RABA KISTNER

GEOTECHNICAL ENGINEERING STUDY

FOR

KLEIN ROAD RECONSTRUCTION – PHASE II
SOUTH WALNUT TO FM 725
NEW BRAUNFELS, TEXAS

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Project No. ANA19-039-00
Revised December 17, 2020

Mr. John Tyler, P.E., RAS
Pape-Dawson Engineers, Inc.
2000 Northwest Loop 410
San Antonio, Texas 78213

RE: Geotechnical Engineering Study – Pavements
Klein Road Reconstruction – Phase II
South Walnut to FM 725
New Braunfels, Texas

Dear Mr. Tyler:

RABA KISTNER Consultants Inc. (RKCI) is pleased to submit the revised report of our Geotechnical Engineering Study for the above-referenced project. Revisions to the original report dated December 17, 2019 include the addition of temporary pavement section options and additional flexible pavement options. This study was performed in accordance with RKCI Proposal No. PNA18-027-00, dated May 21, 2018. Authorization for this study was received by our firm on October 23, 2019. The purpose of this study was to drill borings within the existing roadway and proposed bridge alignments, to perform laboratory testing to classify and characterize subsurface conditions, and to prepare an engineering report presenting foundation design and construction recommendations for the proposed bridge improvements, as well as to provide pavement design and construction guidelines. This report addresses the pavement recommendations and the bridge recommendations will be provided in a separate submittal.

The following report contains our design recommendations and considerations based on our current understanding of finished floor elevations, design tolerances and structural loads. There may be alternatives for value engineering of the foundation and pavement systems, and RKCI 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 CONSULTANTS, INC.

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Attachments
Copies Submitted: Above (1) – Email Only

GEOTECHNICAL ENGINEERING STUDY - PAVEMENTS

For

KLEIN ROAD RECONSTRUCTION – PHASE II
SOUTH WALNUT TO FM 725
NEW BRAUNFELS, TEXAS

Prepared for

PAPE-DAWSON ENGINEERS, INC
San Antonio, Texas

Prepared by

RABA KISTNER CONSULTANTS, INC.
New Braunfels, Texas

PROJECT NO. ANA19-039-00

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ATTACHMENTS

The following figures are attached and complete this report:

INTRODUCTION

RABA KISTNER Consultants Inc. (RKCI) has completed the authorized subsurface exploration and pavement design analysis for the proposed reconstruction of Klein Road from South Walnut Avenue to FM 725 in New Braunfels, Texas. This report briefly describes the procedures utilized during this study and presents our findings along with our recommendations for pavement design and construction guidelines. A separate report was submitted under the same heading for the proposed bridge between Dove Crossing and Roadrunner Avenue with a revised date of March 9, 2020.

PROJECT DESCRIPTION

The roadway to be considered in this study includes Klein Road from FM 725 to South Walnut Avenue which is located in New Braunfels, Texas. The proposed final configuration of the reconstructed roadway will include widening the existing 2 lane roadway to 4 or 5 lanes with drainage improvements and sidewalks/shared-use paths on either side of the alignment. The total roadway length under consideration is approximately 1 mile. Klein Road is to be evaluated in accordance with the *City of San Antonio's Design Guidance Manual,* dated February 2012 regarding Arterial streets. In addition, we have included recommendations for Collector Streets for consideration by the design team. Temporary pavement sections were designed using the Arterial traffic loading reduced to 1.5 years and using remaining design input parameters for a Local Type A Street with Bus Traffic.

LIMITATIONS

This engineering report has been prepared in accordance with accepted Geotechnical Engineering practices in the region of south/central Texas and for the use of Pape-Dawson Engineers, Inc. (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 recommendations submitted in this report are based on the data obtained from the 7 borings and 1 bulk sample collected at this site and the information 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.

BORINGS AND LABORATORY TESTS

Subsurface conditions at the site were evaluated by 7 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 depths below the existing ground surface of approximately 10 ft for the "P-series" borings and depths of approximately 60 ft for both "B-series" borings. The B-Series borings are dual purpose in that they will be used both for the pavement study and for the bridge study (in a separate submittal).

During drilling operations, 25 split-spoon samples (with Standard Penetration Testing) were collected in the P-series borings and 24 Texas Cone Penetrometer (TCP) tests were completed in the B-Series borings with grab samples at each test location.

In addition to the above samples, a bulk sample of the predominant subgrade soil was also collected for use in California Bearing Ratio (CBR) testing and pH-Lime Series testing. The bulk sample was collected in the vicinity of Boring P-103. Each sample was visually classified in the laboratory by a member of our Geotechnical Engineering staff. The geotechnical engineering properties of the strata were evaluated by the following tests:

Type of Test	Number Conducted
Natural Moisture Content	49
Atterberg Limits	9
Percent Passing a No. 200 Sieve	1
California Bearing Ratio (CBR)	1

The results of all laboratory tests are presented in graphical or numerical form on the boring logs illustrated on Figures 2 through 8. Borings B-101 and B-102 are presented on Texas Department of Transportation (TxDOT) format WinCORE logs. A key to classification terms and symbols used on the logs is presented on Figure 9. The results of the laboratory and field testing are also tabulated on Figure 10 for ease of reference. The results of the CBR testing can be found on the Moisture Density Relationship Curve, Figure 11 while the CBR versus the dry density test results can be found on Figure 12. The pH-Lime Series Curve can be found on Figure 13.

Standard penetration test results are noted as "blows per ft" on the P-series boring logs and Figure 10, 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). Where hard or dense materials were encountered, the tests were terminated at 50 blows even if one foot of penetration had not been achieved.

TCP test results are noted as "blows per foot" (divided into 6 in. increments) on the B-series borings logs and Figure 10 where "blows per ft" refers to the number of blows by a falling hammer required for 1 ft of penetration into soil/weak rock. Where hard or dense materials were encountered, each increment was terminated at 50 blows even if 6 in. of penetration had not been achieved in that increment.

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.

FINDINGS AND TEST RESULTS

PAVEMENT DISTRESS OBSERVATIONS

The predominant distress observed along the alignment is high severity fatigue cracking coupled with high severity rutting along a majority of the alignment. In addition, the pavement edges are unconfined and longitudinal cracking as well as spalling of the pavement edges has occurred. The roadway alignment is in very poor condition overall. It is our opinion that the root cause of the poor condition of this section of roadway is due to age of the pavements, excessive traffic loading coupled with weak subgrade support, and insufficient maintenance to reduce the impact of moisture infiltration into the subgrade, further increasing the weakened subgrade condition.

SUBSURFACE

All of the borings were drilled through the existing pavements and the individual layers of the pavement section were measured and recorded in the field. The results are presented in the table below:

	Field Measured Thickness (in.)	
Boring No.	**Asphalt**	**Base Material**
B-101	3-1/2	4-1/2
B-102	2-1/2	6
P-101	6-1/2	8-1/2
P-102	4-1/2	7-1/2
P-103	3-1/2	5
P-104	3	8
P-105	2	5

The subsurface stratigraphy can generally be described as highly plastic dark brown clay overlying moderately plastic to plastic tan and gray clay. It should be noted that the tan and gray clay encountered in our borings had tested plasticity indices ranging from 19 to 53, indicating that the plasticity of tan and gray clay varies greatly along the alignment. Each stratum has been designated by grouping soils that possess similar physical and engineering characteristics. The boring logs should be consulted for more specific stratigraphic information. The lines designating the interfaces between strata on the boring logs represent approximate boundaries. Transitions between strata may be gradual.

Subgrade Strength Characterization

We have assumed the pavement subgrade will consist of recompacted on-site clays. The CBR was measured using ASTM D 1883, *Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils* and was determined to be 3.4 using the soaked sample methodology. This value was determined using 3-points compacted at varying efforts to determine the corrected CBR value at 95 percent of the maximum dry density as determined by TxDOT, Tex-114-E. The moisture-density relationship is presented on Figure 11. Swell was also measured as part of the CBR procedure and was determined to be 2.1 percent. Based on our experience with the soils in this area and given the highly expansive characteristics of the subgrade encountered, we have assumed a design CBR value of 2.5 for use in our pavement section analysis. If clay soils are imported for the purpose of constructing the roadbed then imported materials must be selected that have a CBR value of at least 2.5. If lower quality clay fill materials are utilized, the pavement sections will have to be increased based on the quality (tested CBR value) of the clays imported.

Swell/Heave Potential

Assuming that the clays extend to depths of 15 ft below the existing ground surface, the estimated Potential Vertical Rise (PVR) for this site ranges from 4-1/2 to 6-1/2 in. These values (ranges) were determined using the empirical procedure, Texas Department of Transportation (TxDOT) Tex-124-E, Method for Determining the Potential Vertical Rise (PVR). A surcharge load of 1 psi, an active zone of 15 ft, and dry moisture conditions were assumed in estimating the above PVR values.

Subgrade soils that are highly expansive when water is introduced (i.e. highly plastic soils) will heave, 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 vehicle costs, fuel consumption, and 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 High PI Soils
- 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 moderately plastic soils. Lime and water are mixed with the top 8 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 strong soil matrix that can improve pavement performance and potentially reduce soil heave. However, 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 of the high PI soil may be the only method available to reduce the potential vertical rise of the pavement to an acceptable level. As stated previously, 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 inhibiting water through the use of vertical moisture barriers would reduce the potential for heave since one important component of the heaving mechanism, water, would be reduced. Geocomposite membranes, like geogrids, are also another tool available that may help reduce the damage that heaving subgrades cause to flexible pavements and may be considered in addition to or as an alternative to other mitigation techniques.

It should be noted that the pavement sections derived in the following sections are structurally adequate for the given traffic levels and existing clay 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.

Vertical Moisture Barrier We recommend that a vertical moisture barrier be installed to reduce the potential for moisture infiltration into the flexible base layer and ultimately the subgrade, which can cause expansive soil-related movements. Consideration should be given to extending the curbs through the entire depth of the pavement section, penetrating the subgrade such that the pervious flexible base is better protected from moisture fluctuation. Another option for installing a vertical moisture barrier is to install a polyethylene or polyvinylchloride (PVC) sheet behind the curb (exterior to the roadway), extending from the bottom of the curb and into the subgrade. During construction of the pavement section, particularly compaction of the flexible base, care should be taken to avoid puncturing the PVC sheeting. Prior to installation of the PVC sheeting, depending on the sequencing of installation selected by the contractor, consideration may be given to spraying/coating the exposed base and subgrade sidewalls of the roadway with tack coat to facilitate installation of the PVC sheeting and to reduce the permeability of the flexible base beneath the curb.

Regardless of the method used, the flexible base should be protected during construction to reduce the potential for precipitation to enter the flexible base and, eventually, the subgrade. In addition, the slope of the roadway should be considered and the unprotected edge of the roadway should be protected from sheet flow entering the side of the exposed flexible base, particularly during staged construction. If a vertical moisture barrier is in place prior to permanently covering the flexible base, the vertical moisture barrier can act as a dam and retain water near the curb which can cause rapid deterioration at the pavement edge near the curb.

Horizontal Moisture Barrier It is our understanding that the roadway alignment is to include the installation of shared-use pedestrian and bike path which will run parallel to the roadway. Consideration should be given to installing the paths immediately adjacent to the curb, where permitted by AASHTO, eliminating any green space between the paths and curbs. Installation of the paths adjacent to the curb will essentially provide a horizontal moisture barrier which extends the path for moisture infiltration into the flexible base and subgrade, reducing the potential for expansive soil-related movements within the pavement section. If this option is selected, consideration may also be given to installing the vertical moisture barrier discussed in the previous section at the edge of the path in lieu of at the curb.

