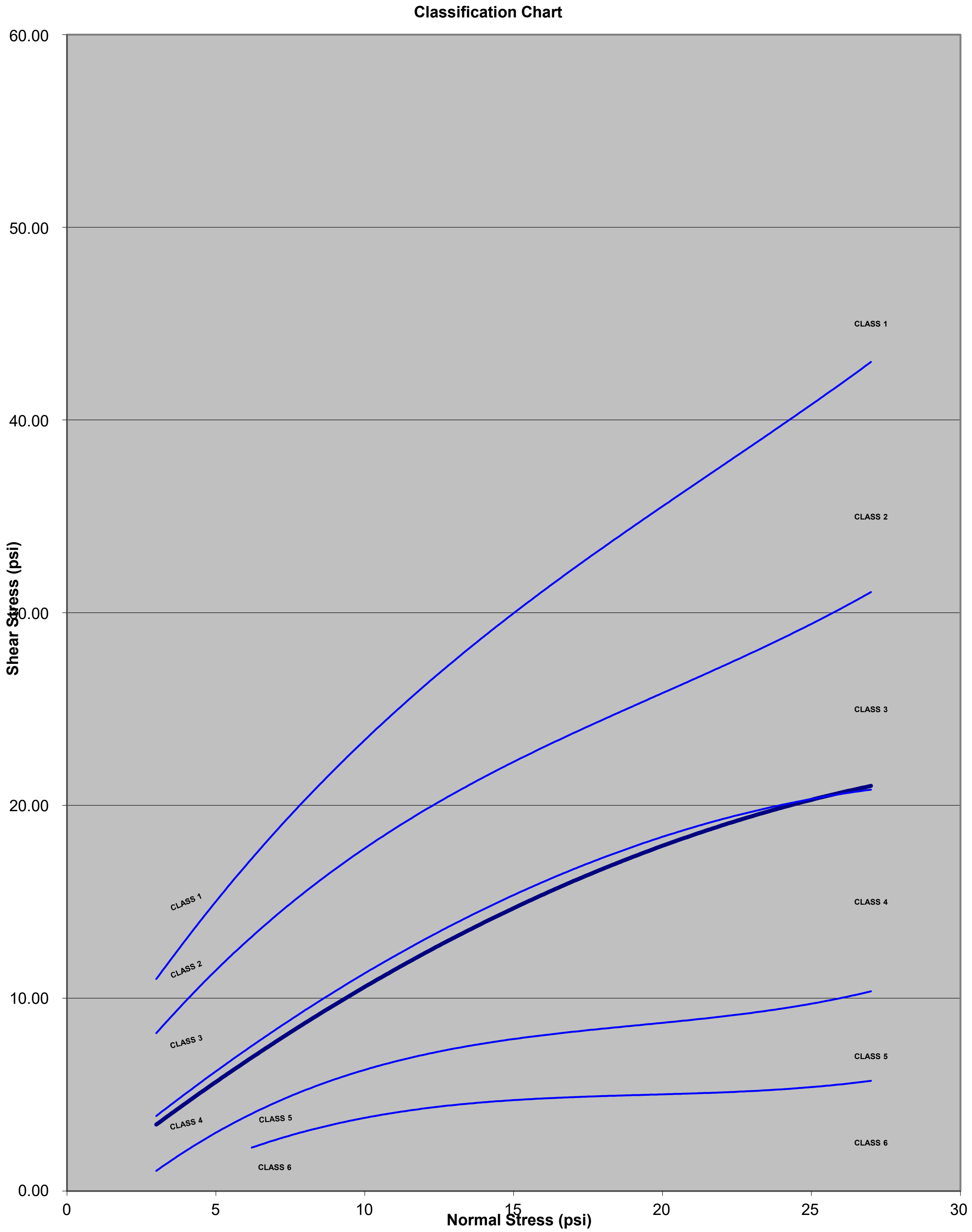
Test Method:	Tested By:	Tech Cert No.:	Tested Date:
TX117	A.Segovia		08/05/24
TX117PI			
TX117PII			

Test Stamp Code:	Omit Test:	Completed Da	Reviewed By:

Locked By:	TxDOT:	District:	Area:

