Pavement Evaluation Report

West Klein Road

New Braunfels, Texas

December 21, 2020

Terracon Project No. 90201363

Prepared for:

City of New Braunfels – Public Works
New Braunfels, Texas

Prepared by:

Terracon Consultants, Inc.
San Antonio, Texas

terracon.com

Terracon

Environmental ■ Facilities ■ Geotechnical ■ Materials

December 21, 2020

Terracon

City of New Braunfels – Public Works
550 Landa Street
New Braunfels, Texas 78130

Attention : Mr. Nathan Garza
C: (830) 221-4082
E: ngarza@nbtexas.org

Re: Pavement Evaluation Report
West Klein Road
New Braunfels, Texas
Terracon Project No. 90201363

Dear Mr. Garza:

Terracon Consultants, Inc. (Terracon) is pleased to submit our Pavement Evaluation Report for West Klein Road in New Braunfels, Texas.

Please contact us if you have any questions or if we can be of further assistance.

Sincerely,
Terracon Consultants, Inc.
(Firm Registration: TX F3272)

Prashant Palusani, EIT
Senior Staff Engineer

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PAVEMENT EVALUATION REPORT
WEST KLEIN ROAD
NEW BRAUNFELS, TEXAS

TERRACON PROJECT NO. 90201363
DECEMBER 21, 2020

1.0 INTRODUCTION

Terracon is pleased to submit this Pavement Evaluation Report for West Klein Road in New Braunfels, Texas. This project was authorized by Mr. Nathan Garza, Capital Projects Manager by issuance of a purchase order on August 13, 2020. The original project scope was performed in general accordance with Terracon Proposal No. P90201363R dated August 11, 2020. A Pavement Data Report 90201193 was issued on June 2, 2020; and, an Interim Pavement Evaluation Report 90201193R1 was issued on July 9, 2020. Both reports are presented in Appendix F.

2.0 PROJECT DESCRIPTION

The overall project includes the widening and reconstruction of West Klein Road from FM 1044 to South Walnut Avenue in New Braunfels, Texas. The 2.1-mile-long project is being constructed in multiple phases. This report ONLY addresses Phases I through IV. These four phases span approximately from Station 0+30 to 68+00.

3.0 PROJECT INFORMATION

For the purpose of this report, we have prepared an abbreviated timeline for the project as noted below.

3.1 Project Timeline

March 27, 2014	Geotechnical Engineering Study and Pavement Recommendations; Raba Kistner Consultants, Inc (RKCI) (Appendix A)
April 01, 2015 and March 30, 2016	Additional Pavement Design Sections; Raba Kistner Consultants, Inc. (RKCI) (Appendix A)

April 10, 2019	Civil Design Drawings; Trihydro Corporation, Inc. (Drawings reviewed were dated as noted)
June, 2018	Based on the testing data provided to us for document review, it is apparent that the initial phase of construction may have started in the month of June 2018 by J3 Construction Company, LLC
July 19, 2019	RKCI report addressing pavement distress
October 17, 2019	Report from Synchropile, Inc addressing pavement distress
November 20, 2019	RKCI report addressing pavement distress
April, 2020	Terracon was contacted by City of New Braunfels regarding premature pavement failures in Phase III
June 2, 2020	Terracon Pavement Data Report for Phase III (Appendix F)
July 9, 2020	Terracon Pavement evaluation Report (Interim) (Appendix F)

3.2 Document Review

The list of documents reviewed by Terracon include the following (Appendix A):

- RKCI geotechnical report (RKCI Project No. ANA14-002-00, dated March 27,2014).
- RKCI proposition 1 and 2 Additional Pavement Sections (RKCI Project no. ANA15-033-00, dated April 1, 2015 and March 30, 2016 respectively)
- Civil Design Plans prepared by Trihydro Corporation, Inc. New Braunfels, Texas dated April 10, 2019 (Job No. 702-407-000)