PAVEMENT RECOMMENDATIONS

DESIGN PARAMETERS – HOT MIX ASPHALT PAVEMENTS

The roadway to be considered in this study includes Klein Road from FM 725 to South Walnut Avenue in New Braunfels, Texas. The proposed roadways are to be evaluated in accordance with the *City of San Antonio's Design Guidance Manual* regarding Arterials. We have also included recommendations for a Collector street for consideration by the design team. Based on information provided by the City of San Antonio, we understand that the following design parameters are required for use in the design of flexible pavements for these types of streets.

Street Classification	Equivalent 18-kip Single Axle Load Applications (ESALs)	Reliability	Serviceability Initial/Terminal	Standard Deviation	Structural Number Minimum/Maximum
Collector	2,000,000	90	4.2/2.5	0.45	2.92/5.08
Arterial	3,000,000	95	4.2/2.5	0.45	3.80/5.76

The required structural number is related to the CBR value of the pavement subgrade and the amount of traffic that the pavement will carry over its service life. The CBR provides an estimate of the relative strength of the subgrade and consequently indicates the ability of the pavement section to carry load. This site specific CBR value is utilized in conjunction with the above specified parameters to determine the required Structural Number (SN) for use in the design of the pavement section.

To determine the required design SN value, we utilized a method based on the 1993 edition of the AASHTO "Guide for the Design of Pavement Structures." The "required by design" SN values are presented below as well as the values subsequently determined in the design of the pavement sections for this site.

Structural Number Recommendations

Street Classification	Structural Number			
	Required by Design	Minimum Value Provided by Design		
		Flex Base Option	Full Depth Asphalt Option	Mechanically Stabilized Layer Option
Collector	4.96	4.94(1)	5.05	5.02
Arterial	5.53	5.66	5.58	5.66

1) The minimum structural number provided by design is slightly lower than the required by design structural number, but the pavement design is expected to perform as intended.

Appendix 10-A of the *City of San Antonio's Design Guidance Manual* states that subgrade soils with a PI greater than 20 must be treated with lime or other proven methods of treatment to reduce the PI of the soil to less than 20. Based on the results of our Atterberg Limits testing performed on the bulk samples and in the upper 5 ft of our borings, the PI of the surficial subgrade clays ranges from 53 to 68. We recommend that pavements at this site include a minimum of 8 in. of lime-treated subgrade. Because of the elevated PIs of the subgrade soil along the alignment, we recommend that 12 in. of lime treated subgrade be included in the pavement section, but only 8 in. will contribute to the overall pavement structural number. We recommend that the required lime content reduce the PI of the subgrade soil to less than 20 and increases the pH of the soil to 12.4 or greater.

PAVEMENT DESIGN PARAMETERS – HOT MIX ASPHALT PAVEMENTS

The following input variables are utilized to design flexible base pavements (commonly referred to as Asphaltic Cement Concrete or Asphalt pavements) when using the procedures detailed in the *1993 AASHTO Guide for Design of Pavement Structures*:

- Performance Period, years
- Roadbed Soil Resilient Modulus, psi
- Serviceability Indices
- Overall Standard Deviation
- Reliability, %
- Design Traffic, 18-kip ESALs

Performance Period, years

The pavement structure was designed for a 20-year performance period which is typical for most flexible pavements.

Roadbed Soil Resilient Modulus, psi

The Resilient Modulus (M_R) is the material property used to characterize the support characteristics of the roadbed soils in flexible pavement design. It is a measure of the soil's deformation response to cyclic applications of loads much smaller than a failure load. Using conventional correlations, local experience and design CBR value of 2.5, a Resilient Modulus of 3,750 psi has been used for this project.

To determine the resilient modulus (M_r) of the subgrade, we utilized the correlation equation shown below:

M_r = 1,500 x CBR

Serviceability Indices

Initial serviceability is a measure of the pavement's smoothness or rideability immediately after construction. Terminal serviceability is the minimum tolerable serviceability of a pavement. When the serviceability of a pavement reaches its terminal value, rehabilitation is required. See the recommended Initial and Terminal Serviceability Indices on the table presented in the *Design Parameters – Hot Mix Asphalt Pavements* section of this report.

Overall Standard Deviation

Overall standard deviation accounts for both chance variation in the traffic prediction and normal variation in pavement performance prediction for a given traffic. Higher values represent more variability; thus, the pavement thickness increases with higher overall standard deviations. A value of 0.45 was utilized for the flexible pavement designs presented herein.

Reliability, %

The reliability value represents a "safety factor," with higher reliabilities representing pavement structures with less chance of failure. The AASHTO Guide recommends values ranging from 50 to 99.9%, depending on the functional classification and the location (urban vs. rural) of the roadway. See the recommended Reliability values on the table presented in the *Design Parameters – Hot Mix Asphalt Pavements* section of this report.

Design Traffic, 18-kip ESALs

The 18-kip ESALs were determined from the traffic data specified in the Unified Development Code for the City of San Antonio. See the recommended values on the table presented in the *Design Parameters – Hot Mix Asphalt Pavements* section of this report.

RECOMMENDED PAVEMENT SECTIONS – HOT MIX ASPHALT PAVEMENTS

Utilizing the design SN values discussed above and minimum layer thicknesses, the optional pavement sections presented in the tables below are recommended.

Clay fill utilized for fill grading should be placed and compacted as discussed in the *On-Site Clay Fill* section of this report. For areas that require fill, the (at a minimum) final 8 in. of fill should be lime treated (see *Lime Treated Subgrade*). If fill grading is not planned and clays remain in place, then lime treatment of the exposed clay subgrade should be performed in conjunction with the scarifying, moisture conditioning, and recompaction described in the *Site Preparation* section of this report.

For this site, the following options for pavement sections are available.

Collector; CBR=2.5	Layer Description	Layer Thickness	Recommended SN Coeff.	SN Extension
Flexible Base Option	Type D Surface Course	2.0 in.	0.44	0.88
	Type C/D Binder Course	3.0 in.	0.44	1.32
	Flexible (Granular) Base	15.0 in.	0.14	2.10
	Lime Treated Subgrade(1)	8.0 in.	0.08	0.64
	Combined Total	**28.0 in.**		**4.94**
Full Depth Asphalt Option	Type D Surface Course	3.0 in.	0.44	1.32
	Type B Base	9.0 in.	0.34	3.06
	Lime Treated Subgrade(1)	8.0 in.	0.08	0.64
	Combined Total	**20.0 in.**		**5.02**
Mechanically Stabilized Layer Option	Type D Surface Course	2.0 in.	0.44	0.88
	Type C/D Binder Course	3.0 in.	0.44	1.32
	Mechanically Stabilized Layer	13.0 in.	0.17	2.21
	Lime Treated Subgrade(1)	8.0 in.	0.08	0.64
	Combined Total	**26.0 in.**		**5.05**

1) As an option, it is recommended that a total of 12 inches of subgrade be considered lime treated for improved pavement performance; however, only 8 inches will be claimed for structural credit in the pavement design.

Arterials; CBR=2.5	Layer Description	Layer Thickness	Recommended SN Coeff.	SN Extension
Flexible Base Option	Type D Surface Course Type C/D Binder Course Flexible (Granular) Base Lime Treated Subgrade(1) **Combined Total**	3.0 in. 3.0 in. 17.0 in. 8.0 in. **31.0 in.**	0.44 0.44 0.14 0.08	1.32 1.32 2.38 0.64 **5.66**
Full Depth Asphalt Option	Type D Surface Course Type C/D Binder Course Type B Base **Combined Total**	2.0 in. 2.0 in. 12.0 in. **16.0 in.**	0.44 0.44 0.34	0.88 0.88 4.08 **5.84**
Mechanically Stabilized Layer Option	Type D Surface Course Type C/D Binder Course Mechanically Stabilized Layer Lime Treated Subgrade(1) **Combined Total**	3.0 in. 3.0 in. 14.0 in. 8.0 in. **28.0 in.**	0.44 0.44 0.17 0.08	1.32 1.32 2.38 0.64 **5.66**
Hybrid Option (Type B/Flexible Base)	Type D Surface Course Type C/D Binder Course Type B Base Flexible (Granular) Base Lime Treated Subgrade(1) **Combined Total**	2.0 in. 3.0 in. 3.0 in. 12.0 in. 8.0 in. **28.0 in.**	0.44 0.44 0.34 0.14 0.08	0.88 1.32 1.02 1.68 0.64 **5.54**
Hybrid Option (Type B/MSL)	Type D Surface Course Type C/D Binder Course Type B Base Mechanically Stabilized Layer Lime Treated Subgrade(1) **Combined Total**	2.0 in. 3.0 in. 3.0 in. 10.0 in. 8.0 in. **26.0 in.**	0.44 0.44 0.34 0.17 0.08	0.88 1.32 1.02 1.70 0.64 **5.56**

1) As an option, it is recommended that a total of 12 inches of subgrade be considered lime treated for improved pavement performance; however, only 8 inches will be claimed for structural credit in the pavement design.

A Mechanically Stabilized Layer (MSL) is a composite layer consisting of flexible (granular) base and a geogrid product. 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.

It should be noted that should the Full Depth Asphalt Option be selected and lime treatment of the subgrade is foregone, that there is an increased risk associated with expansive soil-related movement. The full depth asphalt option is a more rigid pavement section which may me more susceptible to tensile cracking, resulting in premature pavement distress. The owner/design team should understand the risk associated with utilizing this pavement section and an aggressive maintenance schedule should be implemented throughout the life of this pavement section.

TEMPORARY PAVEMENTS

It is our understanding that temporary pavement sections are planned for portions of the project. When the temporary pavements are to be demolished, it is preferred to reclaim the materials and stockpile them for use in construction of final pavement sections. It is also our understanding that the areas that will require temporary pavement sections are located where roadside ditches are currently present. Therefore, grading in these areas will require fill to achieve the final grade elevation of the temporary pavements which may or may not remain depending on the grades required to achieve the final pavement section.

The pavement design life for pavement sections presented for permanent pavement sections were assumed to be 20 years. Assuming a temporary pavement service life of 18 months, the design traffic was linearly interpolated to be 225,000 Equivalent Single Axle Loads (ESALs) for the Arterial street classification. This approach does not take into account any growth factor; therefore, the traffic loading may be considered conservative as the latter years are weighted more heavily when growth factors are taken into account. The street classification for the remaining design parameters were reduced to better align with the ESAL count listed in the City of San Antonio design parameters. A Local Type A with Bus Traffic street classification was selected for the remaining parameters and are listed in the table below.

Street Classification	Reliability	Serviceability Initial/Terminal	Standard Deviation	Structural Number Minimum/Maximum
Local Type A With Bus Traffic	70	4.2/2.0	0.45	2.58/4.20

The recommended temporary pavement section option as well as the City of New Braunfels typical pavement section are presented in the table below.

Temporary Sections CBR=2.5	**Layer Description**	**Layer Thickness**	**Recommended SN Coeff.**	**SN Extension**
225,000 ESALs (approximately 150 trucks/day) Required SN = 3.00	Type D Surface Course	2.0 in.	0.44	0.66
	Type B Base	4.0 in.	0.34	1.36
	Flexible (Granular) Base	6.0 in.	0.14	0.84
	Combined Total	**15.5 in.**		**3.08**
20,000 ESALs (approximately 13 trucks/day) Required SN = 3.33	Type B Base	6.0 in.	0.34	2.04
	Combined Total	**6.0 in.**		**2.04**

It is our understanding that the City of New Braunfels may prefer to utilize a temporary pavement section consisting of 6 in. of Type B Base Material. This pavement section yields a Structural Number of 2.04. Utilizing the Local Type A with Bus Traffic parameters for the back calculation, the resulting available traffic loading is equivalent to approximately 20,000 ESALs, or approximately 13 trucks per day for an 18 month design life. We do not recommend that this pavement section be utilized due to the high potential for the temporary pavements to sustain repeated construction traffic loading which may cause premature pavement distress and subsequent rapid deterioration due to the absence of subgrade stabilization in this area.

