MESQUITE
REAL. TEXAS. ROADS.

ENGINEERING REVIEW DRAFT REPORT

REAL. TEXAS. ROADS.

OPTIMIZED PAVEMENT RECONSTRUCTION

June 4, 2018

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City of Mesquite elected officials and staff have requested this report to investigate and document findings for the Optimized Pavement Reconstruction (OPR) method of rehabilitation of residential concrete streets. This report is an initial evaluation of the results of work done to date under the Optimized Pavement Reconstruction process, with comments and recommendations for modifying processes to improve the quality of the end product.

REAL. TEXAS. ROADS. – AN OVERVIEW

In November 2015, Mesquite voters approved a $125,000,000 bond program for repair of residential city streets. The Real. Texas. Roads. (RTR) program is geared toward rehabilitating city streets in the worst condition (Grade 4- PCI < 56) through multiple contracts for levelling pavements by lifting; full depth milling of asphalt pavements; miscellaneous repairs; and surface reconstruction.

Obtaining optimum results requires attention to the condition of existing pavements and subgrades, repairing pavement failures, proper preparation of existing pavements, and quality construction materials, methods and inspection. City staff begin the process by evaluating streets for rehabilitation based on existing condition scores (PCI), population density, proximity to process in groups, and suitable condition of underground utilities. Pavement assessments are performed to determine if leveling or point repairs are needed through other contracts in the RTR program. Needed repairs to water lines are scheduled. After streets are accepted and scheduled for OPR processing, residents are notified of the approximate timeline for repairs and how it should impact their daily life.

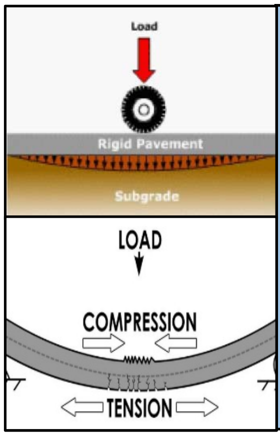
Sites with groundwater issues are investigated to determine the source of water. Leaking service lines and drainage obstructions are addressed as soon as possible before the OPR process, allowing time for subgrade to dry and settle when possible. City staff evaluate upcoming streets and coordinate needed repairs.

Adequate, experienced inspection staff and a cooperative effort between inspection staff and the contractor to make repairs according to specifications are key to good results. Inspectors have the experience and authority to identify damaged pavement for removal and replacement. Adequate staffing is vital to investigate upcoming streets for approximate quantities of repair as well as water and other stability issues that need to be addressed.

Surface reconstruction work, which is a major component of the Real. Texas. Roads. program, utilizes “Optimized Pavement Reconstruction”, an innovative process developed by City staff. (See City of Mesquite website, https://www.cityofmesquite.com/1713/Real-Texas-Roads, for a video demonstrating the process.)

OPTIMIZED PAVEMENT RECONSTRUCTION

Method- Conventional concrete pavement incorporates a single layer of reinforcing steel in the middle of the slab. The steel provides limited shear resistance and restricts movement of the concrete as cracks form, but it does not contribute to the flexural strength of the pavement structure. Most concrete pavement failures initially begin from flexural stresses.



Concrete pavement "bends" under wheel loadings similar to a beam in flexure.

Plain concrete is strong in compression, but weak in tension.
Tensile strength = 10-15% compressive strength

Most concrete pavement failures begin as tensile cracking. Repeated flexing under traffic loads causes the cracks to propagate through the concrete slab.

The single mat of reinforcing steel in most pavements keeps cracks in the concrete from spreading, but does little to strengthen the pavement.

To strengthen concrete, steel bars are placed in the tension zone. Compressive bending stress is carried by the concrete and tensile bending stress is carried by the reinforcing bars

A more effective design utilizes reinforcing steel in the upper and lower sections of pavement to *provide additional structural integrity and slightly increase flexural strength.*[*] In new pavement the steel is within 2 inches of the upper and lower surfaces of the concrete, but any vertical separation of steel will increase strength.

Optimized Pavement Reconstruction (OPR) creates a thicker, bonded concrete mass with two layers of reinforcing steel to *keep cracks tights and strengthen the pavement against flexural movements and failure.*[*] This is expected to increase the working life of pavements at reduced costs vs. complete reconstruction of a conventional section.

Existing concrete pavements are 5 inches thick with a mat of reinforcing steel centered in the concrete. The OPR design removes ~2 inches of concrete at the curb line, reducing to just scratching the surface at the centerline of the roadway. An additional mat of steel is placed on the exposed concrete and fresh concrete is placed, flush with the curb line and 3 inches thick at the centerline. The result is a pavement 5 inches thick at the curb and ~8 inches at centerline, with two mats of steel to *keep cracks tight and improve structural integrity.*[*]

[*] *Transtec Peer Review input*

ADVANTAGES AND RISKS OF OPTIMIZED PAVEMENT RECONSTRUCTION

Advantages- The OPR process offers advantages in cost and convenience to neighborhood residents. Based on actual expenditures in 2016, the process has a contract unit cost of **$65.78/SY**, or $1,079,905/mile. A conservative approach to rehabilitate residential streets in Mesquite would likely be based on complete removal and reconstruction to achieve a 1 inch potential vertical rise (1" PVR) design. A roadway meeting 1" PVR in Forney, TX, (FM 741, FM 740, FM 548) built on the same Houston Black Clay soils common in Mesquite, consisted of

10" reinforced concrete pavement,
1" Type D HMAC,
6" Flexible Base,
30" lime stabilized subgrade.

Including costs for removal of existing pavement and excavation, pricing of this design using current TxDOT low bid tabulations comes to **$161.61/SY,** 246% of the cost for OPR. Actual cost to the City would be higher due to the economy of scale in the TxDOT pricing versus quantities typical in a municipal project. **Comparatively, the OPR process is rehabilitating approximately 3 miles of pavement vs. 1 mile of a 1"PVR design.**

There are additional tangible and intangible costs to consider as well.

The OPR process is an in-house design and construction management program. The cost to the City to produce and manage with in-house staff is exceptionally cost effective. Producing these contracts and managing construction by a consultant engineering firm would add 16% additional engineering and inspection costs.

Intangible cost savings to the OPR method are based largely on **inconvenience to local residents**. Leveling and full-depth repair needs identified by City staff are addressed prior to the OPR process beginning. The OPR process leaves the majority of the existing pavement in place, so residents have access to their driveways outside the 7-10 day period the reinforcing steel is installed, concrete is placed and cured, and necessary cleanup is finished. The contract limits work in most cases to two lots wide so residents have on-street parking in front of their neighbors during this time. Removal and reconstruction of the streets would block access for three to four months in most locations, with heavy equipment processing and moving materials in and out of the work areas. The 1" PVR pavement section would also require **working around or relocating any utilities** (not accounted for in cost comparisons) within five feet or more of the pavement surface.

Risks - The OPR process is innovative, and while it has been successful to date on most roadways where it was applied, it is being used to rehabilitate some of the worst residential pavement in Mesquite. There will be locations where existing conditions are not favorable to OPR, and these will require additional work to correct. In some cases that means going back to repair failures in specific locations.

To date the OPR program has rehabilitated 31.18 lane miles of residential streets.
Visual observations identified 1.77 lane miles showing some form of distress.
1 – (1.77 miles/31.18 miles) = 1 – 0.057 = 0.9434 x 100% = 94.34%. ,
Therefore the process is currently displaying a 94% success rate.