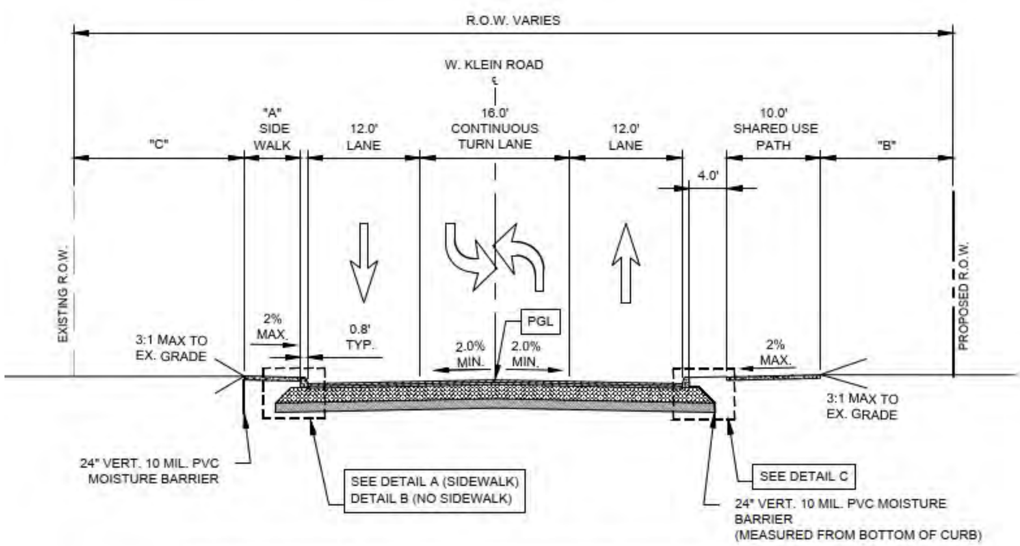
- RKCI reports - Distress Observations/Repair Recommendations (Project No. AND18-008-00, dated July 19, 2019); and, Distress Response Letter (Project No. AND 18-008-00, dated November 20, 2019)

- SynchroPile, Inc Advance Final Report (Project No. ZA19-0805, dated October 17, 2019).

- Testing and inspection reports for prepared during construction by RKCI (Project No. AND18-008-00)

3.3 Pavement Details from Civil Drawings (Sheet 34, Plans dated April 10, 2019)

In cases where a sidewalk is constructed adjacent to the edge of the pavement, the 10 mil PVC moisture barrier is not specified.



STA - STA	A	B	C
0+00 - 0+91	FM 1044 INTERSECTION		
0+91 - 20+49	NONE	VARIES ± 1'-6" - 63'-0"	VARIES ± 1'-6" - 63'-0"
20+49 - 38+40	6'-0"	12'-0"	16'-0"