While the pavement sections presented herein are structurally sufficient to support the anticipated traffic loads presented, they do not take into account the expansive soil-related movements which may significantly reduce the pavement service life. A proactive maintenance plan should be considered for any pavements and level-up and routine maintenance should be part of the temporary pavement section service life.

In order to accommodate the final pavement section, the asphalt layer in the temporary pavement section may be milled and removed or pulverized with the underlying base material with a self-propelled mixer capable of fully mixing the existing roadway section to the depth required. To avoid pulverizing into the subgrade, we recommend a minimum of 2 in. of base material be left in place. The pulverized material should be graded to the design elevation and any asphalt fragments larger than 4 in. should be removed. If additional materials are required to attain the design elevation, the fill material should be selected and placed in accordance with the *Granular Base Course* section of this report and mixed with the pulverized materials. After pulverizing, the material should be compacted in accordance with the *Granular Base Course* section of this report. A prime coat should be placed on the surface of the material prior to any asphalt placement, and as soon as possible after properly compacted.

DESIGN PARAMETERS – PORTLAND CEMENT CONCRETE PAVEMENTS

Based on information provided by the City of San Antonio, we understand that the following design parameters are required for use in the design of rigid pavements for Collector and Arterial streets.

Street Classification	Equivalent 18-kip Single Axle Load Applications (ESALs)	Reliability	Serviceability Initial/Terminal	Standard Deviation	Rigid Pavement Slab Thickness Minimum/Maximum
Collector	3,000,000	90	4.5/2.5	0.35	7.0/9.0
Arterial	4,500,000	95	4.5/2.5	0.35	9.0/13.0

To calculate the required design rigid pavement thickness, we utilized a method based on the 1993 edition of the AASHTO "Guide for the Design of Pavement Structures."

PAVEMENT DESIGN PARAMETERS – PORTLAND CEMENT CONCRETE PAVEMENTS

The following input variables are utilized to design rigid pavements (commonly referred to as Portland Cement Concrete or PCC pavements) when using the procedures detailed in the *1993 AASHTO Guide for Design of Pavement Structures*:

- Performance Period
- 28-day Concrete Modulus of Rupture, psi
- 28-day Concrete Elastic Modulus, (M_r) psi
- Effective Modulus of Subbase/Subgrade Reaction, (k-value) psi/in.
- Serviceability Indices
- Load Transfer Coefficient

- Drainage Coefficient
- Overall Standard Deviation
- Reliability, %
- Design Traffic, 18-kip ESALs

Performance Period

The pavement structure was designed for a 30-year performance period which is typical for most rigid pavements.

28-day Concrete Modulus of Rupture (M_r), psi

The M_r of concrete is a measure of the flexural strength of the concrete as determined by breaking concrete beam test specimens. An M_r of approximately 600 psi at 28 days was used in the analysis and is typical of local concrete production.

28-day Concrete Elastic Modulus, psi

Elastic modulus of concrete is an indication of concrete stiffness and varies depending on the coarse aggregate type used in the concrete. A modulus of 4,000,000 psi is used for this pavement design.

Effective Modulus of Subbase/Subgrade Reaction(k-value), psi/in.

Concrete slab support is characterized by the modulus of subgrade/subbase reaction, otherwise known as the k-value with units typically shown as psi/in. A k-value of 110 psi/in. was used in the rigid pavement design procedure and is based upon a CBR value of 2.5, as discussed above.

Serviceability Indices

Initial serviceability is a measure of the pavement's smoothness or rideability immediately after construction. Terminal serviceability is the minimum tolerable serviceability of a pavement. When the serviceability of a pavement reaches its terminal value, rehabilitation is required. See the recommended Initial and Terminal Serviceability Indices on the table presented in the *City of San Antonio Design Parameters – Portland Cement Concrete Pavements* section of this report.

Load Transfer Coefficient

The load transfer coefficient is used to incorporate the effect of dowels, reinforcing steel, tied shoulders, and tied curb and gutter on reducing the stress in the concrete slab due to traffic loading and therefore causing a reduction in the required concrete slab thickness. The coefficients recommended in the AASHTO Guide are based on findings from the AASHO Road Test presented below.

ESALs (millions)	Doweled & Mesh Reinforcement		Aggregate Interlock Reinforced		Continuously Reinforced		Pavement Classification
	Edge Support		Edge Support		Edge Support		
	No	Yes	No	Yes	No	Yes	
0 - 0.3	3.2	2.7	3.2	2.8	-	-	Local Streets and Roads
0.3 - 1	3.2	2.7	3.4	3.0	-	-	
1 - 3	3.2	2.7	3.6	3.1	-	-	
3 - 10	3.2	2.7	3.8	3.2	2.9	2.5	Arterials and Highways
10 - 30	3.2	2.7	4.1	3.4	3.0	2.6	
over 30	3.2	2.7	4.3	3.6	3.1	2.6	

The load transfer coefficient used in these pavement designs is 3.2 for a Jointed Plain Concrete Pavement, using aggregate interlock reinforcement, with edge support (curbs) and given the traffic count for the street classifications (ESALs).

Drainage Coefficient

The drainage coefficient characterizes the quality of drainage of the subbase layers under the concrete slab. Good draining pavement structures do not give water the chance to saturate the subbase and subgrade; thus, pumping is not as likely to occur.

There is no subbase recommended for this pavement structure. Therefore, the drainage coefficient used in this pavement design is 1.0 and is based upon local design experience for slabs without subbases on expansive clay subgrade.

Overall Standard Deviation

Overall standard deviation accounts for both chance variation in the traffic prediction and normal variation in pavement performance prediction for a given traffic. Higher values represent more variability; thus, the pavement thickness increases with higher overall standard deviations. See the recommended Overall Standard Deviation on the table presented in the *Design Parameters – Portland Cement Concrete Pavements* section of this report.

Reliability, %

The reliability value represents a "safety factor," with higher reliabilities representing pavement structures with less chance of failure. The AASHTO Guide recommends values ranging from 50 to 99.9%, depending on the functional classification and the location (urban vs. rural) of the roadway. See the recommended Reliability on the table presented in the *Design Parameters – Portland Cement Concrete Pavements* section of this report.

Design Traffic 18-kip ESAL

The 18-kip ESALs were determined from the street classifications as discussed previously in the *Design Parameters – Portland Cement Concrete Pavements* section of this report.

RECOMMENDED PAVEMENT SECTIONS – PORTLAND CEMENT CONCRETE PAVEMENTS

The recommended concrete slab thicknesses determined with the inputs discussed above are presented in the table below. An optional lime treated subgrade is recommended to facilitate construction over the clay subgrade but is not required. The contractor may elect to include lime treated subgrade to stabilize saturated soils to create a working or construction platform.

Portland Cement Concrete Design - Cross Sections	Layer Description	TxDOT Spec. Item	Layer Thickness
Collector	PCC Surface Subbase Lime Treated Subgrade(1) **Combined Total**	360 ---- 260	10.0 in.(2) 0.0 in. 8.0 in. **18.0 in.**
Arterials	PCC Surface Subbase Lime Treated Subgrade(1) **Combined Total**	360 ---- 260	11.0 in. 0.0 in. 8.0 in. **19.0 in.**

1) Used as a working or construction platform only
2) exceeds recommended by CoSA

The rigid pavement section for a Collector street presented above exceeds the thickness recommended by CoSA. On the basis of the subsurface soil conditions at this site, we recommend that the thickness presented in the table above be utilized in the Collector street sections.

PAVEMENT CONSTRUCTION CONSIDERATIONS

SITE PREPARATION

Preparation for the right-of-way (for streets, sidewalks, utilities, etc.) should be performed in accordance with the 2014 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 clay 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.

Upon completion of fill grading using the on-site clays, the final 8 in. of fill should be lime treated (see *Lime Treatment of Subgrade*). If fill grading is not planned, then lime treatment of the stripped clay subgrade 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 2014 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, RKCI should be notified, as additional CBR testing and thicker pavement sections may be required.

It is imperative that the subgrade modulus utilized in the pavement design process be met or exceeded by the fill material. In the event that the clay fill used is different than the existing subgrade, the recommendations in this report could be invalidated and the design engineer must be consulted to determine if additional CBR testing and thicker pavement sections are required.

LIME TREATMENT OF SUBGRADE

Lime treatment of the subgrade soils with PIs greater than 20 should be in accordance with the 2014 TxDOT Standard Specifications, Item 260 – *Lime Treatment (Road-Mixed)*. Lime-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. Based on the results of the pH-Lime Series Curve and for estimating purposes, we recommend that at least 6 percent hydrated lime by weight be used to reduce the PI of the subgrade clays or a minimum of 15 pounds/S.Y. for 6 in. of lime treated subgrade, whichever results in the higher percentage. If dry placement of lime is used during construction, an additional 1 percent of lime should be added to account for expected loss. We recommend that further testing be completed during construction to establish the percentage of lime required and the dry unit weight of the soils to be used as the subgrade.

It is also recommended to perform additional laboratory testing to determine the concentration of soluble sulfates in the subgrade soils, in order to investigate the potential for adverse reaction to lime in certain 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. On the basis of the sulfate content testing completed on the bulk sample, the subgrade soils have a low potential for sulfate induced heave with a sulfate content less than 100 ppm.

GEOGRID REINFORCEMENT

The geogrid reinforcement should be selected and placed in accordance with 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 cases. An alternative to the above geogrid should not be considered without approval from RKCI.

GRANULAR BASE COURSE

The flexible base course should be crushed limestone conforming to the 2014 TxDOT Standard Specifications, Item 247 – *Flexible Base*, Type A, Grade 1. 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.

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 2014 TxDOT Standard Specifications, Item 310 – *Prime Coat* or Item 314 – *Emulsified Asphalt Treatment* as well as 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 a PG binder with a minimum high-temperature grade of PG 58, SS-1H, CSS-1H, or EAP&T conforming to the 2014 TxDOT Standard Specifications, Item 300 – *Asphalts, Oils and Emulsions*. See additional requirements for tack coats in the appropriate TxDOT Standard Specifications for Asphaltic Concrete Materials.

ASPHALTIC CONCRETE SURFACE AND/OR BINDER[1] COURSES

The asphaltic concrete surface and/or binder courses should conform to the 2014 TxDOT Standard Specifications, Item 341 – *Dense Graded Hot Mix Asphalt*, Types C or D for the surface and binder, and Type B for the base, if the full depth asphalt section is selected for construction. Recycled asphalt pavement (RAP) should be limited to 20 percent of the total weight of the mix for Types C and D mixes and 30 percent for Type B mixes. Higher percentages of RAP may be permissible depending on the material source. If higher percentages of RAP are desired, contact RKCI for consideration. Asphalt cement grades should conform to the table shown below, which conforms to the requirements of Item 341.

<table>
<tr><th rowspan="2">Street Classifications</th><th colspan="3">Minimum PG Asphalt Cement Grade</th></tr>
<tr><th>Surface Courses</th><th>Binder & Level Up Courses</th><th>Base Courses</th></tr>
<tr><td>Arterials</td><td>PG 76-22</td><td rowspan="2">PG 70-22</td><td rowspan="4">PG 64-22</td></tr>
<tr><td>Collector and Local Type B Streets</td><td rowspan="2">PG 70-22</td></tr>
<tr><td>Local Type A Street With Bus Traffic</td><td rowspan="2">PG 64-22</td></tr>
<tr><td>Local Type A Street Without Bus Traffic</td><td>PG 64-22</td></tr>
</table>

The asphaltic concrete should be compacted on the roadway to contain from 5 to 9 percent air voids computed using 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. 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.