There are three primary risks associated with the OPR process-

1. **Existing pavements with structural failures or subgrade issues not identified during pavement evaluations.** The Real. Texas. Roads. program includes provisions to level and stabilize pavements with subgrade failures, as well as make full depth repairs to areas with extensive structural failures of the existing pavement. But at its root, the RTR program is intended to rehabilitate the worst residential streets in the City of Mesquite, and distresses can be missed in preliminary stages. These can be stress or map cracking that is tight and not spalling at the pavement surface but more deteriorated below the surface. Transverse cracking of the existing pavement may not show significant distress, but movement under traffic can cause broken reinforcing steel at these joints and loss of load transfer, leading to rapid reflective cracking and spalling of the overlay. Subgrade failures will generally be reflected in failures of the existing pavement, but high PI subgrades are subject to shrink/swell movement after the overlay is placed.

2. **Failure of the OPR concrete overlay to properly bond to the existing pavement**. Possible causes of failure to bond are discussed later in this report. Failure of the bond between existing pavement and the overlay will lead to rapid map cracking of the overlay, with significant failures likely. Seven cores of rehabilitated pavements were taken for this report. Five showed a strong bond between existing pavement and the OPR overlay. Both non-bonded cores showed foreign material between the existing pavement and overlay.

3. **Excessive heavy traffic on the repaired street**. In this case the definition of excessive is deceptive. A note later in this report shows one garbage truck to have an exponential impact on pavement life to that of a pickup truck. This is generally evident in the condition of pavements near schools and retail centers, where buses and delivery trucks make up a higher percentage of the traffic. These locations make up a significant part of distresses noted in field reviews. One conclusion of this evaluation may be to remove these locations from OPR application and designate them for full depth repair.

Optimized Pavement Reconstruction is a new method for rehabilitating pavements, with a learning curve associated with proper implementation. City staff make monthly reviews of completed streets to evaluate performance and identify areas showing point failures. These are documented to be addressed. Many risks with the process will be reduced as inspectors become more aware of potential impacts and create specific repair action plans. **Despite these growing pains the process has a >94% success rate based on visual observations of work completed to date, detailed below.**

HISTORY AND PROGRESS

In April 2015, before the RTR bond program was put to the voters, city staff arranged for a two block section of Farley Drive, in the Pecan Bend neighborhood, to be rehabilitated by the OPR method, as a test bed for the method. Existing streets and sidewalks in the neighborhood show significant faulting and failures due to swelling soils and poor subgrade support. A portion of the pavement was rebuilt after premature failure caused by subgrade issues. It should be expected that there will be issues with this segment, as methods were being tested and improved for future work.

In March 2016 the City entered into a one year contract with Austin Bridge and Road to rehabilitate city streets by the OPR method, with options to extend the contract for two additional years. Work began on the first streets designated for repair, in Country Club Estates and Northridge Estates, in June 2016. As of April 2018 the OPR method has been used to rehabilitate 15.5 miles (31 lane miles) of streets in four neighborhoods- Northridge Estates, Country Club Estates, Skyline, and Town East Estates- with work continuing in Town East Estates.

Documentation of streets in City reports list lengths in miles of each segment rehabilitated. Evaluations of pavements in this report will reference lane miles or lane feet of pavement. This is because streets were processed one side at a time, and distresses on one side of the street often do not occur on the opposite side. Rather than account for segments with issues on half their width, this report evaluates each side separately.

FAILURE MODES - READING THE CRACKS

While some cracking of concrete pavement is normal and expected, cracking patterns often indicate a type of distress the pavement is experiencing.

Plastic shrinkage cracking appears soon after concrete is placed, and indicates the surface of the concrete was not protected from heat or wind during placing and curing, or there were significant changes in the temperature of the concrete during the first 24 hours after placement. One form of PSC results from excess bleed water in the concrete, which causes very small cracks or "crazing" of the surface paste, which is typically shallow and of little concern. As plastic shrinkage cracking is typically due to an environmental or material factor on a given day, it often occurs in multiple locations over the full area poured that day, or in multiple pours made from the same batch of concrete.

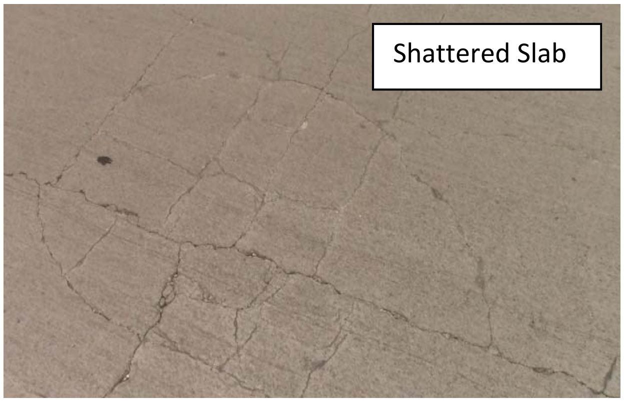
Drying shrinkage cracking *is cracking that occurs in the hardened state of concrete and is related to the ambient wetting and drying cycles that change the moisture state of the concrete, and can lead to permanent concrete shrinkage that results in partial or full depth cracking of the pavement and possible debonding. Over time, temperature and moisture changes in the concrete generate gradients that can lead to* ***curling and warping movements*** *and stresses that, if excessive, may result in cracking and possible debonding.**

*Distinguishing between plastic and drying shrinkage cracks relies more on observation of when they occur relative to the concrete pour, with plastic shrinkage cracks typically appearing shortly after the pavement is placed, and drying shrinkage cracks occurring over an extended time frame.** Shrinkage cracks often extend to the interface between the overlay and existing pavement. They can allow water infiltration to the concrete interface and loss of bond between the layers, with weakening and failure of both existing and overlay concrete.

Reflective cracking is usually transverse cracks that mirror cracks in the existing pavement. Some appear soon after placement, with more typically appearing as the existing pavement flexes under traffic due to uneven subgrade support, eventually breaking through the overlay. OPR overlays offer some resistance to reflective cracking as the additional steel layer contributes to containing cracks rather than relying on just the concrete strength.

**Transtec Peer Review input*

Shattered slabs are the result of repeated loads on an area with poor subgrade support, resulting in closely spaced cracking of the pavement. Areas prone to shattered slabs should show existing cracking prior to overlay, indicating the need for full depth repairs before the overlay is placed. However they are commonly addressed in existing pavements by HMAC patches. These patches often mask the location of weak support until the patch is milled off, and they can be difficult to spot on a milled surface.


Shattered Slab

Debonding typically shows as block or map cracking similar to stress cracking, but may occur in areas with no noticeable cracking in the existing pavement. All cracking of the overlay can lead to debonding due to water infiltration to the interface between pavement and overlay.


Possible Debonding


Shear Failure

Shear failures result from heavy loads inducing high stresses that exceed the capability of the composite pavement structure to support. Typical shear failures result from overweight or non-typical loads, such as garbage trucks or transit mix concrete trucks serving maintenance or construction activities. The culprit is difficult to identify because initial fractures to the concrete are invisible to the naked eye, but grow over time with repeated traffic loading and as surface water infiltrates the pavement and deteriorates the concrete.

INFLUENCES ON PAVEMENT LIFE EXPECTANCY

Most failures of concrete pavement can be traced to basic causes: inadequate design, poor support and movement of the supporting subgrade, high PI subgrades, chemical reactions, water intrusion, heavy loads, and poor quality construction. Pavement rehabilitation must address the added challenge of incorporating existing pavement with unidentified faults and hidden subgrade issues.

Design of residential streets and city thoroughfares is typically based on the number and weight of vehicles expected to use the roadway, converted to a common unit known as Equivalent 18 Kip (18,000lb) Single Axle Loads (ESALs). Residential streets carry mostly passenger vehicles, with lower ESAL values, compared to more frequent heavy truck traffic on thoroughfares, with higher ESAL values. But ESAL based designs address average traffic loadings over a long period of time, neglecting the impact of occasional much heavier loads, such as garbage trucks, on the pavement.