PROPOSED MINOR ARTERIAL STREET
2 LANES W/ CONTINUOUS TURN LANE
6 FT. SIDEWALK AND 10 FT. SHARED USE PATH

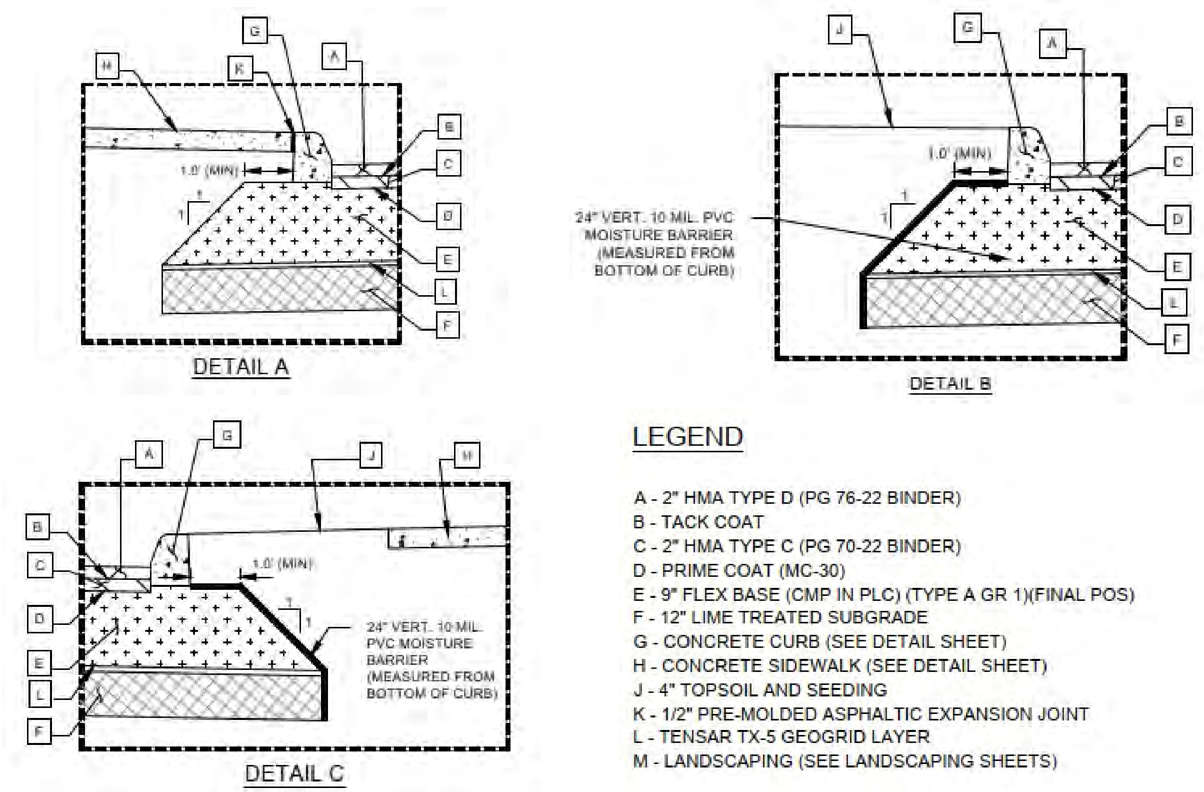


Figure 1. Pavement Cross Section – Plan Sheet No. 34

3.3 Visual Observations

(Performed by Terracon Personnel in April,2020 and on July 2, 2020- Appendix F)

- Severe rutting and alligator cracks, mainly along the curb and wheel path.
- Apparent pumping of fines from the granular base material up through the alligator cracks
- Areas where surface drainage directs runoff towards the pavement.
- A mix of passenger car and heavy traffic including heavy construction equipment some of which appears to be related to the construction of nearby residential subdivisions.

Summary:

Premature distress in the form of alligator cracking (which will most likely lead to potholes) and rutting have been observed in each of the phases evaluated, i.e. Phase I, II and III of the completed pavements. In general, the extent and severity of distress is greater in Phases I and III as compared to Phase II. Phase IV had not been opened to traffic and no distress was observed during our site visit in April 2020. Reports reviewed by Terracon indicate that the distress was first addressed in writing in July 2019.

Based on our review of the testing and inspection reports by RKCI during construction, we did not note non-compliant results or inspections. Tests, if any, that were shown initially as failures were resolved by retests

4.0 DATA ACQUISITION AND ANALYSIS

4.1 Ground Penetrating Radar (GPR)

In general, field data acquisition followed the procedures referenced in American Society for Testing and Materials *Standard D6432-11, Standard Guide for Using the Ground Penetrating Radar Method for Subsurface Investigation* and more information on both the general method and data collection procedures is included in the Standard. GPR instruments transmit and receive high-frequency electromagnetic (EM) waves to acquire data about subsurface conditions. GPR detects differences in the EM properties (relative dielectric permittivity, conductivity and magnetic permeability) of the subsurface or material being scanned. Variations in the GPR signal generally can indicate differences in the material properties such as electromagnetic conductivity and relative dielectric permittivity, which in some cases can be qualitatively linked to other material properties such as density and moisture content. These changes can be effective in identifying the presence and location of items such as subsurface voids, buried concrete, steel tanks, underground utilities, concrete thickness, as well as embedded reinforcing steel in concrete and masonry structures, among other things.