Authorized By:	Authorized Date:	
		5

ANA24-024-00
Figure 5

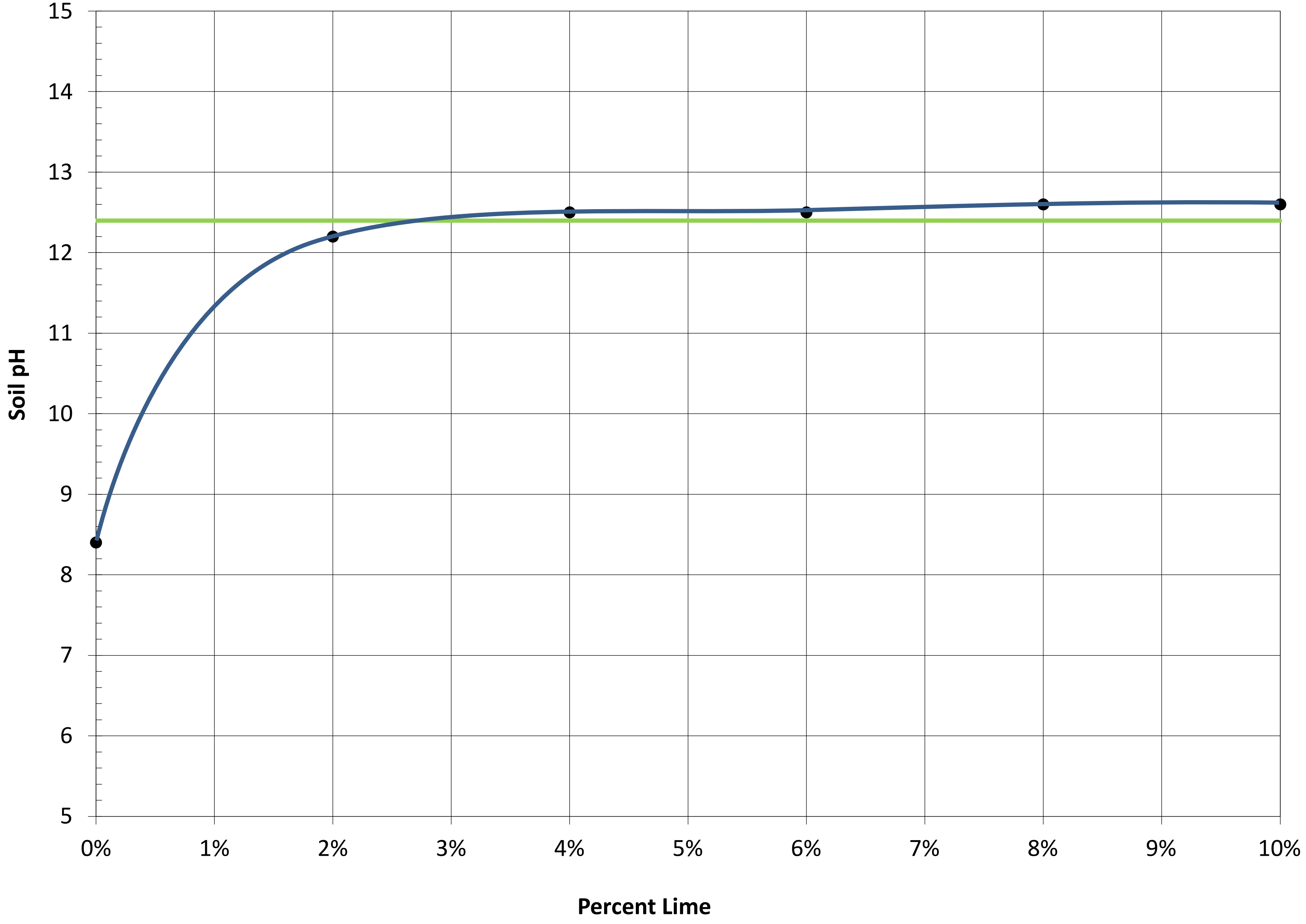


ANA24-024-00

Figure 6

pH-LIME SERIES CURVE

West San Antonio Street, Pavement Reconstruction, New Braunfels, Texas



Texas Department of Transportation

TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

```
------------------------------------------------------------------------------

        PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   1
------------------------------------------------------------------------------
                        COMMENTS ABOUT THIS PROBLEM

Growth Rate = 2%




------------------------------------------------------------------------------
```

BASIC DESIGN CRITERIA

```
  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                   20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                   20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                   10.0
  DESIGN CONFIDENCE LEVEL ( 90.0%)                                          B
  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                            4.5
  FINAL SERVICEABILITY INDEX P2                                            2.5
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                 4.2
  DISTRICT TEMPERATURE CONSTANT                                           31.0
  SUBGRADE ELASTIC MODULUS by COUNTY (ksi)                                12.00
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                           7.0
```

PROGRAM CONTROLS AND CONSTRAINTS

```
  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                 3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)             99.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)              69.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)      6.0
```

TRAFFIC DATA

```
  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                    2400.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                             3565.
  ONE-DIRECTION 20YEAR 18 kip ESAL (millions)                           1.100
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                         70.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION)(MPH)             45.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)        50.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)           6.0
  PERCENT TRUCKS IN ADT                                                    4.0

------------------------------------------------------------------------------
```

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

```
PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   2
```

```
                           INPUT DATA CONTINUED
```

CONSTRUCTION AND MAINTENANCE DATA

```
  MINIMUM OVERLAY THICKNESS (INCHES)                                       1.5
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                   12.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                         1.90
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                         200.0
  WIDTH OF EACH LANE (FEET)                                               12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)               0.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)      0.00
```

DETOUR DESIGN FOR OVERLAYS

```
  TRAFFIC MODEL USED DURING OVERLAYING                                    2
  TOTAL NUMBER OF LANES OF THE FACILITY                                   2
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)             0
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)        1
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                  0.60
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)              0.60
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                         0.00
```

PAVING MATERIALS INFORMATION

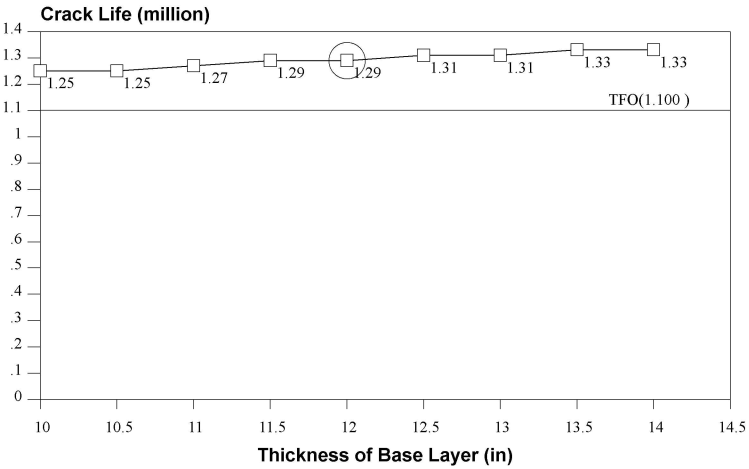
```
              MATERIALS       COST      E     POISSON   MIN.     MAX. SALVAGE
LAYER CODE       NAME        PER CY MODULUS  RATIO   DEPTH    DEPTH   PCT.
  1    A  ASPH CONC PVMT    150.00  500000.   0.35    3.50     6.00   30.00
  2    B  FLEXIBLE BASE      54.00   50000.   0.35   12.00    18.00   75.00
  3    C  STABILIZED SUBGR   15.00   35000.   0.30    6.00    24.00   90.00
  4    D  SUBGRADE(200)       2.00   12000.   0.40  200.00   200.00   90.00


WARNING :
THERE ARE MORE THAN  1000 FEASIBLE INITIAL DESIGNS FOR THIS SET OF MATERIALS
```

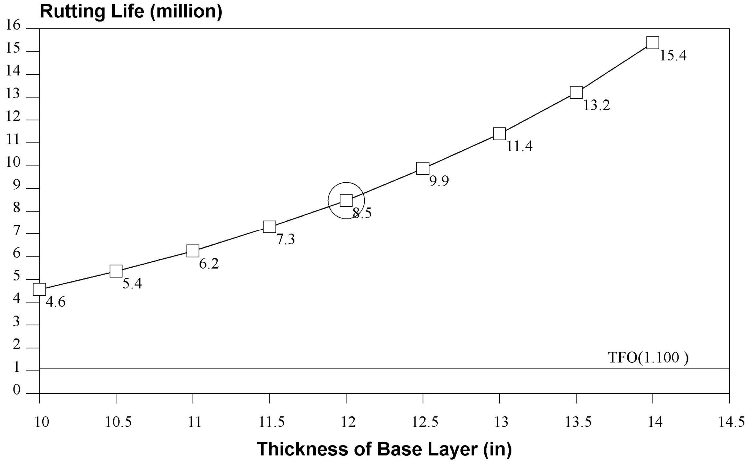
CONSTRAINTS SHOULD BE REVISED - PROBLEM CONTINUES

```
------------------------------------------------------------------------------
                TEXAS DEPARTMENT OF TRANSPORTATION
F P S21-1.5                 FLEXIBLE PAVEMENT SYSTEM              Release:12-12-2018

------------------------------------------------------------------------------

          PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   3
------------------------------------------------------------------------------


     C. LEVEL B       SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST
                         1
------------------------------------------------------------------------------
MATERIAL ARRANGEMENT   ABC
INIT. CONST. COST     35.08
OVERLAY CONST. COST    0.00
USER COST              0.00
ROUTINE MAINT. COST    0.00
SALVAGE VALUE         -5.20
------------------------------------------------------------------------------
TOTAL COST            29.88
------------------------------------------------------------------------------
NUMBER OF LAYERS        3
------------------------------------------------------------------------------
LAYER DEPTH (INCHES)
     D(1)              3.50
     D(2)             12.00
     D(3)              6.00
------------------------------------------------------------------------------
NO.OF PERF.PERIODS      1
------------------------------------------------------------------------------
PERF. TIME (YEARS)
     T(1)             40.
------------------------------------------------------------------------------
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
------------------------------------------------------------------------------


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS      1000










------------------------------------------------------------------------------
```