Although **heavy loads** are typically a minor part of traffic on residential streets, their impact on pavement damage is exponentially higher. A 55,000 lb. garbage truck is equivalent in weight to nine 6,000 lb. pickup trucks, but its impact on pavement is over 600 times greater. Failures of residential streets often begin in areas with heavy loads, such as service boulevards and alley entrances.

Residential pavement typically rests on compacted existing soils, or subgrade. **Stable subgrade** is vital to long term pavement durability. When known subgrade issues exist the design should include stabilization of the subgrade with lime or cement. The greatest danger to long term stability is **water**, which **weakens the subgrade,** and **causes swelling of many soils** containing clay or silt. Localized water issues can weaken subgrade and/or lift a section of pavement, causing cracking and failure of the pavement. Repeated swelling and shrinkage of clay soils propagates reflective cracks through the overlay, indicating uneven support.

Rain is the most obvious source of water problems, but more damage is typically caused by **ground water**, often from leaking water lines and meter connections to service lines. Poor

Swelling subgrade and pavement cracking caused by groundwater – Farley Drive drainage and excessive landscape irrigation also saturate soils. Large trees with roots extending to the pavement can impact the street by physically lifting the pavement through root growth, but more commonly the roots draw groundwater out of the soil in spring and summer and allow it to return in fall and winter, creating an annual shrink/swell issue. Long term pavement stability is enhanced when city staff identify water leaks and other problems as part of regular meter reading, and address them before water causes permanent damage to pavements.

Bonded concrete overlays rely on a **physical interlock** between the existing pavement and new concrete overlay, a significant portion of which develops in the first 24 hours after placement of the concrete. If not properly cured, thermal expansion and contraction of the new concrete due to heat of hydration and ambient cooling can break the bond before it forms fully, leading to early failure of the pavement. Heat radiating from the existing pavement and subgrade will aid in maintaining temperature of the overlay, but inspectors should review overnight temperature forecasts and require matting of fresh concrete when needed to retain heat of hydration, particularly when overnight temperatures will approach freezing. Plastic and drying shrinkage cracking can extend to the existing pavement/overlay interface and allow **water** to penetrate to this layer, weakening the bond between layers.

OPR rehabilitation work requires bonding the new concrete to the existing in order to create a *monolithic pavement structure*.* The bonding process is similar to constructing a bridge deck using precast panels. Several things can cause **failure of the bond**. The existing pavement is **texture**d by milling to create a rough surface for the overlay to bond to. Performed according to specifications, this is a fairly foolproof process, and helps identify weak pavement segments in need of further repair. Prior to placing the overlay the existing surface must be cleaned of **loose dirt** and aggregates. Evaluating the condition of existing pavement and assuring surfaces are properly cleaned prior to placing the overlay relies on **adequate experienced inspection staff** on-site. When applied properly, bonding adhesives can enhance the bond of the overlay, but when applied improperly or allowed to cure too long, they can actually act as a bond breaker. For this reason the best approach is to sweep the surface, pressure wash any chemical contaminants (diesel) and loose dirt from the pavement, then blow the surface (compressed air) to remove all remaining debris and surface water. As with a bridge deck, a damp existing surface provides the best bond.

*The **coefficient of thermal expansion (CTE)** of the aggregate in the overlay plays a big role in potential cracking and debonding. Aggregates with a low CTE, such as limestone, typically have less temperature related cracking and debonding, while siliceous river gravels with a high CTE increase the chances of cracking and debonding. Using concrete with no siliceous river gravel or aggregates with known high CTE or, at a minimum, ensuring compatibility exists between aggregates in the existing PCC pavement and overlay will decrease the likelihood of debonding due to unequal thermal expansion of aggregates in the two layers.**

**Transtec Peer Review input*

Deflection (caused by heavy loads, clays - shrinking and swelling) **and curling** of pavement (particularly on the edges) can initiate debonding and, ultimately, shear failures. It is critical that bonding initiates, engaging the additional steel placed in the upper portion (tension zone) during swelling behavior, resisting cracking and debonding. This second mat of steel helps enhance swelling resistance and pavement performance.

It was noted earlier that thermal expansion and contraction of the overlay in the first 24 hours can cause a loss of mechanical bond with the existing pavement. Likewise, water infiltration through cracks can weaken the bond. When the bond is already weakened by other factors, bending of the existing pavement due to weak subgrade will accelerate failure of the overlay, particularly reflective cracks propagating through the overlay.

FIELD OBSERVATIONS

The Optimized Pavement Reconstruction rehabilitation method is an innovative approach to rehabilitating residential streets, and will be improved through experience and review. The following comments detail distresses observed during visual inspection of roadways that have had OPR work. While they emphasize defects identified, the comments are intended to identify challenges and facilitate solutions in order to make the OPR process more successful.

Driving reviews and video recordings were made of roads in all four subdivisions, as well as Farley Drive. Walking evaluations were done where significant pavement distress was noted. Videos typically recorded ⅓-½ of a given street and were reviewed in the office where they could be stopped to see details not clear at driving speeds.

These comments are based on visual observation of pavements on April 30 and May 2, 2018, with conjecture based on aerial and street view photos of roadways prior to overlays, taken from Google Maps and Google Earth. Distress percentages are subjective values based on observation. More precise evaluations require photos or video shot before work began, information from inspection reports on existing pavement condition, weather conditions, and any irregularities in construction, as well as testing of cores taken from pavements. City staff intends to take drone surveys of before and after cracking patterns.

A variety of distresses were seen in all pavements, with some requiring corrective work by the contractor. All streets showed transverse cracking, which is normal and expected, but excessive transverse cracking was seen in some locations. Swelling soils due to groundwater were identified by shifting of the curbs. Saturated subgrades were indicated by water stains at cracks in the pavement. These are presumed to be groundwater, as the last rainfall was ~1/2 inch on April 21 and no irrigation systems were noted. Likely stress cracking and shear failures were seen, as well as possible debonded locations. Cores taken in selected locations can confirm the nature and severity of failures. Construction inspection reports can also provide information on the condition of existing pavements. Observations are grouped according to location.

FARLEY DRIVE

Length of work- 960 lane feet.
Distressed sections- NB & SB lanes, Wichita to Hastings- 400 lane feet
Success rate- 58%

This street has several distresses and has already had a segment removed and reconstructed full depth. Being the “test” street without the benefit of leveling and spot repairs utilized on RTR streets, distresses are expected, as the OPR process was untried at this time, and movement due to poor subgrade support would accelerate degradation. Shifting curbs and sidewalks in the area indicate high PI swelling clays and groundwater problems. A water leak is indicated by a meter box full of water as well as water seeping through cracks in the curb and pavement. There is a high likelihood this street will require significant maintenance, but it served to work out many bugs in the OTR method.

NORTHRIDGE ESTATES
Length of work- 10.82 lane miles.
Distressed sections- Ridgeview- Spalling at transverse joints, Gross to Lee (20%)- 0.14 lane miles
Hillcrest- Map cracking & water stains SB &NB, Galloway to Northridge (40%)- 0.18 lane miles
Royal Crest- Map cracking, repairs in progress SB & NB at Andrew- ~300’, 0.06 lane miles
Royal Crest- Transverse & map cracking SB at Rosemont- ~200’, 0.04 lane miles
Crestpark- SB lane, Ridgeview to alley (80%)- 150’, 0.03 lane miles
Northridge- Hillcrest to Ridgeview NB, transverse and map cracking (75%)- 0.30 lane miles
Total Distressed lanes- 0.75 lane miles
Success rate- 93%

Streets in Northridge Estates were overlaid about two years ago. Low volume residential streets are generally in good condition, but higher traffic entrances into the neighborhood, and at Tisinger Elementary School, are showing distress, with point failures in some locations.