The GPR survey was conducted using an SIR 4000 control unit equipped with a 1600 MHz antenna made by Geophysical Survey Systems Inc. (GSSI). The effective depth of the GPR antenna used for the survey are shown on the following table.

Antenna (MHz)	Depth Range of Interest (feet)
1,600	0-1.5
900	0-3
800	0-3.5
400	0-8
300	0-10

The survey was conducted using a series of parallel scans across the survey area. A total of 8 scans were performed along the roadway as shown in Exhibit C-1 of Appendix C. The results of the GPR survey are summarized in Section 4.2.

4.2 Ground Penetrating Radar Scan - Results and Discussion

Six areas were scanned at locations along the southwest bound roadway (Phase III) 3-1 through 3-6. This portion of the roadway has been utilized by vehicles for the longest amount of time. Two areas were scanned along the northeast bound roadway (Phase IV) 4-1 and 4-2. The approximate station numbers for the scan locations are shown in Table 1.

Table 1: Station Numbers for GPR Scan locations

Area	Phase of Const.	Sta. Start	Sta. Stop	Width (ft)	Length (ft)	Latitude	Longitude	Direction	Opened to traffic prior to GPR survey
3-1	III	50+34.60	50+60.00	20	26	29.645549	-98.117148	SW bound	Yes
3-2	III	51+53.00	51+98.00	20	46	29.645773	-98.116895	SW bound	Yes
3-3	III	53+44.80	53+94.85	20	50	29.646205	-98.116404	SW bound	Yes
3-4	III	55+8.30	55+47.70	20	40	29.646507	-98.116068	SW bound	Yes
3-5	III	58+25.00	58+35.00	20	10	29.647068	-98.115430	SW bound	Yes
3-6	III	64+74.00	65+13.50	20	40	29.648383	-98.113910	SW bound	Yes
4-1	IV	58+24.50	58+34.28	20	10	29.646991	-98.115340	NE bound	No
4-2	IV	64+74.00	65+13.25	20	40	29.648327	-98.113856	NE bound	No

Note 1: The Latitude and Longitude readings are from the north corner of the GPR survey area.
Note 2: The Station Numbers are the approximate start and stopping points parallel to the curb.

At the time of the GPR data acquisition, northeast bound roadway (Phase IV) was not in use. These two scans were selected to allow comparison of the used and unused portions of the roadway. The surfaces of the asphalt at portions of the survey areas on the southwest-bound (Phase III) lanes were cracked and depressed, whereas, the northeast-bound lanes were intact, and no cracks were observed.

The attached exhibits C-2 thru C-17 in Appendix C show selected cross-sectional profiles of the GPR scans on the left side of the exhibit and a plan view on the right side of the exhibit. The plan views were created from the GPR scans conducted in the X and Y grid directions over each survey area. The sectional views are selected to include localized significant variations in GPR reflections and are depicted by a dotted green line on the plan view. Photographs of the GPR scan areas are included below the GPR scans. The approximate locations of the GPR scan areas are shown on an aerial photograph as shown in Exhibit C -1 of the roadway vicinity. The following paragraphs discuss the variations in GPR reflections vs depth as shown in sectional view.

Consistent and parallel radar reflections around 1 foot below the pavement were visible in all the scans. This is shown by a transition from light gray to white or blue in the profile views. This is indicative of a change in either moisture content and/or density of the soil.

Radar reflections were visible from around 2 to 4 feet which were not parallel and occurred at varying depths. These reflections indicate variations or changes in the subsurface soils. The variations over a wider depth extent are indicative of more gradual changes in the subsurface materials. This could occur from the uneven mixing of soils with a different composition or variations in the lime stabilization mixing, distribution of soils from depression of the asphalt above and/or surface water infiltration.