Figure 8c

	Thickness (inches)	*Modulus (ksi)*	*Poisson's Ratio*	*Material Name*
AC	3.50	500.00	0.35	ASPH CONC PVMT
Base	12.00	50.00	0.35	FLEXIBLE BASE
Subbase	6.00	35.00	0.30	STABILIZED SUBGR
Subgrade	200.00	12.00	0.40	SUBGRADE(200)





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): 1.10 (million)

Crack Life:	1.29 (million)	ε_τ =	214.00 ($\mu\varepsilon$)
Rut Life:	8.48 (million)	ε_v =	-297.00 ($\mu\varepsilon$)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:1.10millions.
Also the start ADT:2400.0 and ending ADT:3565.0

Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output	**(FPS21-1.5Release:12-12-2018)**		
Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			

ANA24-024-00
Figure 8d

	Thickness (inches)	*Modulus (ksi)*	*Poisson's Ratio*	*Material Name*
ASPH CONC PVMT	3.50	500.00	0.35	ASPH CONC PVMT
FLEXIBLE BASE	12.00	50.00	0.35	FLEXIBLE BASE
STABILIZED SUBGR	6.00	35.00	0.30	STABILIZED SUBGR
SUBGRADE(200)	200.00	12.00	0.40	SUBGRADE(200)
Bed Rock		1200.00	0.15	Bed Rock

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	12000.0 (lb)
Percentage of TandemAxles	50.0 (%)
Modified Cohesionmeter Value	300.0
Design Wheel Load	15600.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	4.20

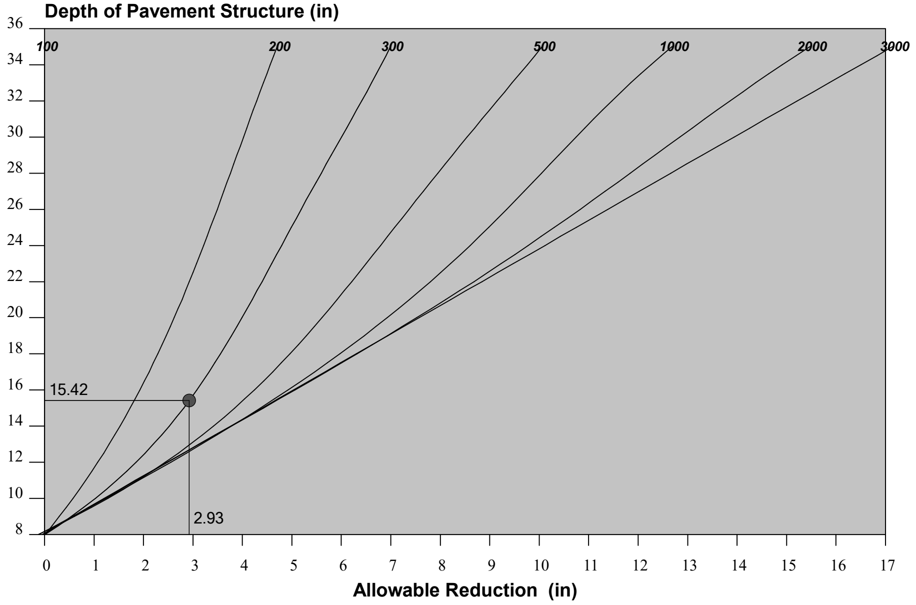
User Input TTC based on historical TEX-117-E

RESULT:

Triaxial Thickness Required	15.4 (in)
The FPS Design Thickness	21.5 (in)
Allowable Thickness Reduction	2.9 (in)
Modified Triaxial Thickness	12.5 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !



Thickness Reduction Chart for Stabilized Layers

FPS 21 Triaxial Design Check Output	**(FPS21-1.5Release:12-12-2018)**		
Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			

Figure 8e

TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

```
--------------------------------------------------------------------------------

             PAVEMENT DESIGN TYPE # 2 -- ACP + FLEX BASE OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE     PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   1
--------------------------------------------------------------------------------
                        COMMENTS ABOUT THIS PROBLEM

Growth Rate = 2%




--------------------------------------------------------------------------------
```

BASIC DESIGN CRITERIA

```
  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                  20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                  20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                  10.0
  DESIGN CONFIDENCE LEVEL ( 90.0%)                                         B
  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                           4.5
  FINAL SERVICEABILITY INDEX P2                                           2.5
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                4.2
  DISTRICT TEMPERATURE CONSTANT                                          31.0
  SUBGRADE ELASTIC MODULUS by COUNTY (ksi)                               12.00
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                          7.0
```

PROGRAM CONTROLS AND CONSTRAINTS

```
  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)            99.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)             69.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)     6.0
```

TRAFFIC DATA

```
  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                   2400.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                            3565.
  ONE-DIRECTION 20YEAR 18 kip ESAL (millions)                          1.100
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                        70.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION)(MPH)            45.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)       50.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)          6.0
  PERCENT TRUCKS IN ADT                                                   4.0

--------------------------------------------------------------------------------
```

PAVEMENT DESIGN TYPE # 2 -- ACP + FLEX BASE OVER SUBGRADE

```
PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE     PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   2
```

INPUT DATA CONTINUED

CONSTRUCTION AND MAINTENANCE DATA

```
MINIMUM OVERLAY THICKNESS (INCHES)                                        1.5
OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                    12.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                          1.90
ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                          200.0
WIDTH OF EACH LANE (FEET)                                                12.0
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)                0.00
ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)       0.00
```

DETOUR DESIGN FOR OVERLAYS

```
TRAFFIC MODEL USED DURING OVERLAYING                                     2
TOTAL NUMBER OF LANES OF THE FACILITY                                    2
NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)              0
NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)         1
DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                   0.60
DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)               0.60
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                          0.00
```