Ridgeview Street coming off Gross Road provides access into the neighborhood, hence it carries a significant volume of heavy truck traffic relative to other streets in the neighborhood. Significant transverse cracking appears to be reflecting from the existing pavement. Initial indications are the existing pavement has poor subgrade support, with excessive movement at cracks. A section of the southbound lane has been removed for reconstruction. A pavement core taken on May 24 indicates no debonding is occurring between the reflective cracking.

Hillcrest Street in front of Tisinger Elementary School has significant map cracking, indicating possible stress failures or debonding of the overlay. Stains at multiple cracks in the pavement indicate water is pumping from under the pavement. Transverse cracking with water stains and shifting curbs on Northridge Drive at Hillcrest indicate additional subgrade issues. Fixing these problems require repairing leaking water lines. Installation of drain systems to intercept groundwater is not an option, as there is not storm drain system to tie into. A pavement core was taken at 1800 Hillcrest in an area of map cracking in the southbound lane. It showed no debonding of the overlay despite a ¼” layer of HMAC between the existing pavement and overlay. Due to the evidence of water pumping, a soil sample will be tested for moisture content and potential vertical rise of the subgrade.

Royal Crest Drive, Northridge Drive, and Crest Park- all higher volume streets with indications of high PI clays and swelling due to groundwater- show significant cracking, noted above, with full depth repairs being made at the intersection of Royal Crest and Andrew.

COUNTRY CLUB ESTATES
Length of work- 6.74 lane miles
Distressed sections- Sarazen- NB & SB, La Prada to Caribbean, transverse and map cracking (80%)- 0.27 lane miles
Antilles- NB & SB, Sandra Lynn to Gus Thomason, transverse and map cracking (25%)- 0.20 lane miles
Kiamesha- SB & NB, Nabholtz to Strayhorn, transverse and map cracking (40%)- 0.05 lane miles
Total distress- 0.52 lane miles
Success rate- 92%

Country Club Estates is mostly residential streets, divided by La Prada Drive. All streets showed normal transverse cracking, but were in overall good condition. The exceptions were south of La Prada, particularly Sarazen Drive between Antilles and Caribbean Drives. This section shows significant transverse and some map cracking. Google’s street view of Sarazen dated June 2016 showed a lot of standing water after a rain, and significant longitudinal cracking of the existing pavement. Antilles Drive also shows a lot of transverse and some map cracking. Reviewing photos or video from before overlaying might be beneficial to identify a cause, as there were no visible subgrade issues (i.e., no curb heaves and no signs of groundwater pumping).

North of La Prada there are small areas with transverse and map cracking, including Kiamesha Way at Nabholtz Lane. A pavement core taken here was debonded, and showed a thin layer of HMAC between the existing pavement and overlay. There was a leaking water line at the intersection of Kiamesha and Tam O Shanter, but the pavement in this area didn’t show significant distress. Overall the streets north of La Prada appear in good condition.

SKYLINE
Length of work- 5.40 lane miles
Distressed sections- No significant distress locations
Total distress- 0.00 lane miles
Success rate- 100%

Ten streets in the Skyline neighborhood were overlaid in the summer of 2017. The majority of pavement in this neighborhood is in good condition, but three locations on Bobwhite, Sesame, and Mockingbird were identified with shrinkage cracking. The areas included about half of the pour made in the affected section (~150’ each). No further distress was noted in these locations. A review of construction inspection records for these streets might indicate a reason for the cracking (high temperatures, low humidity, windy, high concrete slump). A pavement core taken at 300 Mockingbird in an area of shrinkage cracking was fully bonded.

TOWN EAST ESTATES
Length of work- 8.04 lane miles
Distressed sections-
Bamboo- NB & SB, Emerald to Bahamas, significant map cracking (90%)- 0.20 lane miles
Harlan- NB & SB, Emily to Hula, map cracking (25%)- 0.04 lane miles
Emerald- SB & NB, higher rate of transverse cracking (10%)- 0.10 lane miles
Palm- SB & NB south of Motley, extensive transverse and map cracking (50%)- 0.08 lane miles
Total distress- 0.42 lane miles
Success rate- 95%, with significant issues on Bamboo at Range ES

Work in Town East Estates began in February 2017, and is ongoing. City crews and/or contractors were making repairs to water lines at the time of this inspection. Additional water leaks were visible awaiting repair. Although this neighborhood has the most recent rehabilitation work it has significant distresses on Bamboo Street and Palm Drive, but only on short segments in high traffic areas. Initial assessment is that OPR is not performing well on higher volume streets, but low volume residential streets are in good condition.

Bamboo Street has been overlaid between Emerald and Bahamas Drives, a two block section in front of Range Elementary School. Being at a school, this section carries more passenger traffic but also heavy vehicles (school busses, delivery and industrial garbage trucks). Heavy vehicles cause more damage to pavement than passenger vehicles, so this may be impacting the condition of the pavement. A walking examination shows extensive transverse and map cracking. It appears the overlay has debonded, and has a high likelihood of failing. A pavement core taken at the Catalina intersection showed debonding with silt between the concrete layers. Photographs or video taken before the overlay should be reviewed for weak areas in the pavement, but it is unlikely city inspectors would have allowed the overlay to progress if the existing pavement showed large scale failures. A review of inspection records is in order.

Emerald Drive is a wider roadway and appears to carry more traffic through the neighborhood. It has higher transverse cracking rates than other streets and one identified area of map cracking (3720), possibly as a result of a failure in the existing pavement. The southbound lane near Harlan shows signs of shrinkage cracking near the centerline, but no noticeable distress in the area. A pavement core at this location (3901), in an area of shrinkage cracking, was well bonded. Overall it appears to be in better condition than Bamboo, in spite of an active water leak at one intersection.

Palm Drive within the neighborhood is in comparable condition to other residential streets. However the first block off of Motley serves commercial traffic, and shows significant cracking up to the service drive behind the strip mall. A January 2017 aerial photo from Google Earth shows multiple existing repairs, and street view images from November 2016 show extensive failures in the southbound lane. These appear to be reflecting through the OPR overlay. A pavement core from the northbound lane was well bonded, with an existing pavement depth of 11”- apparently a prior repair. A review of the inspection records for this segment should be made for conditions contributing to the cracking.

Overall, streets in this neighborhood are in good condition, although work is ongoing. Streets that carry higher than average traffic, such as Bahamas near Bamboo (school access), show higher transverse cracking than others. The area of greatest concern appears to be Bamboo between Emerald and Bahamas.

NEXT STEPS

Field observations should be corroborated with input from City of Mesquite inspection personnel as well as the contractor. Photo and video logs by City or contractor staff can establish prior conditions. Absent photo logs, aerial views from NCTCOG files may be correlated to observed distresses. City staff review completed streets weekly to identify areas showing distress, including any requiring reworking by the contractor.

Samples cored from pavements can verify if the overlay properly bonded to the existing pavements, and offer clues to why some areas might not have bonded. **Pavement cores were taken at the following locations. Photos and observations are in Appendix A.**

- 1009 Ridgeview Street, SB lane. Confirmed bond in area between transverse cracks.
- 1800 Hillcrest Street, SB lane near east drive to Tisinger Elementary School. Confirmed bond in area of map cracking. Soil sample will be taken to test for moisture content and potential vertical rise (PVR). **Existing pavement appears to contain siliceous river gravel aggregate, which may contribute to debonding due to unequal thermal expansion.**
- 5115 Kiamesha at Nabholtz intersection. Core showed loss of bond in area of block cracking. **A thin layer of HMAC between pavement and overlay may be causing map cracking and loss of bond.**
- 300 Mockingbird, NB lane. Verified bond in area of shrinkage cracks.
- Bamboo Drive at Catalina, EB lane in map cracking. **Debonding with significant silt/clay residue between layers was noted on core sample.**
- Palm Drive, SB lane south of Motley, map cracking near curb. Verified bond and demonstrated 11” existing pavement depth. Soil sample will be taken to test for moisture content and PVR.
- 3901 Emerald Drive, SB lane. Verified bond in area of shrinkage cracking.