Some reflections at 7 feet which are nearly continuous across the survey profiles were observed in most of the scans. This radar response (signal amplitude) was less apparent in the scans acquired over the closed lanes – survey areas 4-1 and 4-2. These reflections may be related to a change in moisture content of the soil. However, the consistent depth and thickness of the radar reflections suggests that the cause is more regional than incidental.

4.3 Multi-Channel Ground Penetrating Radar (MCGPR)

Multi-Channel Ground Penetrating Radar system consists of an IDS GeoRadar stream of EM to collect data. The stream EM consists of 38 channels of combination of 200MHz to 600 MHz antenna frequencies oriented both in horizontal and vertical dipole directions. Unlike the portable GPR scanner which was initially used to confirm that the technique was viable, this can be used to collect wide swaths of data in single a pass. Phases I, II, III and IV were scanned using MCGPR scanner. The data was collected in a single direction using both its horizontal and vertical antennas and the data was georeferenced using a survey grade GPS antenna mounted on top of the Stream EM unit.

MCGPR data was post-processed using the GRED software suite by IDS GeoRadar. MCGPR post-processing was done utilizing position correction and background removal (filtering). The MCGPR data was evaluated and compared with the data obtained from portable GPR scanner. The MCGPR scan output is shown in Exhibit C-18 through C-25 in Appendix C which shows evidence of localized inconsistencies in the underlying materials for locations 3-1 through 3-6 which further confirm the portable GPR scan data. In locations 4-1 and 4-2, the significant disturbance beyond 40 inches depth could possibly be due to the presence of old buried utility pipelines in the area.

4.4 Falling Weight Deflectometer (FWD) Testing - Data Acquisition

A falling weight deflectometer (FWD) is a non-destructive testing device used to evaluate physical properties of pavement. It is a device designed to simulate deflection of a pavement surface caused by a fast-moving truck. The FWD applies a dynamic load that simulates the loading of a moving wheel. This load pulse is transmitted to the pavement through a 300-millimeter (mm) diameter circular load plate. The load pulse generated by the FWD momentarily deforms the pavement under the load plate and pavement response is captured through a series of 7 sensors placed at 1 foot apart from each other. The pavement response is analyzed to determine the elastic moduli, stresses and strains of each modeled layer. FWD testing was performed along the Phases I through IV. The FWD testing sequence is shown in Exhibit D-1 and D-2 in Appendix D.

4.5 Falling Weight Deflectometer Testing (FWD) - Results and Discussion

Using the FWD data, a modulus (stiffness) of each layer is obtained by back calculation in MODULUS software. A wide range of variations were observed in the modulus of each layer. Typical modulus values included in the TxDOT Pavement manual are shown in Table 2. All the computed moduli are shown in Exhibit D-3 through D-19 in Appendix D. The following tables (Table 3 through Table 5) summarize the lowest, average and highest moduli values for each of the pavement layers.

Table 2: Typical Moduli - TXDOT Pavement Manual

Layer Type	Typical Modulus values, ksi
Raw Subgrade	8 – 20
Lime Treated Subgrade	30 – 45
Untreated Flexible Base	40 – 70

Table 3: Moduli for Untreated Flexible Base (Typical range 40 – 70 ksi)

FWD Section	Lowest Moduli, ksi	Average Moduli, ksi	Highest Moduli, ksi
P-1	12.8	73	550
P-2	6.4	48.4	555.1
P-3	14	167.8	899.6
P-4	13	74.8	462.3
P-5	5	91.8	561.8
P-6	11.9	290.33	1916.8

Table 4: Moduli for Lime Treated Subgrade (Typical range 30 – 45 ksi)

FWD Section	Lowest Moduli, ksi	Average Moduli, ksi	Highest Moduli, ksi
P-1	11.8	140	1225.8
P-2	11.4	133.9	1005.9
P-3	7.9	77.6	369.9
P-4	13.2	127.4	1526.3
P-5	17.3	275.0	3482.8
P-6	6.1	229.08	1529.8

Table 5: Moduli for Raw subgrade (Typical range 8 – 20 ksi)

FWD Section	Lowest Moduli, ksi	Average Moduli, ksi	Highest Moduli, ksi
P-1	11.2	17.7	25.3
P-2	9	14.9	27.1
P-3	8.2	16.8	29.3
P-4	12.8	16.7	22.4
P-5	13.1	17.1	26.8
P-6	11.1	19.3	34.1

The FWD data indicates a large variation and non-uniformity in the moduli values for the untreated flexible base and lime treated subgrade layers. This corelates to the GPR scan images showing the moisture variations in these layers.