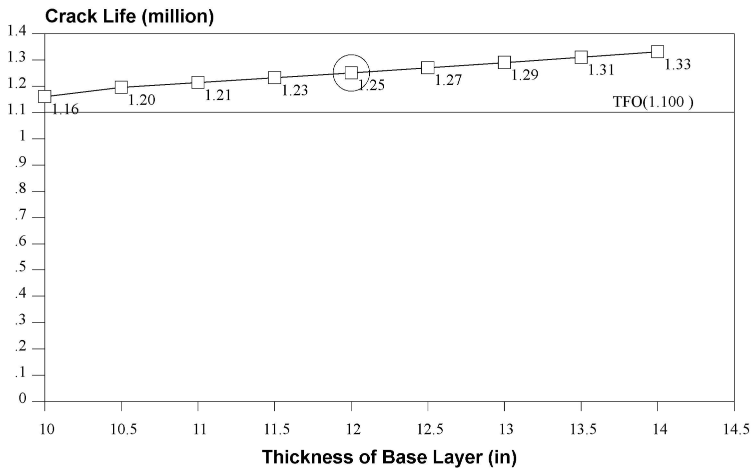
PAVING MATERIALS INFORMATION

```
            MATERIALS       COST      E     POISSON   MIN.     MAX. SALVAGE
LAYER CODE     NAME        PER CY MODULUS  RATIO    DEPTH    DEPTH   PCT.
  1    A  ASPH CONC PVMT   150.00  500000.   0.35    4.50     8.00   30.00
  2    B  FLEXIBLE BASE     54.00   35400.   0.35   12.00    24.00   75.00
  3    C  SUBGRADE(200)      2.00   12000.   0.40  200.00   200.00   90.00
```

Texas Department of Transportation

```
--------------------------------------------------------------------------------
                   TEXAS DEPARTMENT OF TRANSPORTATION
F P S21-1.5                FLEXIBLE PAVEMENT SYSTEM              Release:12-12-2018

--------------------------------------------------------------------------------

           PAVEMENT DESIGN TYPE # 2 -- ACP + FLEX BASE OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   3
--------------------------------------------------------------------------------


     C. LEVEL B       SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST
                         1
--------------------------------------------------------------------------------
MATERIAL ARRANGEMENT   AB
INIT. CONST. COST     36.75
OVERLAY CONST. COST    0.00
USER COST              0.00
ROUTINE MAINT. COST    0.00
SALVAGE VALUE         -4.94
--------------------------------------------------------------------------------
TOTAL COST            31.81
--------------------------------------------------------------------------------
NUMBER OF LAYERS        2
--------------------------------------------------------------------------------
LAYER DEPTH (INCHES)
     D(1)              4.50
     D(2)             12.00
--------------------------------------------------------------------------------
NO.OF PERF.PERIODS      1
--------------------------------------------------------------------------------
PERF. TIME (YEARS)
     T(1)              38.
--------------------------------------------------------------------------------
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
--------------------------------------------------------------------------------


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS       200











--------------------------------------------------------------------------------
```

	Thickness (inches)	*Modulus (ksi)*	*Poisson's Ratio*	*Material Name*
AC	4.50	500.00	0.35	ASPH CONC PVMT
Base	12.00	35.40	0.35	FLEXIBLE BASE
Subgrade	200.00	12.00	0.40	SUBGRADE(200)



Fatigue Crack Model:

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

f_1 =7.96E-02

f_2 = 3.291

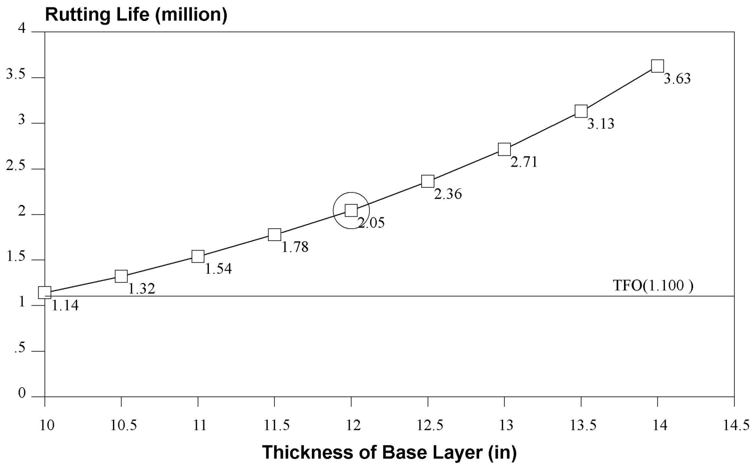
f_3 = .854

Rutting Model:

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

f_4 =1.37E-09

f_5 = 4.477



TFO(Traffic to 1st Overlay): 1.10 (million)

Crack Life: 1.25 (million) $\varepsilon_\tau =$ 216.00 ($\mu\varepsilon$)

Rut Life: 2.05 (million) $\varepsilon_v =$ -408.00 ($\mu\varepsilon$)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:1.10millions.
Also the start ADT:2400.0 and ending ADT:3565.0

Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)

Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL

Design Type:Asphalt concrete + Flexible Base over Subgrade

Figure 9d

	Thickness (inches)	*Modulus (ksi)*	*Poisson's Ratio*	*Material Name*
ASPH CONC PVMT	4.50	500.00	0.35	ASPH CONC PVMT
FLEXIBLE BASE	12.00	35.44	0.35	FLEXIBLE BASE
SUBGRADE(200)	200.00	12.00	0.40	SUBGRADE(200)
Bed Rock		1200.00	0.15	Bed Rock

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	12000.0 (lb)
Percentage of TandemAxles	50.0 (%)
Modified Cohesionmeter Value	300.0
Design Wheel Load	15600.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	4.20

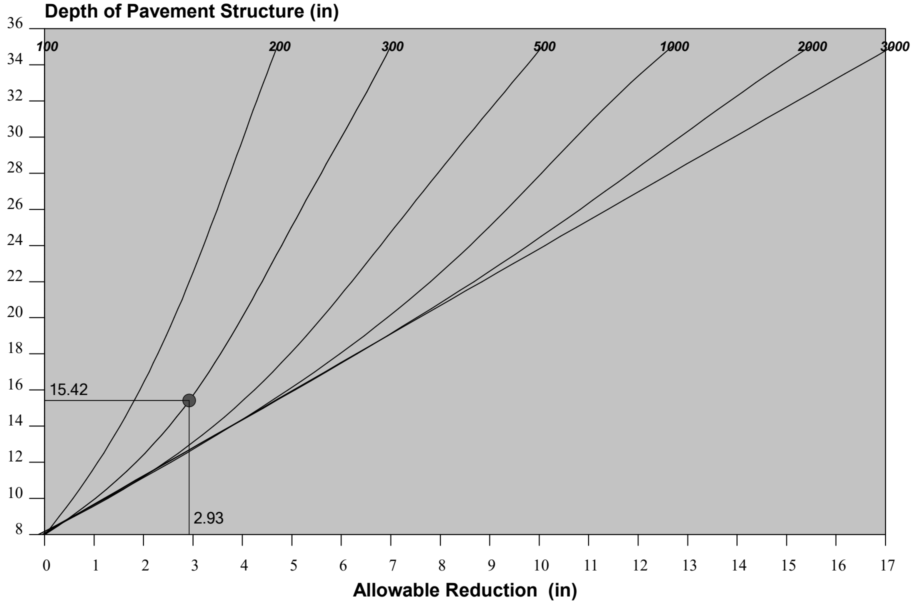
User Input TTC based on historical TEX-117-E

RESULT:

Triaxial Thickness Required	15.4 (in)
The FPS Design Thickness	16.5 (in)
Allowable Thickness Reduction	2.9 (in)
Modified Triaxial Thickness	12.5 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !



Thickness Reduction Chart for Stabilized Layers

FPS 21 Triaxial Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL

Design Type:Asphalt concrete + Flexible Base over Subgrade

Texas Department of Transportation

TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

```
                 PAVEMENT DESIGN TYPE # 7 -- USER DEFINED PAVEMENT

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE     PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   1
--------------------------------------------------------------------------------
                        COMMENTS ABOUT THIS PROBLEM

Growth Rate = 2%




--------------------------------------------------------------------------------
```

BASIC DESIGN CRITERIA

```
  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                   20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                   20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                   10.0
  DESIGN CONFIDENCE LEVEL ( 90.0%)                                          B
  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                            4.5
  FINAL SERVICEABILITY INDEX P2                                            2.5
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                 4.2
  DISTRICT TEMPERATURE CONSTANT                                           31.0
  SUBGRADE ELASTIC MODULUS by COUNTY (ksi)                                12.00
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                           7.0
```

PROGRAM CONTROLS AND CONSTRAINTS

```
  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                 3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)             99.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)              69.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)      6.0
```

TRAFFIC DATA

```
  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                    2400.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                             3565.
  ONE-DIRECTION 20YEAR 18 kip ESAL (millions)                           1.100
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                         70.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION)(MPH)             45.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)        50.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)           6.0
  PERCENT TRUCKS IN ADT                                                    4.0

--------------------------------------------------------------------------------
```

ANA24-024-00
Figure 10a

Texas Department of Transportation

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TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

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                 PAVEMENT DESIGN TYPE # 7 -- USER DEFINED PAVEMENT

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   2
------------------------------------------------------------------------------

                           INPUT DATA CONTINUED
```

CONSTRUCTION AND MAINTENANCE DATA

```
  MINIMUM OVERLAY THICKNESS (INCHES)                                      1.5
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                  12.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                        1.90
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                        200.0
  WIDTH OF EACH LANE (FEET)                                              12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)              0.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)     0.00
```

DETOUR DESIGN FOR OVERLAYS

```
  TRAFFIC MODEL USED DURING OVERLAYING                                   2
  TOTAL NUMBER OF LANES OF THE FACILITY                                  2
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)            0
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)       1
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                 0.60
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)             0.60
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                        0.00
```

PAVING MATERIALS INFORMATION

```
             MATERIALS       COST     E    POISSON   MIN.    MAX. SALVAGE
LAYER CODE      NAME        PER CY MODULUS  RATIO   DEPTH   DEPTH   PCT.
  1    B  DENSE-GRADED HMA T150.00  500000.   0.35    2.00    2.00   30.00
  2    C  DENSE-GRADED HMA T150.00  650000.   0.35    5.00   12.00   90.00
  3    M  FLEXIBLE BASE      54.00   50000.   0.35    4.00    6.00   75.00
  4    T  SUBGRADE            2.00   12000.   0.40  200.00  200.00   90.00
```

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             PAVEMENT DESIGN TYPE # 7 -- USER DEFINED PAVEMENT

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

001   San Antonio     COMAL      0000    00    000    W. SA St.  8/30/2024   3
--------------------------------------------------------------------------------


     C. LEVEL B       SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST
                         1
--------------------------------------------------------------------------------
MATERIAL ARRANGEMENT   BCM
INIT. CONST. COST     35.17
OVERLAY CONST. COST    0.00
USER COST              0.00
ROUTINE MAINT. COST    0.00
SALVAGE VALUE         -6.65
--------------------------------------------------------------------------------
TOTAL COST            28.51
--------------------------------------------------------------------------------
NUMBER OF LAYERS        3
--------------------------------------------------------------------------------
LAYER DEPTH (INCHES)
     D(1)              2.00
     D(2)              5.00
     D(3)              4.00
--------------------------------------------------------------------------------
NO.OF PERF.PERIODS      1
--------------------------------------------------------------------------------
PERF. TIME (YEARS)
     T(1)              40.
--------------------------------------------------------------------------------
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
--------------------------------------------------------------------------------


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS        75
```
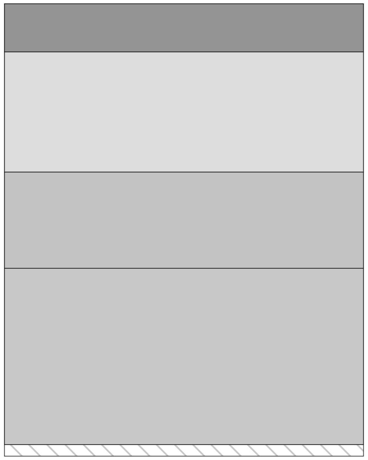
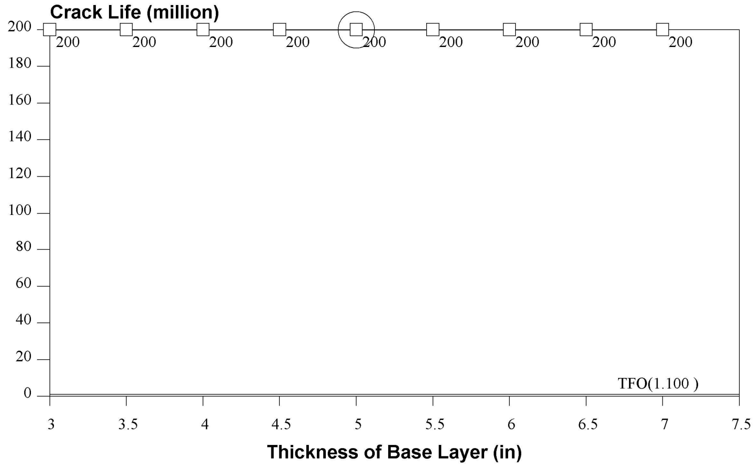

Figure 10c



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
2.00	500.00	0.35	DENSE-GRADED HMA Thin
5.00	650.00	0.35	DENSE-GRADED HMA Thick
4.00	50.00	0.35	FLEXIBLE BASE
200.00	12.00	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

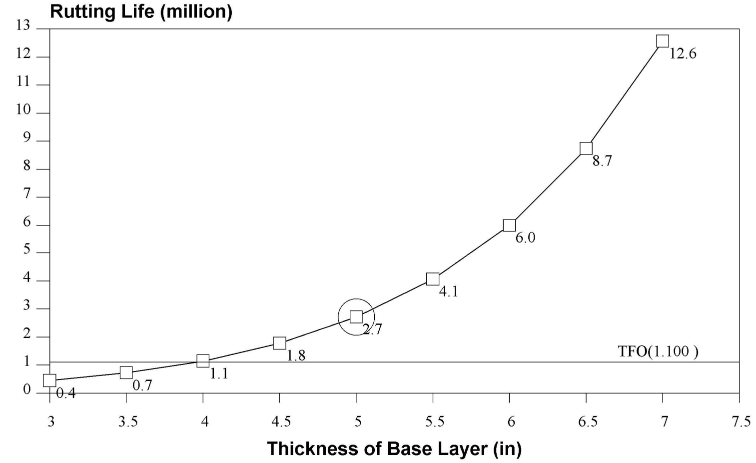
f_3 = .854

Rutting Model:

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

f_4 =1.37E-09

f_5 = 4.477



TFO(Traffic to 1st Overlay): 1.10 (million)

Crack Life: 200.00 (million) $\varepsilon_\tau =$ -15.60 ($\mu\varepsilon$)

Rut Life: 2.71 (million) $\varepsilon_v =$ -383.00 ($\mu\varepsilon$)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:1.10millions.
Also the start ADT:2400.0 and ending ADT:3565.0

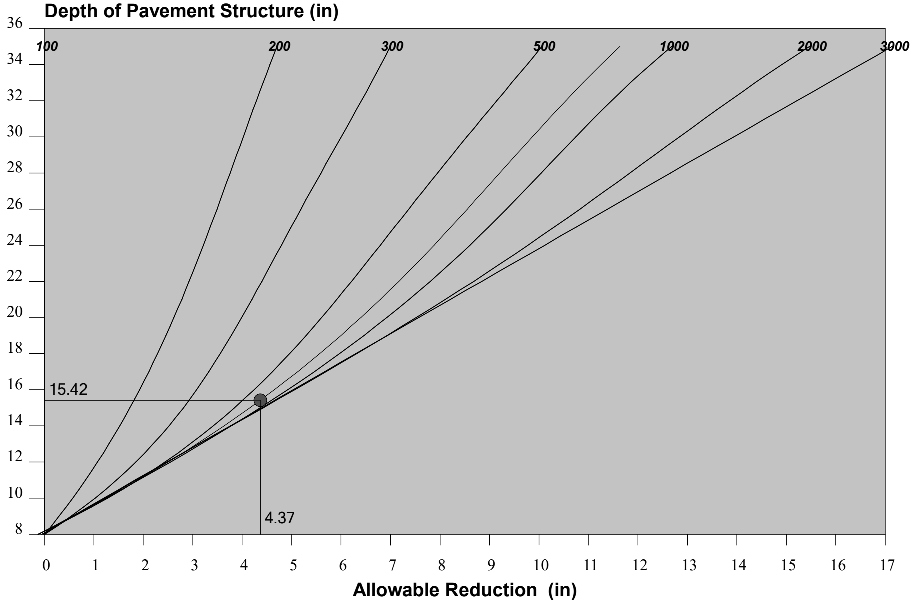
Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL
Design Type:User Defined Pavement Design			

ANA24-024-00
Figure 10d

	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	5.00	650.00	0.35	DENSE-GRADED HMA Thick
FLEXIBLE BASE	4.00	50.00	0.35	FLEXIBLE BASE
SUBGRADE	200.00	12.00	0.40	SUBGRADE
Bed Rock		1200.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	12000.0 (lb)
Percentage of TandemAxles	50.0 (%)
Modified Cohesionmeter Value	800.0
Design Wheel Load	15600.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	4.20

User Input TTC based on historical TEX-117-E

RESULT:

Triaxial Thickness Required	15.4 (in)
The FPS Design Thickness	11.0 (in)
Allowable Thickness Reduction	4.4 (in)
Modified Triaxial Thickness	11.1 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !

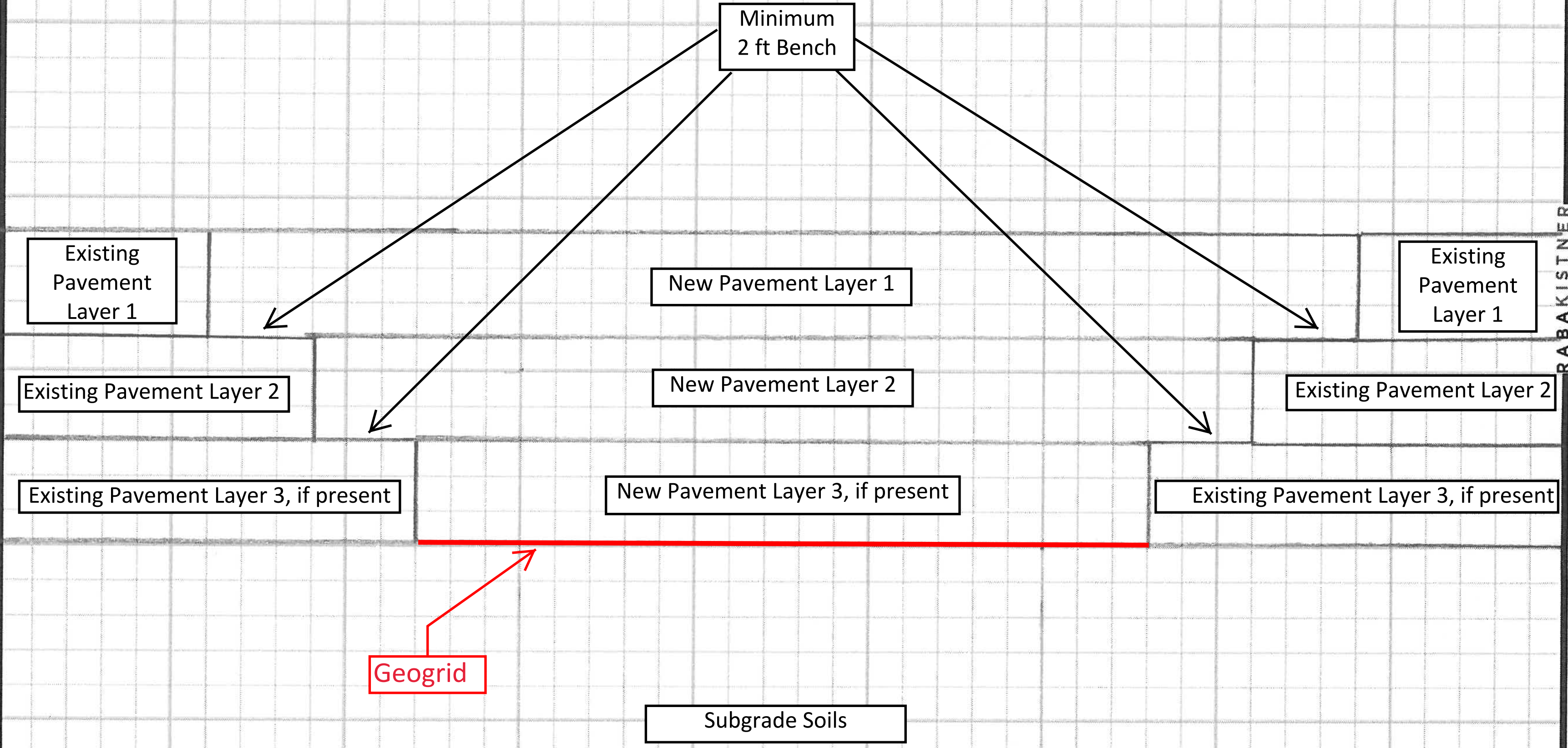
FPS 21 Triaxial Design Check Output (FPS21-1.5Release:12-12-2018)