CONCLUSIONS & LESSONS LEARNED TO IMPROVE QUALITY (PENDING FURTHER REVIEW)

- The OPR process as measured to date, displays a >90% success rate.
- In-house City of Mesquite design and inspection, saves a minimum of 16% of a private consultant design, inspection and administration fee.
- In-house City of Mesquite design and inspection allows a cutting edge (OPR) rehab option utilization.
- The OPR process currently provides approximately 3 miles of rehab vs. 1 mile of a no risk PVR 1" pavement design.
- The OPR process is not a "silver bullet" to solve all problems with existing pavements, but when utilized with the other components of the Real. Texas. Roads. program it appears to be a useful tool to extend the life of residential streets at a reduced cost vs. full depth reconstruction.
- Addressing ground water issues relies on correcting leaking water lines and surface drainage issues, as there are no storm drain systems to outfall French drain systems into.
- As administered to date on streets with high traffic volumes or heavy vehicles, the OPR process appears problematic; action plans to enhance success rates can be created for evaluation, such as:
    - The addition of grade beams, or
    - The use of thicker pavement sections. This would create multiple challenges, including drainage and access.
- Add additional inspection to enhance success rates.
    - Focus on cleanliness inspection to enhance bond,
    - Focus on replacement of pavement substrate that is highly fractured,
    - Identify moving slabs/joints and sawcut the overlay at those locations.
- *Ensure compatibility exists between aggregates in the existing PCC pavement and OPR overlay. When necessary, match the use of siliceous river gravel or aggregates with known high CTE between existing pavement and OPR overlay.**
- Utilize WWRebar mats or wire mats instead of tied reinforcing steel to improve steel distribution and improvement of concrete cover. This practice has been enacted by the City of Mesquite.
- *Consider intermediate sawcutting of the overlay to reduce curling and warping stresses.**
- In response to ongoing evaluations of work to date, City inspectors have established more accurate criteria for when to utilize full depth repairs prior to OPR overlays, due to excessive deterioration of the existing pavement. This increased expenditure up front will improve the long-term performance of the OPR process.

**Transtec Peer Review input*

APPENDIX A – PAVEMENT CORE
LOCATIONS, MEASUREMENTS AND PHOTOS
&
EAST TEXAS TESTING LABORATORIES FINAL REPORT
WITH POTENTIAL VERTICAL RISE RESULTS

CITY OF MESQUITE PAVEMENT CORES

Pavement cores were taken at the following locations.

- 1009 Ridgeview Street, SB lane. Confirmed bond in area between transverse cracks.
- 1800 Hillcrest Street, SB lane near east drive to Tisinger Elementary School. Confirmed bond in area of map cracking. Soil sample will be taken to test for moisture content and potential vertical rise (PVR).
- Palm Drive, SB lane south of Motley, map cracking near curb. Verified bond and demonstrated 11" existing pavement depth. Soil sample will be taken to test for moisture content and PVR.
- 5115 Kiamesha at Nabholtz intersection. Core showed loss of bond in area of block cracking. Thin layer of HMAC between pavement and overlay may be causing map cracking in this area.
- 3901 Emerald Drive, SB lane. Verified bond in area of shrinkage cracking.
- Bamboo Drive at Catalina, EB lane in map cracking. Debonding with significant silt/clay residue between layers. Unclear whether this is a cause or result of the debonding.
- 300 Mockingbird, NB lane. Verified bond in area of shrinkage cracks.

Bill,
I have attached photos of the cores, and the observations of them tabulated below.

Street	Thickness of Concrete (in.)	Thickness of Overlay (in.)	Bond Between Layers (Y/N)	Encountered Rebar (Y/N)
Ridgeview St.	6.5	2.625	Y	N
Hillcrest St.	6.25	2.5	Y	N
Palm Dr.	11	2.625	Y	Y
Kiamesha Way	9	3.25	N	Y
Emerald Dr.	11.75	2.5	Y	N
Bamboo Dr.	7	2.75	N	Y
Mockingbird Tr.	7.25	2.875	Y	N

As you can see, 5 cores were intact with well bonded overlay, and 2 were not bonded. Additional observation was that there was 1/8" -1/2" layer of asphalt between concrete layers on Hillcrest (which was still bonded), and a very thin (approx. 1/16 or less) layer of asphalt between concrete layers on Kiamesha Way (which was not bonded).

The underlying soil was not treated and appeared to be natural, so we will plan to drill the PVR samples behind the curb. Please let me know if you have any questions, and I will keep you posted on the drilling schedule.

Drew Irvin, P.E.
ETTL Engineers & Consultants, Inc.
817-962-0048 – O
512-750-5762 – C
www.ettlinc.com

1009 Ridgeview Street, SB lane.

Confirmed bond in area between transverse cracks.

1800 Hillcrest Street, SB lane near east drive to Tisinger Elementary School.

Confirmed bond in area of map cracking.

Existing pavement appears to contain siliceous river gravel aggregate.

Palm Drive, SB lane south of Motley, map cracking near curb.

Verified bond and demonstrated 8.5” existing pavement depth.

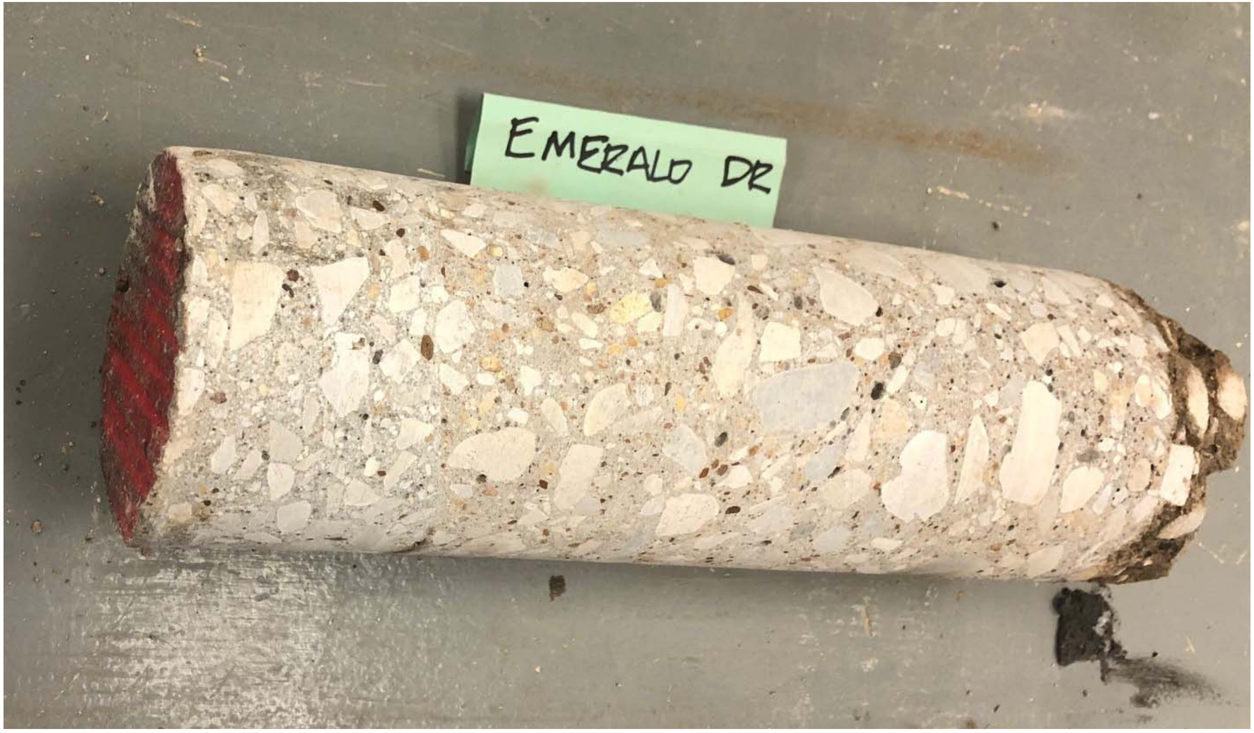
5115 Kiamesha at Nabholtz intersection.