4.6 Historical Aerial Photographs

Exhibit E-1 through E-6 in Appendix E show the historical aerial photographs of the region starting from 2008 and going back to 1964. Aerial photographs indicate that the area used to be an agricultural land and there was a water stream crossing West Klein road flowing downstream in the southwest direction. Due to recent land development and urbanization, there is no visible water on the surficial layers but there might be a residual water flow along the old stream in the residual underlying soils. Due to the presence of high plasticity soils and a moisture barrier installed in the roadway section, the area might be experiencing some vertical movements due to change in the moisture conditions.

5.0 DISCUSSION

5.1 Pavement Design

Based on the review of the geotechnical and supplemental reports prepared by RKCI, we have summarized the pavement designs and compared them to those shown on the Design Documents. The summary is present in the Table 6.in the following page

Table 6: Pavement Design

	Design dated March 27, 2014 [1]		Design dated March 30, 2016 [4]				Design Documents	When Opened to Traffic
			FM 1044 to Klein Meadows		Klein Meadows to Walnut Ave.			
	Collector	Arterial	10 Yr	20 Yr	10 Yr	20 Yr	----	----
Structural Number (Design)	5.22	5.8	4.08	4.58	4.22	4.8	3.93	3.05
Type D Surface Course (in.)	2.0	3.0	2.0	2.0	2.0	2.0	2.0 in. / Type D	See Note 5
Type C / D Binder Course (in.)	3.0	3.0	2.0	2.5	2.0	3.0	2.0 in. / Type C	2.0 in. / Type C
Flexible (Granular)Base [2] (in.)	12.0	13.0	12.0	14.0	13.0	14.0	9.0 in. w/geogrid	9.0 in. w/geogrid
Lime treated Subgrade (in.)	8.0 [3]	8.0	8.0	8.0	8.0	8.0	12.0 in.	12.0 in.
Combined Total (in.)	25.0	27.0	24.0	26.5	25.0	27.0	25.0 in.	23 in.

(1) Design was based on City of San Antonio pavement design manual.
(2) Flexible base layer may be reduced by 5 in. if geogrid is included at the bottom of flexible base layer, creating an MSL.
(3) It is recommended that a total of 12 inches of subgrade be lime treated for improved pavement performance; however, only 8 inches will be claimed for structural credit in the pavement design.
(4) Pavement design was revised on the new traffic data provided to RKCI.
(5) As a result of phased construction, the pavement was opened to traffic before construction of the 2-inch Type D Surface Course.

Based on the information presented in Table 6, pavement thickness from design documents prepared by Trihydro Corporation differ from the pavement design in the Raba Kistner's Geotech report dated March 30, 2016. Reason for the variation in thickness of the layers is unclear at the time of this report.

5.2 Design and Construction of Roadways

Construction documents prepared by Trihydro Corporation proposed phased construction of West Klein Rd from FM 1044 to Walnut Avenue. The construction was divided into eight phases where each phase was to be completed, opened to traffic and moved on to the next phases. Phase I included the construction of South lane from Sta. 03+00 to Sta. 39+00 and Phase II included construction of North lane from Sta. 03+00 to 39+00. Construction documents specify early opening of pavement to traffic with 2 inches of HMAC type C Binder course without the application of final surface HMAC Type D surface course.