Highway	W. SA St.	Problem	001
C-S-J	0000 - 00 - 000	Date	8/30/2024
District	San Antonio	County	COMAL

Design Type:User Defined Pavement Design

Figure 11: Pavement Benching Diagram

NTS



ATTACHMENT B

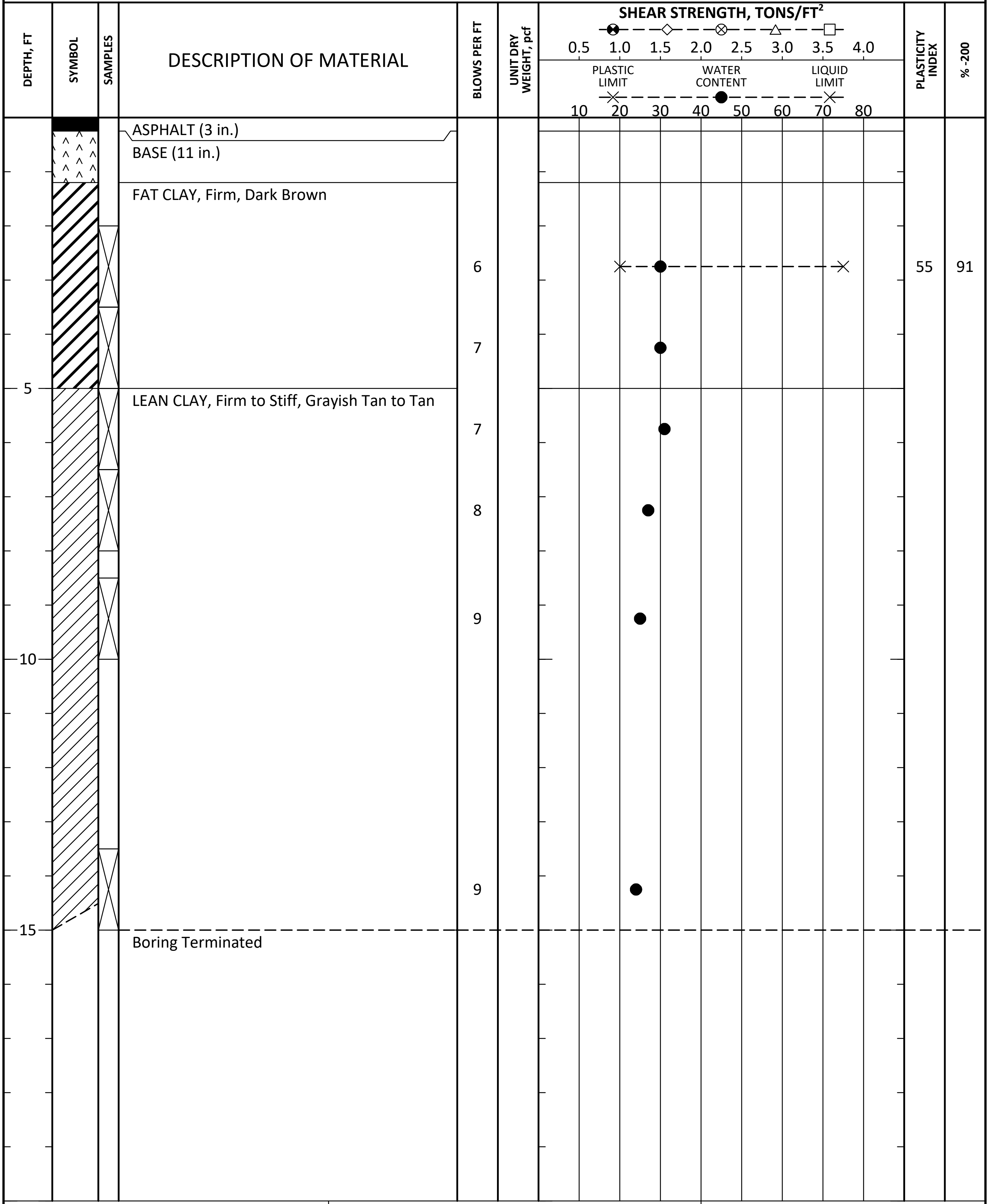
LOG OF BORING NO. B-101

Preliminary Pavement Study
West San Antonio Street & South Water Lane
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.67990; W 98.15343



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 15.0 ft
DATE DRILLED: 9/20/2023

DEPTH TO WATER: Dry
DATE MEASURED: 9/20/2023

PROJ. No.: ANA23-035-00
FIGURE: B1

LOG OF BORING NO. B-102

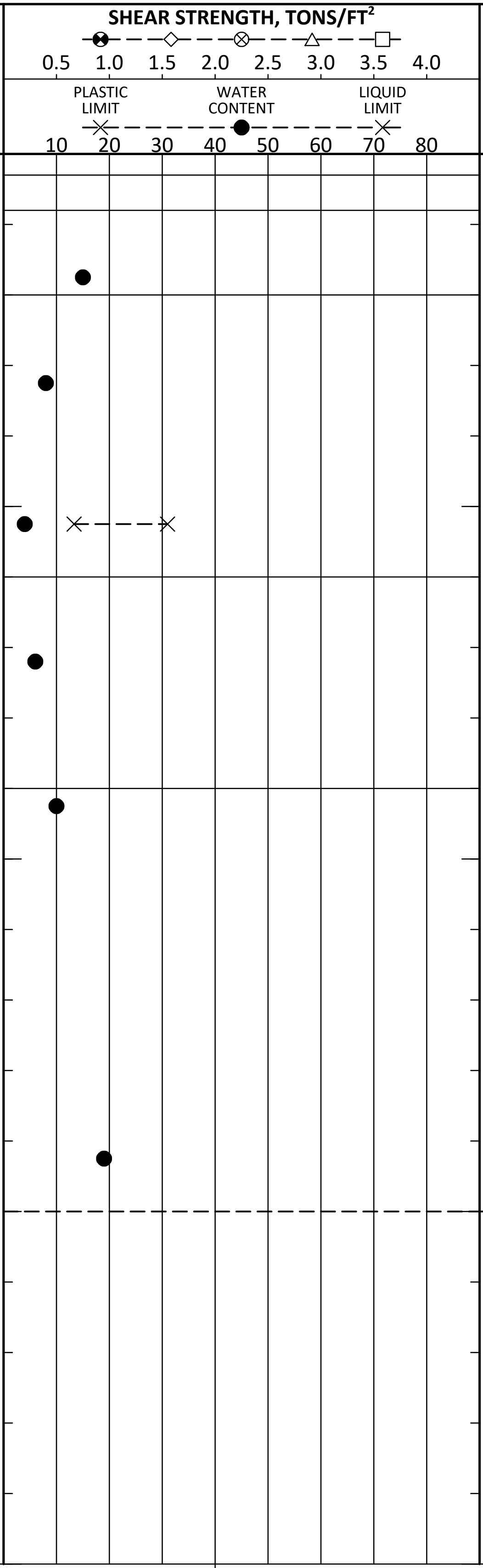
Preliminary Pavement Study
West San Antonio Street & South Water Lane
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.68243; W 98.14929

DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
ASPHALT (4 in.)				
BASE (6 in.)				
FAT CLAY, Stiff, Dark Brown	13			
LEAN CLAY, Stiff to Very Stiff, Tan, with calcareous deposits and gravel	25 27		 18	 74
LEAN CLAY, Hard, Tan, with calcareous deposits and gravel	50/11"			
LEAN CLAY, Hard to Very Stiff, Grayish Tan, with ferric staining	30 20			
Boring Terminated				



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 15.0 ft
DATE DRILLED: 9/20/2023
DEPTH TO WATER: Dry
DATE MEASURED: 9/20/2023
PROJ. No.: ANA23-035-00
FIGURE: B2

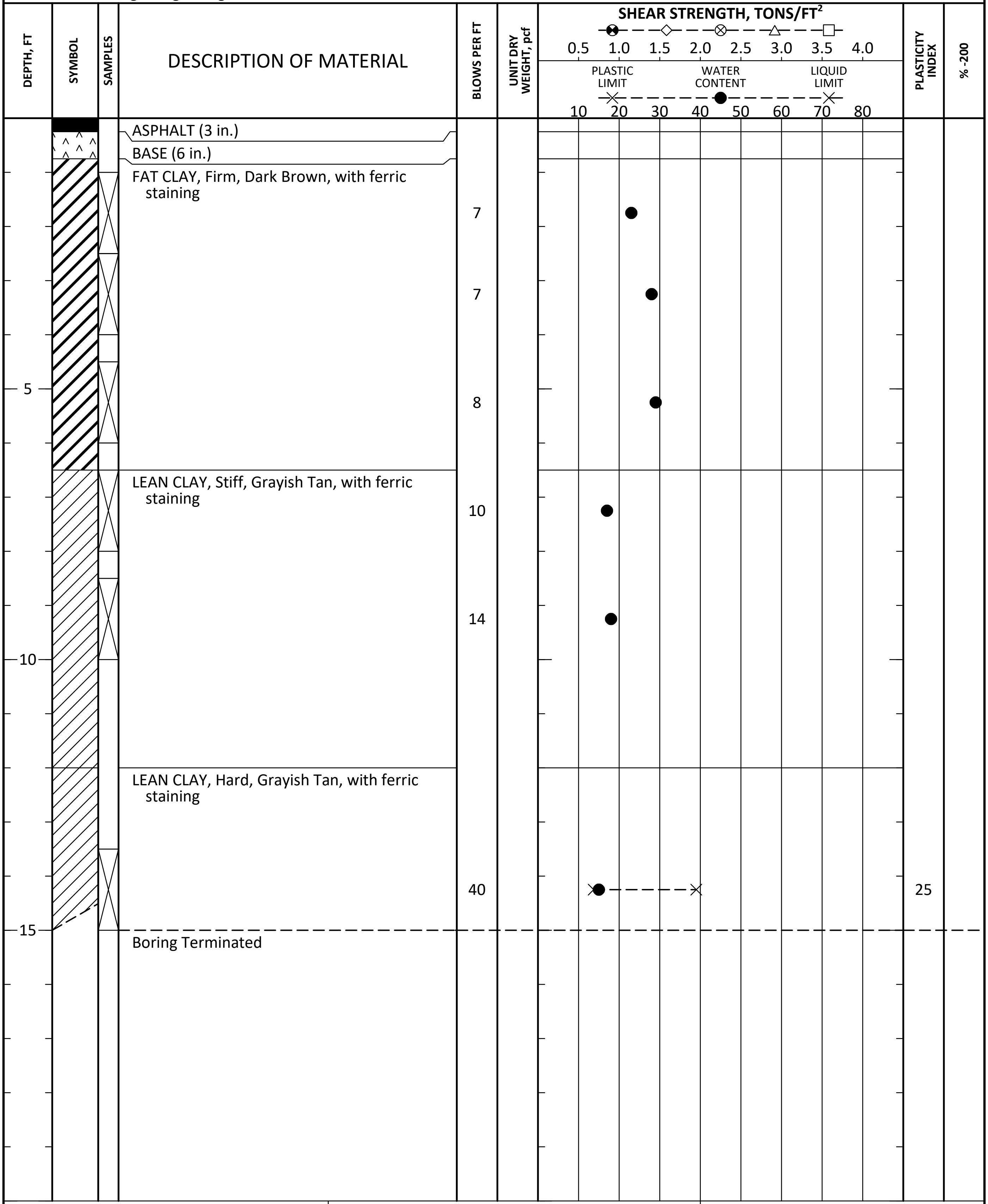
LOG OF BORING NO. B-103

Preliminary Pavement Study
West San Antonio Street & South Water Lane
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.68008; W 98.14974



DESCRIPTION OF MATERIAL	BLOWS PER FT	PLASTICITY INDEX
ASPHALT (3 in.)		
BASE (6 in.)		
FAT CLAY, Firm, Dark Brown, with ferric staining	7 7 8	
LEAN CLAY, Stiff, Grayish Tan, with ferric staining	10 14	
LEAN CLAY, Hard, Grayish Tan, with ferric staining	40	25
Boring Terminated		

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	15.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA23-035-00
DATE DRILLED:	9/20/2023	**DATE MEASURED:**	9/20/2023	**FIGURE:**	B3

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Preliminary Pavement Study
West San Antonio Street & South Water Lane
New Braunfels, Texas

FILE NAME: ANA23-035-00 CONB - SA STREET & WATER LANE RECONSTRUCTION

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-101	2.0 to 3.5	6	30	75	20	55	CH		91		
	3.5 to 5.0	7	30								
	5.0 to 6.5	7	31								
	6.5 to 8.0	8	27								
	8.5 to 10.0	9	25								
	13.5 to 15.0	9	24								
B-102	1.0 to 2.5	13	15								
	2.5 to 4.0	25	8								
	4.5 to 6.0	27	4	31	13	18	CL		74		
	6.5 to 7.9	50/11"	6								
	8.5 to 10.0	30	10								
	13.5 to 15.0	20	19								
B-103	1.0 to 2.5	7	23								
	2.5 to 4.0	7	28								
	4.5 to 6.0	8	29								
	6.5 to 8.0	10	17								
	8.5 to 10.0	14	18								
	13.5 to 15.0	40	15	39	14	25	CL				

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

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