It is recommended that the hot mix asphalt concrete pavement be placed with a paving machine only and not with a motor grader unless prior approval is granted by the Engineer for special circumstances. The asphalt layer should preferably be placed as soon as possible after the flexible base has been accepted and the prime coat has been placed. This will further protect the flexible base and subgrade from undue moisture fluctuation due to precipitation or sheet flow from rain events.

[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.

PORTLAND CEMENT CONCRETE

The Portland cement concrete should conform to the requirements of the 2014 TxDOT Standard Specifications, Item 360 – *Concrete Pavement*, for a Hydraulic Cement Concrete Class P. Liquid membrane-forming curing compound should be applied as soon as practical after broom finishing the concrete surface and should conform to Section 2.4, Curing Materials. 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 2014 TxDOT Standard Specifications, Item 341 – *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 3.4.1 and 3.4.2. Other texturing techniques may be utilized as described in ACI 330.1-03, Section 3, Subparagraph 9.

CONCRETE PAVEMENT TYPE

Jointed Plain Concrete Pavement (which is referred to by TxDOT as Concrete Pavement Contraction Design or CPCD) is suggested for roadways with crosswalks, adjacent parking, or sidewalks and is recommended as the pavement type for this city street.

JOINT SPACING AND DETAILS

Construction joint spacing should not exceed 15 ft in either the longitudinal or transverse direction. The depth of sawcut should be a minimum of 1/4 of the slab depth (1/3 the slab depth is recommended) if utilizing a conventional saw or 1 in. when using an early entry saw (early entry sawing is recommended). The width of the joint will be a function of the sealant chosen to seal the joint. It is recommended that a joint seal be utilized to minimize the introduction of incompressible material into the joint.

It is recommended that dowel bars be used to provide load transfer and reduce differential movement (or faulting) across transverse joints. Dowels should be smooth #9 bars (Grade 60 steel) spaced 12 in. on center with an embedment length of at least 8 in.

Tie bars should be used to tie longitudinal joints within the pavement lanes and at the shoulder. Tie bars should be deformed #4 bars at a minimum (Grade 60 steel) spaced 36 in. on center with a minimum length of 30 in.

Isolation joints must be used around fixed structures including light standard foundations and drainage inlets to offset the effects of differential horizontal and vertical movements. Premolded joint fillers should be used around the fixed structures prior to placing the concrete pavement to prevent bonding of the slab to the structure and should extend through the depth of the slab but slightly recessed from the pavement surface to provide room for the joint sealant.

SUGGESTED PAVEMENT DETAILS

Suggested details that can be utilized for construction are:

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

See Figure 14 of the Attachments for the above joint details.

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.

Longitudinal Cracking

It should be understood that asphalt pavement sections in highly expansive soil environments, such as those encountered at this site, 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. All cracks that develop in concrete pavements should be routed and sealed regularly. Joints in concrete pavements should be maintained to reduce the influx of incompressible materials that restrain joint movement and cause spalling and/or cracking. Other typical TxDOT or City of San Antonio/New Braunfels maintenance techniques should be followed as required.

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.

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

ATTACHMENTS

RABA KISTNER

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(830)214-0627 FAX

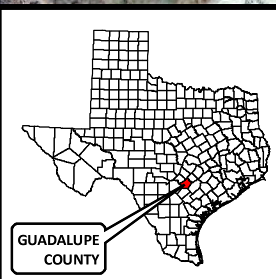
www.rkci.com

TBPE Firm Number 3257

SOURCE: Aerial photograph obtained from Google Earth Pro - 2018

BORING LOCATION MAP

KLEIN ROAD RECONSTRUCTION - PHASE II
SOUTH WALNUT TO FM 725
NEW BRAUNFELS, TEXAS



PROJECT No.:	ANA19-039-00
ISSUE DATE:	12/2/2019
DRAWN BY:	LAW/KRB
CHECKED BY:	DAB
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

DRILLING LOG

WinCore
Version 3.0

County	Guadalupe	Hole	B-101	District	San Antonio
Highway	Klein Road	Structure	Bridge	Date	09/11/19
CSJ		Station		Grnd. Elev.	
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	Properties MC	Properties LL	Properties PI	Properties Wet Den. (pcf)	Additional Remarks
			ASPHALT, (3-1/2 in.)							
			BASE MATERIAL, (4-1/2 in.)							
2			CLAY, Dark Brown, Very Soft to Soft, with traces of gravel			34	87	68		
4		4 (6) 5 (6)	CLAY, Tan to Gray, Stiff, with traces of gravel							
6										
8						30	70	53		
		9 (6) 7 (6)								
10										
12						22				
14		13 (6) 15 (6)								
			CLAY, Tan, Very Stiff to Hard							
16										
18						20				
		37 (6) 36 (6)								
20										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger:** Dylan Bunn

Organization: Raba-Kistner Consultants, Inc.

FIGURE: 2a

DRILLING LOG

WinCore
Version 3.0

County	Guadalupe	Hole	B-101	District	San Antonio
Highway	Klein Road	Structure	Bridge	Date	09/11/19
CSJ		Station		Grnd. Elev.	
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			CLAY, Tan, Very Stiff to Hard							
22										
						18				
24		29 (6) 31 (6)								
26										
28						19				
		50 (2.5) 50 (1.75)								
30										
32										
						18				
34		50 (1.25) 50 (1)								
36			CLAY, Gray, Very Hard							
38						16				
		50 (2) 50 (1.25)								
40										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger:** Dylan Bunn

Organization: Raba-Kistner Consultants, Inc.

FIGURE: 2b

DRILLING LOG

WinCore Version 3.0	County: Guadalupe	Hole: B-101	District: San Antonio
	Highway: Klein Road	Structure: Bridge	Date: 09/11/19
	CSJ	Station	Grnd. Elev.
		Offset	GW Elev.: N/A

Elev. (ft)	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
40–44	50 (1.5) 50 (0.75)	CLAY, Gray, Very Hard			16				
44–49	50 (1.5) 50 (0.75)				14				
49–54	50 (1.25) 50 (0.5)				16				
54–59	50 (1.25) 50 (1)				17				
60									

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger: Dylan Bunn** **Organization: Raba-Kistner Consultants, Inc.**

FIGURE: 2c

DRILLING LOG

WinCore
Version 3.0

County	Guadalupe	Hole	B-102	District	San Antonio
Highway	Klein Road	Structure	Bridge	Date	09/13/19
CSJ		Station		Grnd. Elev.	
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			ASPHALT, (2-1/2 in.)							
			BASE MATERIAL, (6 in.)							
2			CLAY, Dark Gray, Stiff, with traces of gravel			15				
4		8 (6) 16 (6)	CLAY, Tan, Very Stiff to Hard							
6										
8						18				
		26 (6) 29 (6)								
10										
12						16	41	32		
14		21 (6) 16 (6)								
16										
18						18				
		33 (6) 47 (6)								
20										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger:** Dylan Bunn **Organization:** Raba-Kistner Consultants, Inc.

FIGURE: 3a

DRILLING LOG

WinCore
Version 3.0

County	Guadalupe	Hole	B-102	District	San Antonio
Highway	Klein Road	Structure	Bridge	Date	09/13/19
CSJ		Station		Grnd. Elev.	
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, Tan, Very Stiff to Hard							
22										
						18				
24		50 (6) 50 (6)								
26										
28						17				
		50 (5) 50 (4)								
30										
32										
						19				
34		50 (2) 50 (1.5)								
			CLAY, Gray to Tan, Very Hard							
36										
38						19				
		50 (1.5) 50 (0.75)								
40										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger: Dylan Bunn** **Organization: Raba-Kistner Consultants, Inc.**

DRILLING LOG

WinCore
Version 3.0

County	Guadalupe	Hole	B-102	District	San Antonio
Highway	Klein Road	Structure	Bridge	Date	09/13/19
CSJ		Station		Grnd. Elev.	
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			CLAY, Gray to Tan, Very Hard							
42										
						19				
44		50 (0.75) 50 (0.5)								
46										
48						19				
		50 (0.5) 50 (0.25)								
50										
52										
						16				
54		50 (1) 50 (0.5)								
56										
58						17				
		50 (1.5) 50 (0.5)								
60										

Remarks:

The ground water elevation was not determined during the course of this boring.

Driller: Eagle Drilling **Logger: Dylan Bunn** **Organization: Raba-Kistner Consultants, Inc.**

FIGURE: 3c

LOG OF BORING NO. P-101

Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.66537; W 98.09450

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	WATER CONTENT (approx.)	PLASTIC LIMIT	LIQUID LIMIT	PLASTICITY INDEX	% -200
0–0.5	ASPHALT (6-1/2 in.)							
0.5–1.3	BASE MATERIAL (8-1/2 in.)							
1.3–6	CLAY, Firm, Dark Brown, with traces of gravel and ferric staining	8						
		8						
		8					57	
6–8	Clay, Firm, Reddish-Tan to Gray, with calcareous material	9						
8–10	CLAY, Firm, Tan and Gray, Blocky	11						
10	Boring Terminated							

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

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

DEPTH DRILLED: 10.0 ft
DATE DRILLED: 9/11/2019
DEPTH TO WATER: Dry
DATE MEASURED: 9/11/2019
PROJ. No.: ANA19-039-00
FIGURE: 4

LOG OF BORING NO. P-102

Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.66385; W 98.09624

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	ASPHALT (4-1/2 in.)				
	BASE MATERIAL (7-1/2 in.)				
	CLAY, Firm, Dark Brown, with traces of gravel	7			
		6			
5		7			
	CLAY, Stiff, Tan and Gray, Blocky, with ferric staining	11		50	
	CLAY, Silty, Hard, Light Tan	50/5"		35	89
	Boring Terminated				
10					
15					

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

DEPTH DRILLED:	9.4 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA19-039-00
DATE DRILLED:	9/11/2019	**DATE MEASURED:**	9/11/2019	**FIGURE:**	5

LOG OF BORING NO. P-103

Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.65989; W 98.10079

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	WATER CONTENT / ATTERBERG LIMITS	PLASTICITY INDEX	% -200
0	ASPHALT (3-1/2 in.)					
	BASE MATERIAL (5 in.)					
	CLAY, Firm, Dark Brown, with gravel and ferric staining	7		●		
		8		●		
5		8		●		
	CLAY, Firm, Tan and Gray, with calcareous material					
	CLAY, Silty, Hard, Tan	29		● – – ×	21	
		37		●		
10	Boring Terminated					
15						

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

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

DEPTH DRILLED: 10.0 ft	**DEPTH TO WATER:** Dry	**PROJ. No.:** ANA19-039-00	
DATE DRILLED: 9/11/2019	**DATE MEASURED:** 9/11/2019	**FIGURE:** 6	

LOG OF BORING NO. P-104

Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.65781; W 98.10307

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	WATER CONTENT (%)	PLASTICITY INDEX	% -200
0	ASPHALT (3 in.)					
	BASE MATERIAL (8 in.)					
	CLAY, Stiff, Dark Brown	8				
		9				
5	CLAY, Silty, Very Stiff, Tan and Gray	13				
		24				
		31			19	
10	Boring Terminated					

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

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

DEPTH DRILLED: 10.0 ft
DATE DRILLED: 9/13/2019
DEPTH TO WATER: Dry
DATE MEASURED: 9/13/2019
PROJ. No.: ANA19-039-00
FIGURE: 7