Core showed loss of bond in area of block cracking.

Thin layer of HMAC between pavement and overlay may be causing map cracking in this area.

3901 Emerald Drive, SB lane.

Verified bond in area of shrinkage cracking.



Bamboo Drive at Catalina, EB lane in map cracking.

Debonding with significant silt/clay residue between layers.

Unclear whether this is a cause or result of the debonding.

300 Mockingbird, NB lane.

Verified bond in area of shrinkage cracks.

ETTL Engineers & Consultants Inc.

GEOTECHNICAL ✶ MATERIALS ✶ ENVIRONMENTAL ✶ DRILLING ✶ LANDFILLS

June 15, 2018

Bill Nelson
CP&Y
1820 Regal Row #200
Dallas, Texas 75235

SUBJECT: City of Mesquite Concrete Overlay Bond Investigation
ETTL Job No. C 8652-1812

Dear Mr. Nelson:

This study was performed at your request and authorization to proceed granted on May 22, 2018 in accordance with our proposal dated May 15, 2018. Field operations were conducted on May 23, June 4, and June 7, 2018.

The purpose of this investigation was to define and evaluate the bond between existing concrete pavement and overlay concrete pavement in seven (7) streets in the City of Mesquite, as a part of an investigation into their pavement repair project. The concrete in 7 locations were cored to determine the condition of the bond between layers of concrete, and 2 locations were designated for subsurface investigation of the underlying clay soils for the purpose of calculating the potential vertical rise (PVR).

Street	Total Thickness of Concrete (in.)	Thickness of Overlay (in.)	Bond Between Layers (Y/N)	Encountered Rebar (Y/N)
Ridgeview St.	6.5	2.625	Y	N
Hillcrest St.	6.25	2.5	Y	N
Palm Dr.	11	2.625	Y	Y
Kiamesha Way	9	3.25	N	Y
Emerald Dr.	11.75	2.5	Y	N
Bamboo Dr.	7	2.75	N	Y
Mockingbird Tr.	7.25	2.875	Y	N

Table 1: Observations and Measurements of Street Cores

The subsurface conditions were sampled by two (2) sample core borings each drilled to a depth of 10 feet. The locations to be cored and drilled were marked in the field by the client. The field boring logs were prepared as drilling and sampling progressed. The final boring logs are included as an attachment. Descriptive terms and symbols used on the logs are in accordance with the Unified Soil Classification System (ASTM D 2487). A reference key is also attached.

Upon return to the laboratory, a geotechnical engineer visually examined the soil samples and assigned laboratory tests. By determining the Atterberg liquid and plastic limits (ASTM D 4318) and percentage of fines passing the No. 200 sieve (ASTM D 1140), field classification of all samples was verified. Also conducted were natural moisture content tests (ASTM D 2216). These results are presented in the individual logs of boring attached.

Expansive soils such as are found throughout the soil profile swell when they absorb moisture and shrink as they dry. When expansive soils are covered by an impermeable surface such as pavement, seasonal moisture fluctuation at the interior of the covered area tends to be reduced or eliminated due to the lack of exposure to natural wetting and drying conditions (i.e., wind, rain, sun, vegetative, etc.). At the perimeter of the pavement, however, infiltration into the subgrade soils from surface drainage could lead to local swelling of the clays resulting in tilt or distortion of the pavement.

At the time of exploration, the moisture content of the surficial 10' of expansive clay soils encountered was dry to moderate. Potential for swelling is considered to be high under conditions at the time of drilling. Potential for shrinkage is predicted to be low to moderate. As the moisture content of the soil changes from what it was at the time of sampling, the potential for swelling and shrinkage will change accordingly. For example, the highly expansive clays that exhibit high swell potential because they are currently dry could swell significantly when exposed to moisture prior to or during construction, lowering further swell potential, but increasing the shrinkage potential.

The assessment of the impact of expansive soils given below is predicated on soil moisture change that is a result of normal climatological fluctuation. Factors such as poor drainage and consequent ponding water, plumbing leakage, excavation details (e.g. permeable backfill in trenches or beneath structures) and vegetation can result in moisture changes (and consequent swelling or shrinkage) outside the ranges predicted herein.

One method for quantifying the potential for subgrade movement due to moisture change at any given location is to calculate the Potential Vertical Rise (PVR) (Tex 124 E Modified). This calculation takes into account the inter-relationship between depth, PI, and fluctuations in soil moisture. The maximum potential movements of the final grade (also the maximum differential movement at final grade level), PVR, due to normal climatological fluctuations in soil moisture content in B-1 (Hillcrest

Street) is **4.5 inches** and in B-2 (Palm Drive) **5.25 inches**. These calculations are based on assumed dry conditions and an estimated seasonal moisture fluctuation zone of approximately 10 feet.

If you have any questions concerning this matter please contact us. Thank you for the opportunity to be of service.