During the construction of Phase II, the south side of the pavement was completed and opened to traffic, but the pavement layers on the other side were still exposed to environmental conditions with no protection against moisture seepage. During this period, heavy rainfall caused ponding of water on road in some occasions. The general higher elevations on the north side of the pavement and the pavement profile sloping towards the south provided an opportunity for the water to seep into the flexible base and lime treated subgrade layers of South bound lane. Water entering the pavement layers might have been trapped in the roadway section due to the PVC moisture barrier placed behind the curb and high plasticity of soils surrounding the area. Also, the sidewalk area containing high plastic soils was left open during construction which further increased the risk of trapped water. Trapped water might have started weakening the underlying layers which resulted in inadequate structural support for the present traffic. In addition, the heavy construction traffic may have expedited the failure.

The construction traffic was rerouted to only one side of the pavement which perhaps resulted in more traffic in each lane than anticipated. Narrow lanes due to construction also change the wheel paths of the traffic. The pavement edges disintegrate from the curb as the wheels are much closer and weakens the bond between the curb and hot mix asphalt. In addition, frequent construction traffic including loaders, trailers and trucks were observed with their wheel paths rubbing against the curb as shown in the Figure 2. This created high edge stresses resulting in weakening and most likely opening of the joint between pavement and the adjacent curb.

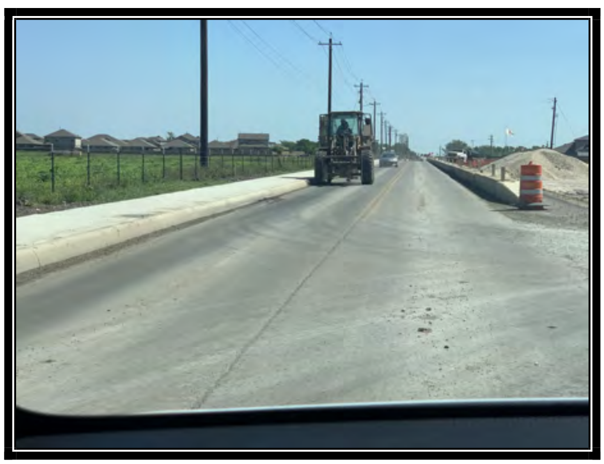


Figure 2: Loader wheel path (Phase III)

During the construction, the PVC moisture barrier might not have been installed in accordance with the geotechnical recommendation as stated in the report dated March 30, 2016. The design drawings specify that the installation of moisture barrier should be done from the bottom of the curb to penetrate the subgrade. During our interactions with the contractor, it was mentioned that the 24-inch-deep 10 mil. PVC moisture barrier was installed behind the curb. However, it was not clear whether it was installed from the top or the bottom of the curb. Inadequate depth of moisture barrier could also lead to water seeping into the roadway subgrade causing the pavement to fail prematurely.

During the construction, several rainfall events occurred resulting in wetting of the materials placed during the previous days. Areas of flooding were reported. After the rainfall event, there were no records found for proof rolling observation or other testing on the wetted materials.

There is a possibility of moisture seeping into the underlying layers and getting trapped in the roadway sections. Based on our GPR scans, the area has significant variations in either density of the material or moisture content or both.

6.0 CONCLUSIONS

Based on the data presented in this report, our knowledge of the project and our experience with similar projects, it is our opinion that factors contributing to the premature distress in the pavements include the following:

- Water entering and weakening the pavement layers as discussed in this report.
- Opening to traffic without placement of the final 2-inch layer of Type D HMAC layer (about 22 percent of the overall structural number for the pavement section).
- High volume of heavily loaded vehicles (some from construction traffic related to the roadway and some related to construction in the adjacent residential subdivisions) crossing the pavement coupled with their wheel paths close to the curb as discussed in this report.

7.0 RECOMMENDATIONS

Recommendations related to future investigations of existing conditions and/or reconstruction of the pavements include the following:

- Design and construct more robust measures to control moisture variations in the pavement layers both during and after construction.
- Utilize pavement materials that are less susceptible to damage from changes in moisture content.
- Consider the effects of construction related traffic on the design and performance of the pavements.
- Avoid opening of the pavements to traffic until they have been completed.