LOG OF BORING NO. P-105

Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

RABA KISTNER
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 29.65597; W 98.10525

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	ASPHALT (2 in.)				
	BASE MATERIAL (5 in.)				
	CLAY, Firm, Dark Brown, with traces of gravel	8			
		6			
5		5		53	
		6			
	CLAY, Gray and Tan, mottled	9			
10	Boring Terminated				
15					

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

DEPTH DRILLED:	10.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	ANA19-039-00
DATE DRILLED:	9/13/2019	**DATE MEASURED:**	9/13/2019	**FIGURE:**	8

KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

SOIL TERMS		ROCK TERMS		OTHER
CALCAREOUS	PEAT	CHALK	LIMESTONE	ASPHALT
CALICHE	SAND	CLAYSTONE	MARL	BASE
CLAY	SANDY	CLAY-SHALE	METAMORPHIC	CONCRETE/CEMENT
CLAYEY	SILT	CONGLOMERATE	SANDSTONE	BRICKS / PAVERS
GRAVEL	SILTY	DOLOMITE	SHALE	WASTE
GRAVELLY	FILL	IGNEOUS	SILTSTONE	NO INFORMATION

WELL CONSTRUCTION AND PLUGGING MATERIALS

BLANK PIPE	BENTONITE	BENTONITE & CUTTINGS	CUTTINGS	SAND
SCREEN	CEMENT GROUT	CONCRETE/CEMENT	GRAVEL	VOLCLAY

SAMPLE TYPES

AIR ROTARY	MUD ROTARY	SHELBY TUBE
GRAB SAMPLE	NO RECOVERY	SPLIT BARREL
CORE	NX CORE	SPLIT SPOON
GEOPROBE SAMPLER	PITCHER	TEXAS CONE PENETROMETER
ROTOSONIC -DAMAGED	ROTOSONIC -INTACT	DISTURBED

STRENGTH TEST TYPES

POCKET PENETROMETER

TORVANE

UNCONFINED COMPRESSION

TRIAXIAL COMPRESSION UNCONSOLIDATED-UNDRAINED

TRIAXIAL COMPRESSION CONSOLIDATED-UNDRAINED

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

PROJECT NO. ANA19-039-00

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
El = 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

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

FILE NAME: ANA19-039-00 PAVEMENTS.GPJ 12/16/2019

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	3.0 to 4.0		34								
	4.0			87	19	68					
	8.0 to 9.0		30								
	9.0			70	17	53					
	13.0 to 14.0		22								
	18.0 to 19.0		20								
	23.0 to 24.0		18								
	28.0 to 29.0		19								
	33.0 to 34.0		18								
	38.0 to 39.0		16								
	43.0 to 44.0		16								
	48.0 to 49.0		14								
	53.0 to 54.0		16								
	58.0 to 59.0		17								
B-102	3.0 to 4.0		15								
	8.0 to 9.0		18								
	13.0 to 14.0		16	41	9	32					
	18.0 to 19.0		18								
	23.0 to 24.0		18								
	28.0 to 29.0		17								
	33.0 to 34.0		19								
	38.0 to 39.0		19								
	43.0 to 44.0		19								
	48.0 to 49.0		19								
	53.0 to 54.0		16								
	58.0 to 59.0		17								
P-101	1.0 to 2.5	8	30								
	2.5 to 4.0	8	31								
	4.5 to 6.0	8	31	76	19	57	CH				
	6.5 to 8.0	9	42								
	8.5 to 10.0	11	28								
P-102	1.0 to 2.5	7	29								
	2.5 to 4.0	6	30								
	4.5 to 6.0	7	31								
	6.5 to 8.0	11	28	68	18	50	CH				
	8.5 to 9.5	50/5"	13	46	11	35	CL		89		
P-103	1.0 to 2.5	7	28								
	2.5 to 4.0	8	27								
	4.5 to 6.0	8	24								

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

CU = Consolidated Undrained Triaxial

PROJECT NO. ANA19-039-00

RABA KISTNER

FIGURE 10a

RESULTS OF SOIL SAMPLE ANALYSES

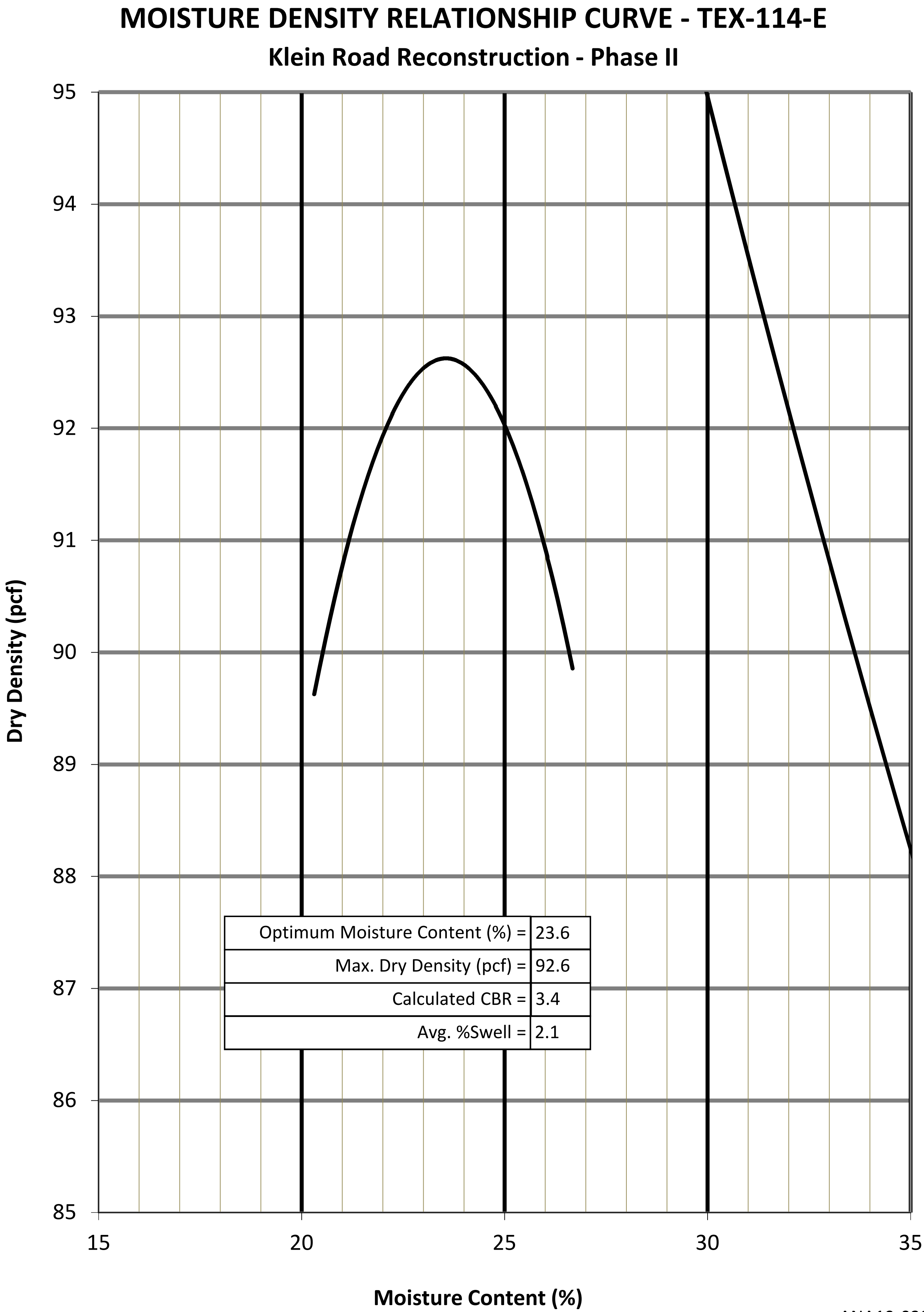
PROJECT NAME: Klein Road Reconstruction - Phase II
South Walnut to FM 725
New Braunfels, Texas

FILE NAME: ANA19-039-00 PAVEMENTS.GPJ 12/16/2019

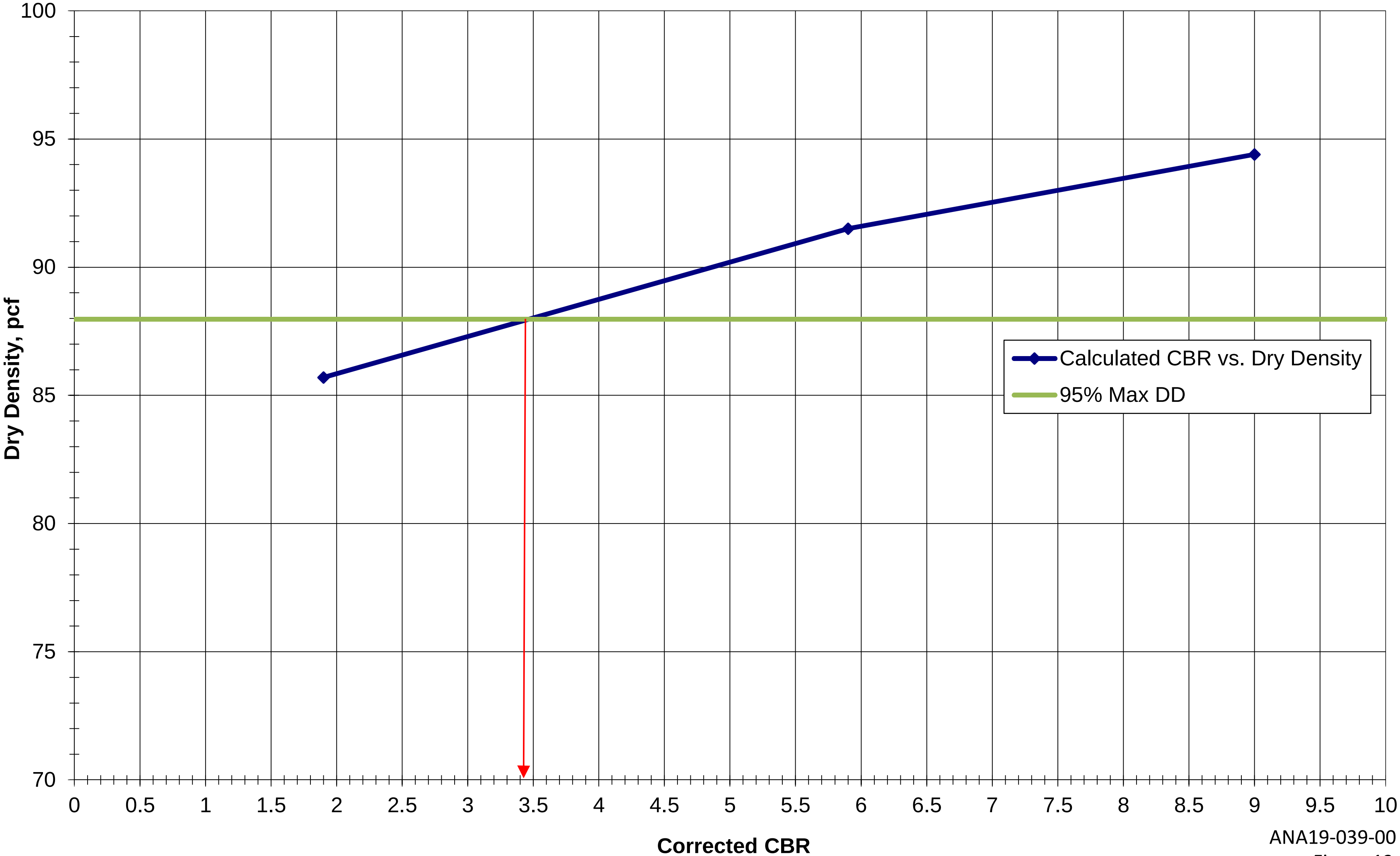
Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
P-103	6.5 to 8.0	29	13	34	13	21	CL				
	8.5 to 10.0	37	12								
P-104	1.0 to 2.5	8	37								
	2.5 to 4.0	9	29								
	4.5 to 6.0	13	19								
	6.5 to 8.0	24	13								
	8.5 to 10.0	31	14	32	13	19	CL				
P-105	1.0 to 2.5	8	5								
	2.5 to 4.0	6	34								
	4.5 to 6.0	5	35	73	20	53	CH				
	6.5 to 8.0	6	35								
	8.5 to 10.0	9	19								