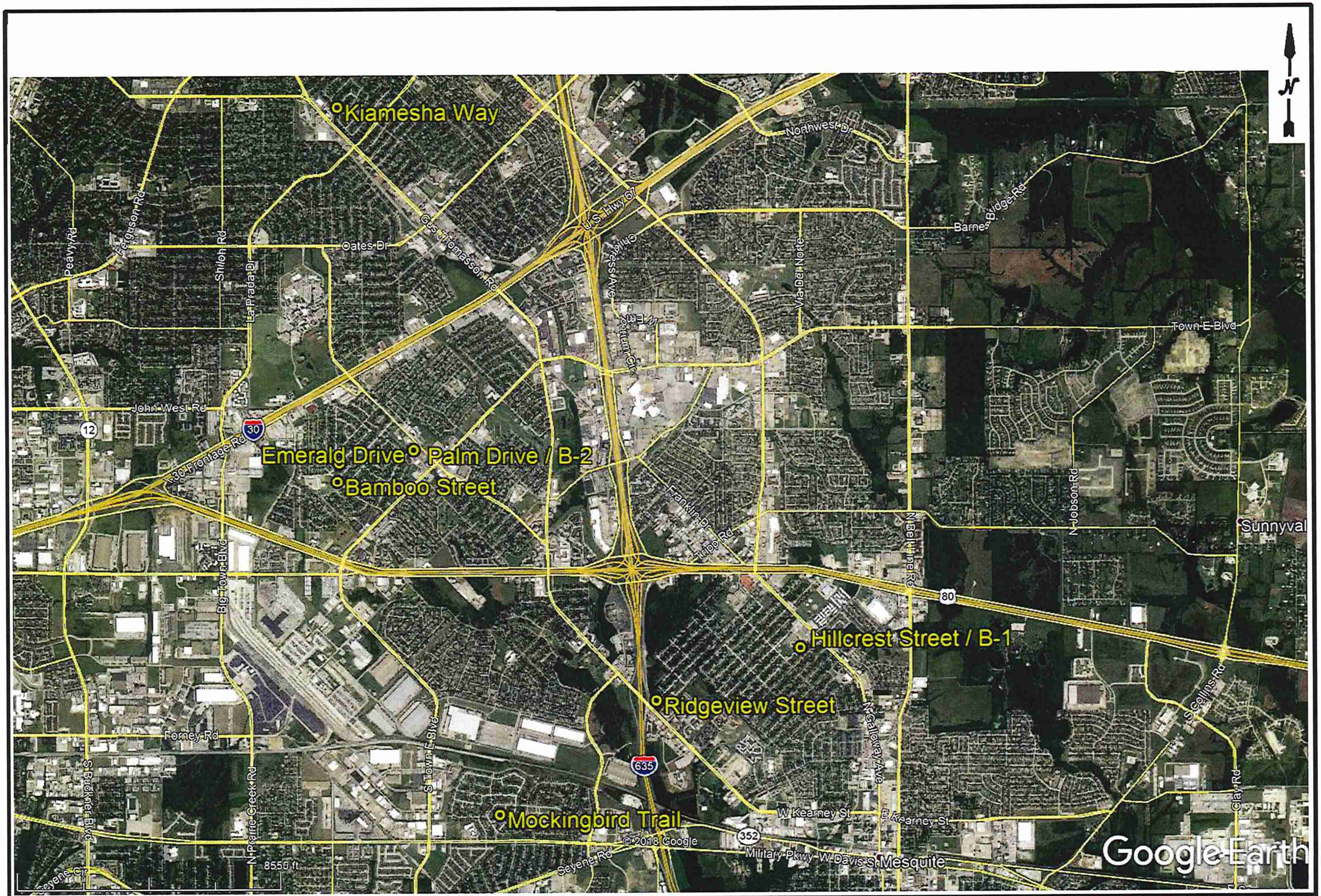
Sincerely,
ETTL Engineers & Consultants Inc.
Texas Registered Engineering Firm #F3208

Andrew B. Irvin, P.E.
Project Manager

ANDREW B. IRVIN
122008

June 15, 2018

Distribution: (PDF)



0 4275 8550

Scale In Feet

ETTL ENGINEERS & CONSULTANTS
MAIN OFFICE
1717 EAST ERWIN
TYLER, TEXAS 75702
903-595-4421

CP&Y MESQUITE PVR
MESQUITE, TEXAS

PLATE II - VICINITY MAP
JOB NO.: C8652-1812
SCALE: AS SHOWN
DATE: JUNE 2018

APPROVED BY:

DRAWN BY:
A.K.B.

ETTL ENGINEERS & CONSULTANTS

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

LOG OF BORING B-1

PROJECT: CP&Y Mesquite PVR
Mesquite, Texas

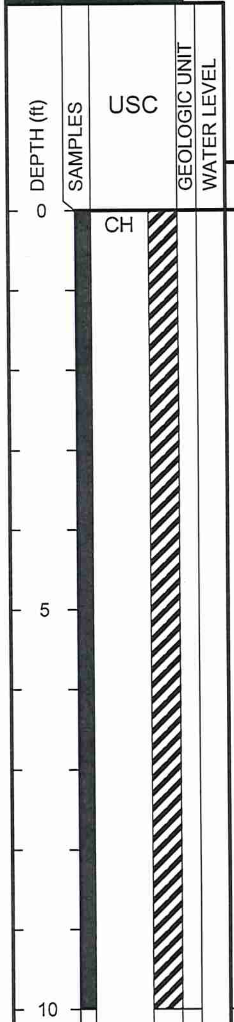
DRILL RIG: CME 75

PROJECT NO.: C8652-1812

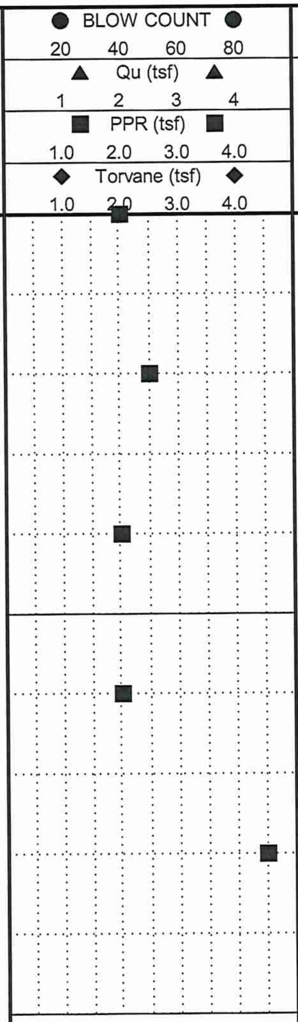
BORING TYPE: Flight Auger

DATE 6/7/18

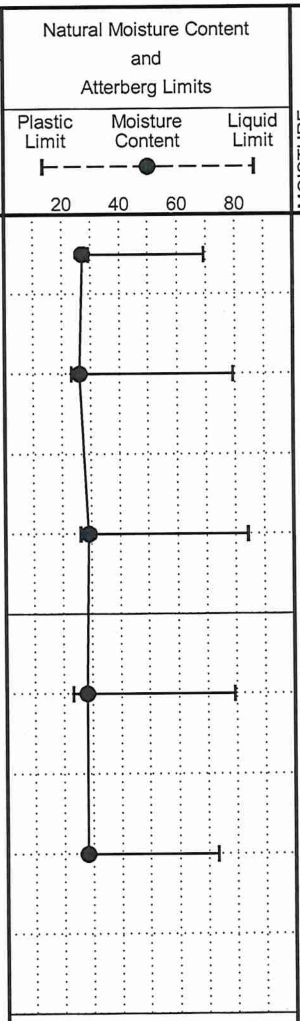
SURFACE ELEVATION



MATERIAL DESCRIPTION	FIELD STRENGTH DATA	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	SIEVE ANALYSIS MINUS #200 SIEVE (%)	PLUS #40 SIEVE (%)	PLUS #4 SIEVE (%)	SWELL TEST DRY DENSITY (pcf)	FREE SWELL (%)	ZERO SWELL PRESSURE (ksf)	MOISTURE CONTENT (%)
FAT CLAY(CH) stiff; brown	P=2.0	27	69	29	40	73	10	2				
	P=2.5	26	79	23	56	93	4	0				
--brown and tan; moist	P=2.0	29	84	26	58	91	4	0				
	P=2.0	28	79	23	56	91	6	2				
--hard	P=4.5	28	73	28	45	99	1	0				
Bottom of Boring @ 10'												



TRIAXIAL TEST DATA: DRY DENSITY (pcf) | MAX DEVIATOR STRESS (tsf) | MOISTURE CONTENT (%)



Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Dry and open upon completion.

Key to Abbreviations:
N - SPT Data (blows/ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)
Tx - Texas Cone Penetrometer (blows/ft)

Notes:
Hillcrest Steet

GPS Coordinates: N32.78565°, W96.6073°

Driller: W.E.S.T. Drilling, Inc.