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

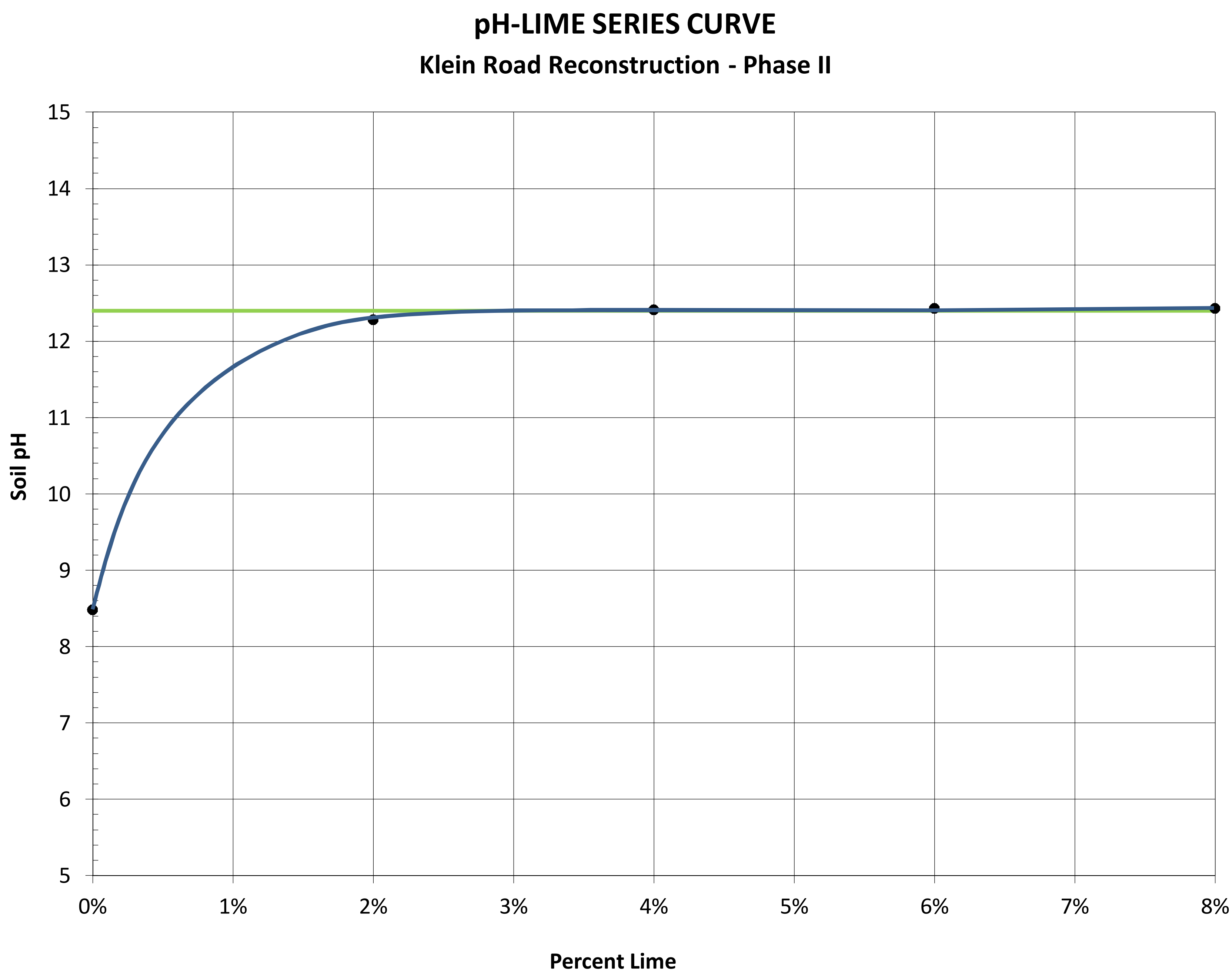
CU = Consolidated Undrained Triaxial

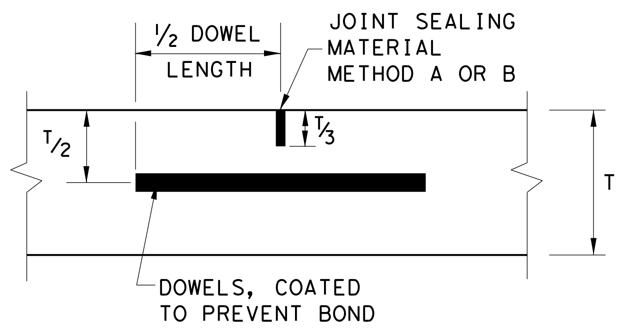

MOISTURE DENSITY RELATIONSHIP CURVE - TEX-114-E
Klein Road Reconstruction - Phase II
95
94
93
92
91
90
89
88
87
86
85
Dry Density (pcf)
15
20
25
30
35
Moisture Content (%)
Optimum Moisture Content (%) = 23.6
Max. Dry Density (pcf) = 92.6
Calculated CBR = 3.4
Avg. %Swell = 2.1

Corrected CBR vs. Dry Density
Klein Road Reconstruction - Phase II

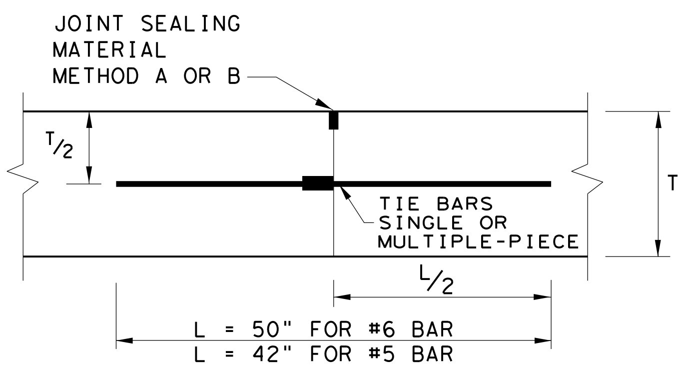


ANA19-039-00
Figure 12

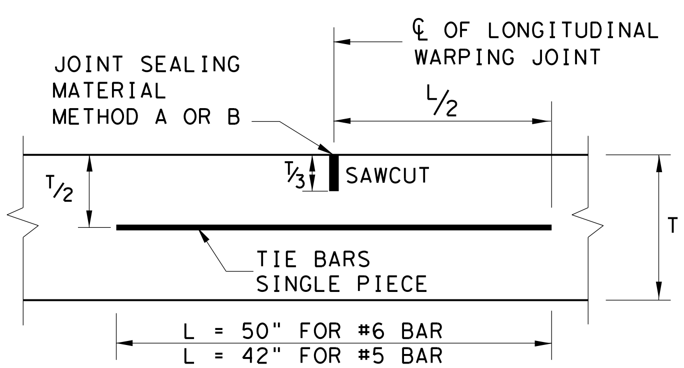

pH-LIME SERIES CURVE
Klein Road Reconstruction - Phase II
Soil pH
15
14
13
12
11
10
9
8
7
6
5
0%
1%
2%
3%
4%
5%
6%
7%
8%
Percent Lime



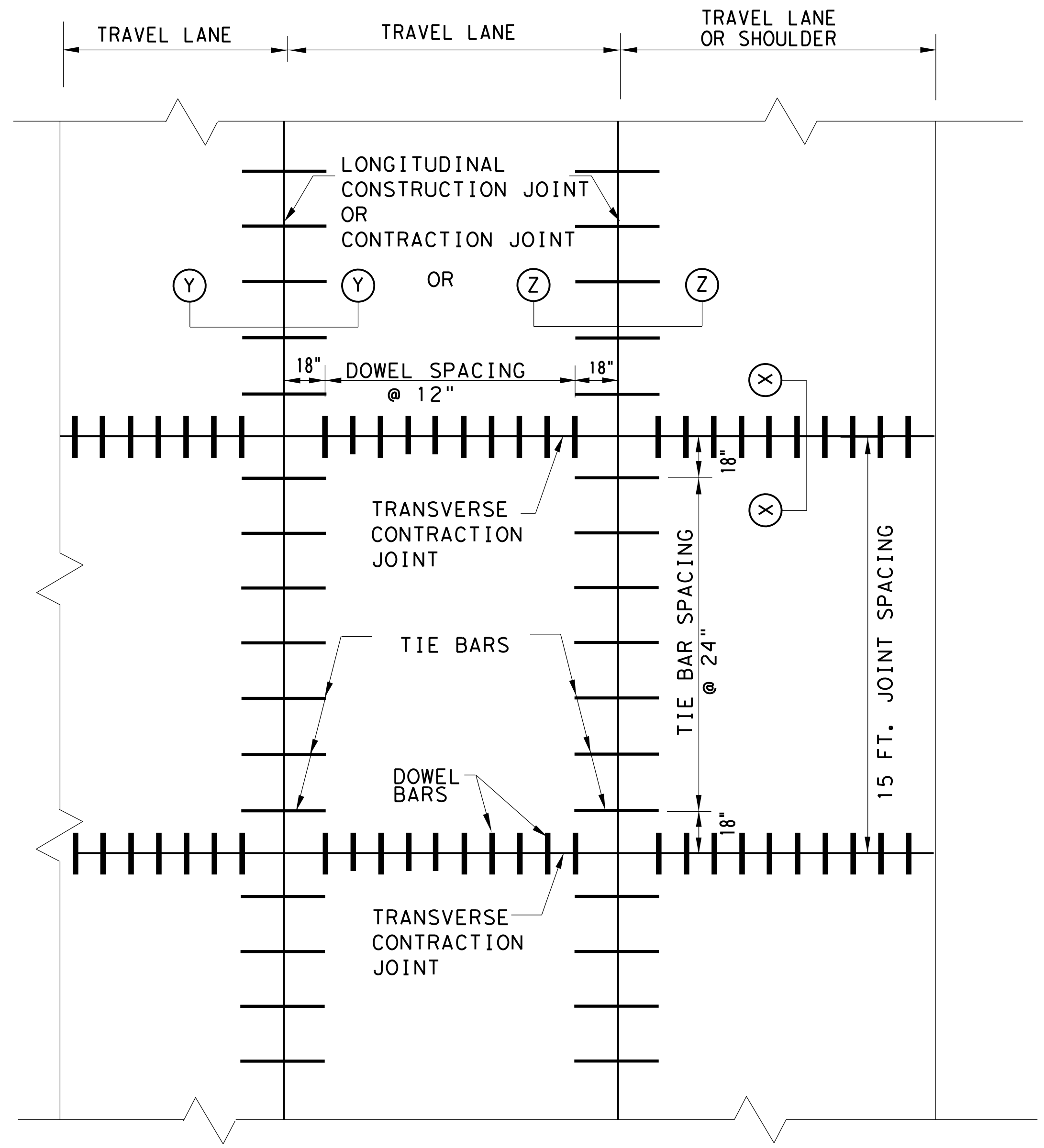
TRANSVERSE CONTRACTION JOINT
SECTION X-X



LONGITUDINAL CONSTRUCTION JOINT
SECTION Y-Y



LONGITUDINAL CONTRACTION JOINT
SECTION Z-Z



TYPICAL PAVEMENT LAYOUT
PLAN VIEW (NOT TO SCALE)

GENERAL NOTES

1. DETAILS FOR PAVEMENT WIDTH, PAVEMENT THICKNESS AND THE CROWN CROSS-SLOPE SHALL BE SHOWN ELSEWHERE IN THE PLANS. PAVEMENTS WIDER THAN 100 FT. WITHOUT A FREE LONGITUDINAL JOINT ARE NOT COVERED BY THIS STANDARD.
2. FOR FURTHER INFORMATION REGARDING THE PLACEMENT OF CONCRETE AND LOAD TRANSFER DEVICES REFER TO THE GOVERNING SPECIFICATION FOR "CONCRETE PAVEMENT".
3. THE SPACING BETWEEN TRANSVERSE CONTRACTION JOINTS SHALL BE 15 FT. UNLESS OTHERWISE SHOWN IN THE PLANS.
4. TRANSVERSE CONSTRUCTION JOINTS MAY BE FORMED BY USE OF METAL OR WOOD FORMS EQUAL IN DEPTH TO THE DEPTH OF PAVEMENT, OR BY METHODS APPROVED BY THE ENGINEER.
5. USE HAND-OPERATED IMMERSION VIBRATORS TO CONSOLIDATE THE CONCRETE ADJACENT TO ALL THE FORMED JOINTS.
6. PAVEMENT WIDTHS OF MORE THAN 15 FT. SHALL HAVE A LONGITUDINAL JOINT (SECTION Z-Z OR SECTION Y-Y). THESE JOINTS SHALL BE LOCATED WITHIN 6 IN. OF THE LANE LINE UNLESS THE JOINT LOCATION IS SHOWN ELSEWHERE ON THE PLANS.
7. THE JOINT BETWEEN OUTSIDE LANE AND SHOULDER SHALL BE A LONGITUDINAL CONTRACTION JOINT (SECTION Z-Z) UNLESS OTHERWISE SHOWN IN THE PLANS. THE SAW CUT DEPTH FOR THE LONGITUDIANL CONTRACTION JOINT (SECTION Z-Z) SHALL BE ONE THIRD OF THE SLABTHICKNESS (T/3).
8. WHEN TYING CONCRETE GUTTER AT A LONGITUDINAL JOINT, THE TIE BAR LENGTH OR POSITION MAY BE ADJUSTED. PROVIDE 3 IN. OF CONCRETE COVER FROM THE BACK OF GUTTER TO THE END OF TIE BAR.
9. REPLACE MISSING OR DAMAGED TIE BARS WITHOUT ADDITIONAL COMPENSATION BY DRILLING MIN. 10 IN. DEEP AND GROUTING TIE BARS WITH TYPE III, CLASS C EPOXY. MEET THE PULL-OUT TEST REQUIREMENTS IN ITEM 361.
10. WHEN AN MONOLITHIIC CURB IS SPECIFIED, THE JOINT IN THE CURB SHALL COINCIDE WITH PAVEMENT JOINTS AND MAY BE FORMED BY ANY MEANS APPROVED BY THE ENGINEER.
11. DOWEL BAR PLACEMENT TOLERANCE SHALL BE +/- 1/4 IN. HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE SPECIFIED.WHERE DOWEL BAR BASKETS ARE USED, REMOVE THE SHIPPING WIRES.
12. THE DETAIL FOR JOINT SEALANT AND RESERVOIR IS SHOWN ON STANDARD SHEET "CONCRETE PAVING DETAILS, JOINT SEALS."

TABLE NO.1 DOWELS (SMOOTH BARS)

SLAB THICKNESS T (IN.)	BAR DIA. AND LENGTH	AVERAGE SPACING (IN.)
6 to 7.5	1" X 18"	12
8 to 10	1 1/4" X 18"	12
>= 10.5	1 1/2" X 18"	12

TABLE NO.2 TIE BARS (DEFORMED BARS)

SLAB THICKNESS T (IN.)	BAR SIZE	AVERAGE SPACING (IN.)
6 to 7.5	#5	24
>= 8	#6	24

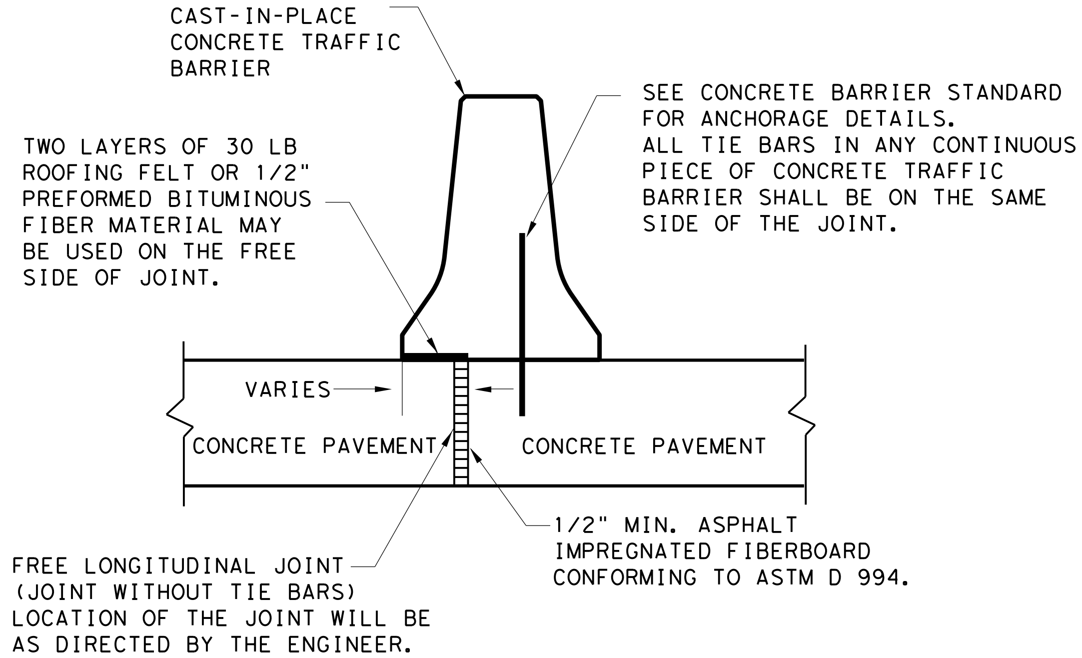
Project No. ANA19-039-00
Figure 14a

Texas Department of Transportation
Design Division Standard

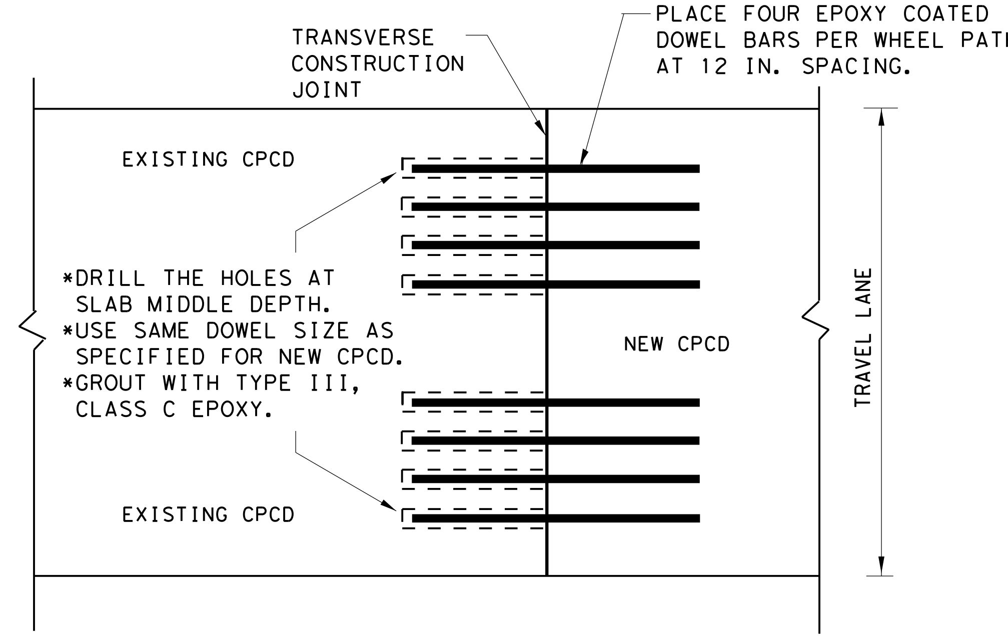
CONCRETE PAVEMENT DETAILS CONTRACTION DESIGN
T-6 to 12 INCHES
CPCD-14

FILE: cpcd14.dgn	DN: TxDOT	DN: HC	DW: HC		CK: AN
© TxDOT: DECEMBER 2014	CONT	SECT	JOB		HIGHWAY
REVISIONS					
	DIST		COUNTY		SHEET NO.

DATE:
FILE:



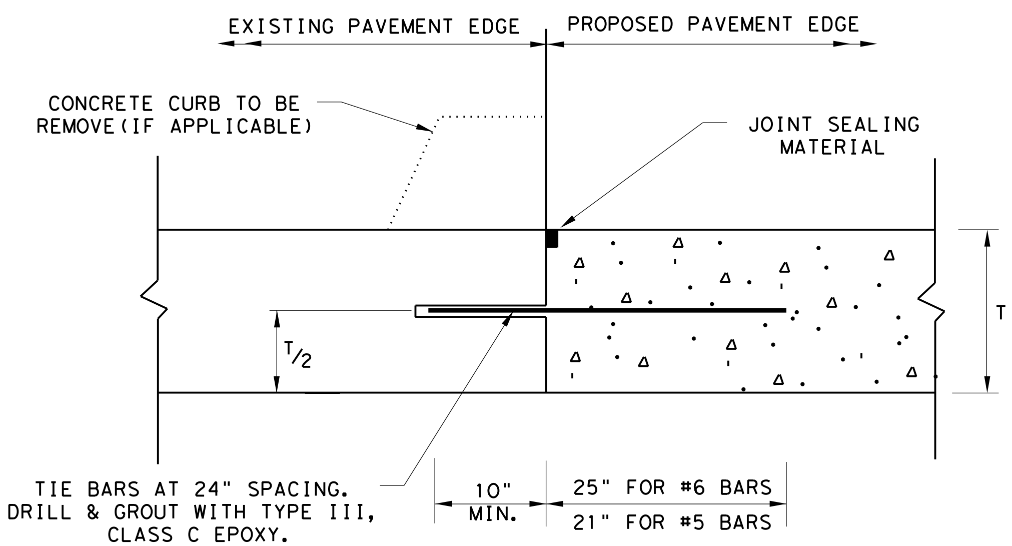
FREE LONGITUDINAL JOINT DETAIL



TRANSVERSE JOINT DETAIL

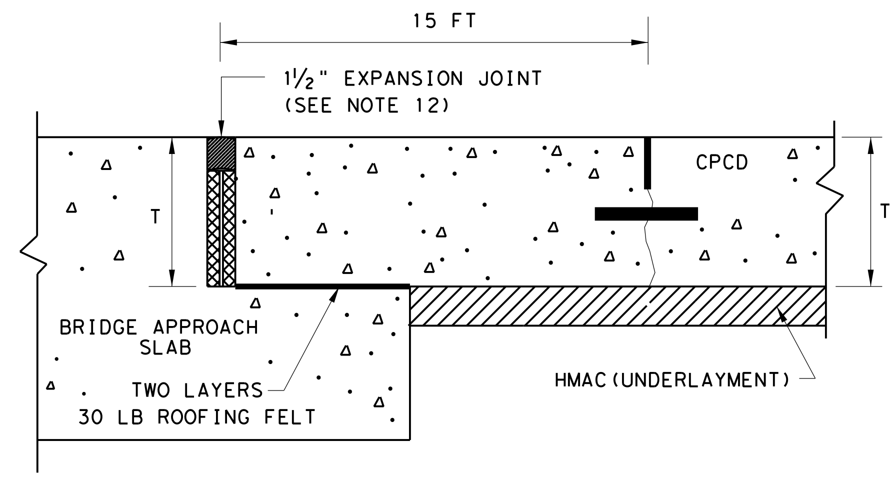
EXISTING CPCD TO NEW CPCD

PLAN VIEW (NOT TO SCALE)



1. BEFORE WIDENING WORK, DEMONSTRATE THAT THE BOND STRENGTH OF THE EPOXY-GROUTED TIE BARS MEETS THE REQUIREMENTS OF PULL-OUT TEST SPECIFIED IN ITEM 361.
2. SPACE TIE BARS AT 24" SPACING. USE #6 BARS FOR 8" AND THICKER SLABS, USE #5 BARS FOR LESS THAN 8" THICK SLABS.
3. THE TRANSVERSE JOINTS OF PROPOSED PAVEMENT SHALL COINCIDE WITH EXISTING PAVEMENT JOINTS UNLESS OTHERWISE SHOWN ON THE PLANS.

LONGITUDINAL WIDENING JOINT DETAIL



TRANSVERSE EXPANSION JOINT DETAIL

AT BRIDGE APPROACH

Texas Department of Transportation

Design Division Standard

CONCRETE PAVEMENT DETAILS

CONTRACTION DESIGN

T-6 to 12 INCHES

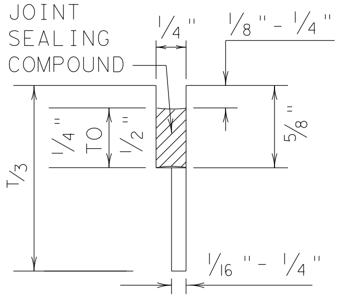
CPCD-14

FILE: cpcd14.dgn	DN: TxDOT	DN: HC	DW: HC	CK: AN
© TxDOT: DECEMBER 2014	CONT	SECT	JOB	HIGHWAY
REVISIONS	DIST		COUNTY	SHEET NO.

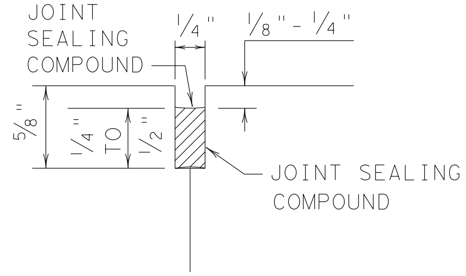
Project No. ANA19-039-00
Figure 14a

DATE:
FILE:

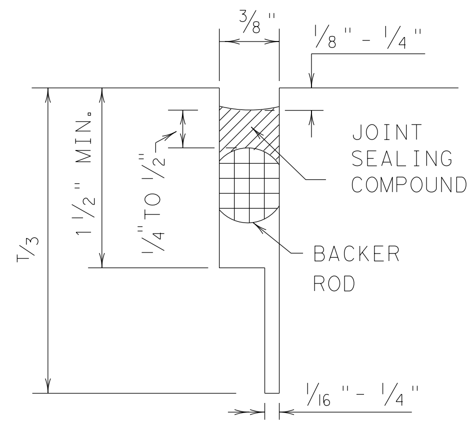
METHOD B: JOINT SEALING COMPOUND



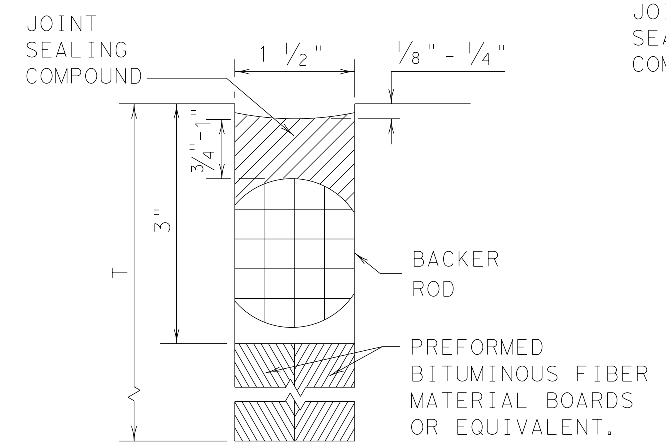
LONGITUDINAL SAWED CONTRACTION JOINT



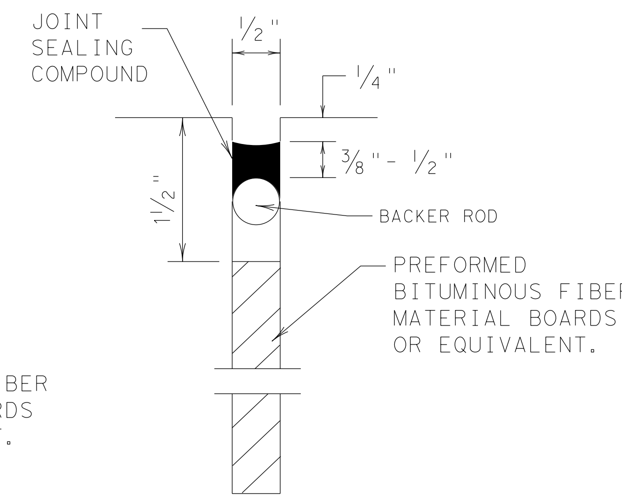
LONGITUDINAL OR TRANSVERSE CONSTRUCTION JOINT



TRANSVERSE SAWED CONTRACTION JOINT

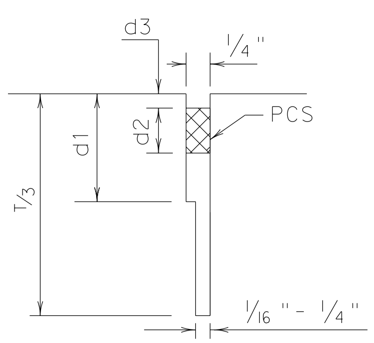


TRANSVERSE FORMED EXPANSION JOINT

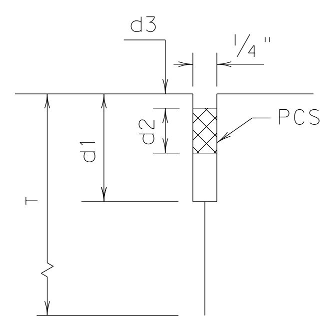


FORMED ISOLATION JOINT

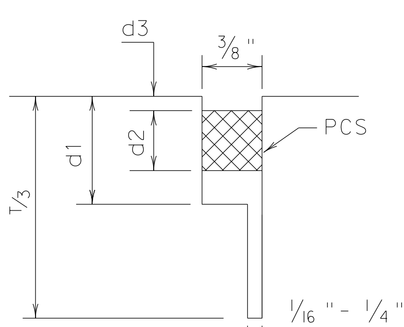
METHOD A: PREFORMED COMPRESSION SEALS (PCS)(DMS-6310 CLASS 6)



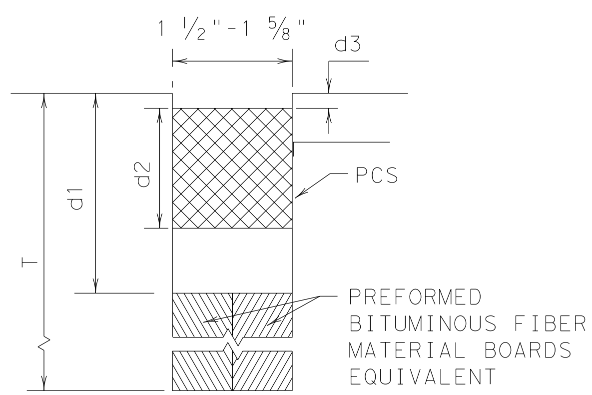
LONGITUDINAL SAWED CONTRACTION JOINT



LONGITUDINAL CONSTRUCTION JOINT



TRANSVERSE SAWED CONTRACTION JOINT



TRANSVERSE FORMED EXPANSION JOINT

GENERAL NOTES

1. UNLESS OTHERWISE SHOWN IN THE PLANS, EITHER METHOD "A" OR METHOD "B" MAY BE USED.
2. THE LOCATION OF JOINTS SHALL BE AS SHOWN ELSEWHERE IN THE PLANS.
3. THE JOINT RESERVOIR FOR SEALANT OR PCS SHALL BE SAWED UNLESS OTHERWISE SHOWN ON THE PLANS FOR THE LONGITUDINAL AND TRANSVERSE CONSTRUCTION JOINTS AND THE SAWED JOINTS.
4. DIMENSIONS d1, d2, AND d3 SHOWN IN METHOD A SHALL BE IN ACCORDANCE WITH THE PREFORMED COMPRESSION SEAL MANUFACTURER'S RECOMMENDATION.
5. REFER TO DMS-6310 "JOINT SEALANTS AND FILLERS" FOR THE CLASSIFICATIONS.
6. FOR SAWED LONGITUDINAL JOINT, LONGITUDINAL OR TRANSVERSE CONSTRUCTION JOINT, USE JOINT SEALANT CLASS 5 OR 8 UNLESS OTHERWISE SHOWN ON THE PLAN OR APPROVED.
7. FOR TRANSVERSE SAWED CONTRACTION, TRANSVERSE FORMED EXPANSION JOINT, AND ISOLATION JOINT USE JOINT SEALANT CLASS 5 OR 8 AT NEW JOINTS. USE JOINT SEALANT CLASS 4,5,7,OR 8 FOR MAINTAINING EXISTING JOINTS.
8. THE JOINTS SHALL BE CLEANED IN ACCORDANCE WITH THE ITEM 438 "CLEANING AND SEALING JOINTS" OR ITEM 713 "CLEANING AND SEALING JOINTS AND CRACKS (CONCRETE PAVEMENT)".
9. ISOLATION JOINTS ACCOMMODATE HORIZONTAL AND VERTICAL MOVEMENTS THAT OCCUR BETWEEN A PAVEMENT AND A STRUCTURE. ISOLATION JOINTS MAY BE USED FOR BRIDGE ABUTMENTS, INTERSECTIONS, CURB AND GUTTER, OLD AND NEW PAVEMENTS, OR AROUND DRAINAGE INLETS, MANHOLES, FOOTINGS AND LIGHTING STRUCTURES.

Project No. ANA19-039-00
Figure 14b

Texas Department of Transportation | Design Division Standard

CONCRETE PAVING DETAILS

JOINT SEALS

JS-14

FILE: js14.dgn	DN: TxDOT	CK: HC	DW: HC	CK: AN
© TxDOT: DECEMBER 2014	CONT	SECT	JOB	HIGHWAY
REVISIONS	DIST	COUNTY		SHEET NO.

DATE:
FILE:

Important Information About Your

Geotechnical Engineering Report

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

The following information is provided to help you manage your risks.

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 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 your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the 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.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of 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,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- 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 study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the 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 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 construction recommendations included in your report. *Those 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 recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower 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. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing 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 Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors 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 contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors 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 contractors do not 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.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental 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 geoenvironmental 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, a number of 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 ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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