Logger: Drew Irvin

ETTL ENGINEERS & CONSULTANTS

MAIN OFFICE
1717 East Erwin
Tyler, Texas 75702
(903) 595-4421

LOG OF BORING B-2

PROJECT: CP&Y Mesquite PVR
Mesquite, Texas

DRILL RIG: CME 75

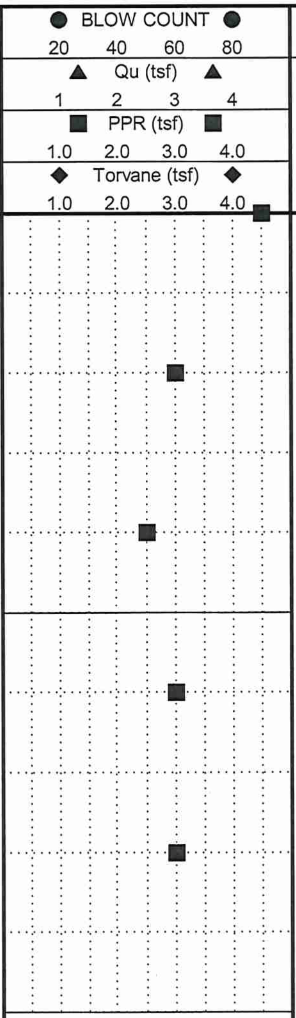
PROJECT NO.: C8652-1812

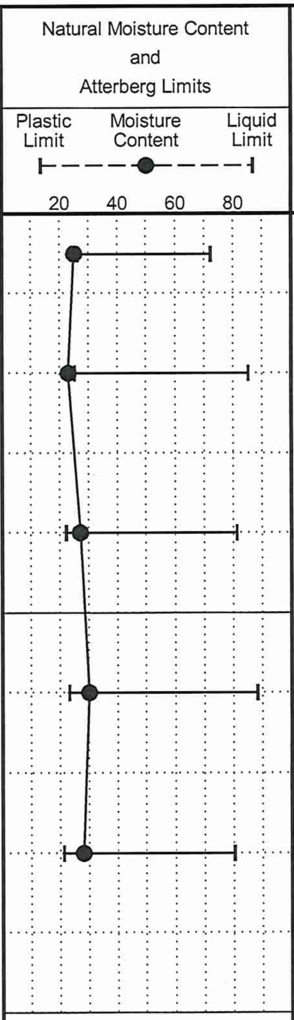
BORING TYPE: Flight Auger

DATE 6/4/18

SURFACE ELEVATION

DEPTH (ft)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	TRIAXIAL TEST DATA: DRY DENSITY (pcf)	TRIAXIAL TEST DATA: MAX DEVIATOR STRESS (tsf)	TRIAXIAL TEST DATA: MOISTURE CONTENT (%)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%): LIQUID LIMIT LL	ATTERBERG LIMITS(%): PLASTIC LIMIT PL	ATTERBERG LIMITS(%): PLASTICITY INDEX PI	SIEVE ANALYSIS: MINUS #200 SIEVE (%)	SIEVE ANALYSIS: PLUS #40 SIEVE (%)	SIEVE ANALYSIS: PLUS #4 SIEVE (%)	SWELL TEST: DRY DENSITY (pcf)	SWELL TEST: FREE SWELL (%)	SWELL TEST: ZERO SWELL PRESSURE (ksf)	SWELL TEST: MOISTURE CONTENT (%)
0	CH	FAT CLAY(CH) hard; brown	P=4.5				25	72	26	46	82	5	0				
		--very stiff	P=3.0				23	85	25	60	84	5	0				
	CH	FAT CLAY(CH) stiff; brown and gray; with calcareous nodules	P=2.5				27	81	22	59	86	5	0				
5		--tan and gray	P=3.0				30	88	23	65	78	14	9				
			P=3.0				28	80	21	59	85	5	1				
10		Bottom of Boring @ 10'															





Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: Dry and open upon completion.

Key to Abbreviations:
N - SPT Data (blows/ft)
P - Pocket Penetrometer (tsf)
T - Torvane (tsf)
L - Lab Vane Shear (tsf)
Tx - Texas Cone Penetrometer (blows/ft)

Notes: Palm Drive

GPS Coordinates: N32.803406°, W96.648008°

Driller: W.E.S.T. Drilling, Inc.

Logger: Drew Irvin

Boring Log Descriptive Terminology

Key to Soil Symbols and Terms

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	○	GW	Well-graded gravels, gravel sand mixtures, little or no fines.
			●	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	●	GM	Silty gravels, gravel-sand-silt mixtures.
			▨	GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	▩	SW	Well-graded sands, gravelly sands, little or no fines.
			▒	SP	Poorly graded sands, gravelly sands, little or no fines.
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▒	SM	Silty sands, sand-silt mixtures.
			▨	SC	Clayey sands, sand-clay mixures.
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			▨	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			▤	OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			▧	CH	Inorganic clays of high plasticity, fat clays.
			▦	OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			▦	PT	Peat and other highly organic soils.

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

Criteria For Descriptors

Consistency of Fine Grained Soils

Consistency	N-Value (uncorrected)
Very Soft	< 2
Soft	2 - 4
Medium Stiff	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	> 30

Apparent Density of Coarse Grained Soils

Relative Density	N-Value (uncorrected)
Very Loose	< 4
Loose	4 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

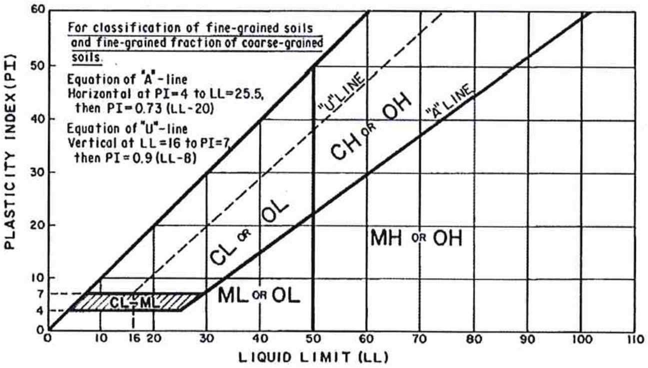
Moisture Condition

Dry	-Absence of moisture, dusty, dry to the touch.
Moist	-Damp, but no visible water.
Wet	-Visible free water.

Definition of Particle Size Ranges

Soil Component	Size Range
Boulder	> 12 in (300 mm)
Cobble	3 in (75 mm) - 12 in (300 mm)
Gravel	No. 4 Sieve (4.75 mm) to 3 in (75 mm)
Sand	No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm)
Silt	< No. 200 Sieve (0.075 mm)*
Clay	< No. 200 Sieve (0.075 mm)*

*Use Atterberg limits and chart below to differentiate between silt and clay.



Angularity of Coarse-Grained Particles

Angular	-Particles have sharp edges and relative plane sides with unpolished surfaces.
Subangular	-Particles are similar to angular description, but have rounded edges.
Subrounded	-Particles have nearly plane sides, but have no edges.
Rounded	-Particles have smoothly curved sides and well-rounded corners and edges.

Notes

SPT (Standard Penetration Test-ASTM D1586):
The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.
Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)
Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).
WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.

APPENDIX B – Text of Peer Review

The Transtec Group, Inc.
6111 Balcones Drive
Austin, Texas 78731 USA
www.TheTranstecGroup.com

To: Mr. Ralph Browne **Memo No.** 218031-001
From: Mauricio Ruiz, PE **Date:** 29 June, 2018

Re: Mesquite Real.Texas.Roads. – Optimized Pavement Reconstruction Report, a Peer Review (DRAFT)

Overview

This Tech Memo documents a peer review of the CP&Y Report titled "Engineering Review Draft Report Real.Texas.Roads. Optimized Pavement Reconstruction" for the city of Mesquite dated June 4, 2018.

The above mentioned report presents the findings of an engineering assessment of several city streets in the city of Mesquite that underwent rehabilitation with the Optimized Pavement Reconstruction (OPR) method.

Recommendations on OPR Report Technical Content

In general, the OPR report concludes that a significant level of success has been achieved with the implementation of this procedure that has resulted in significant savings for the city of Masquite. The following are some recommendations to revise the report to be more in line with pavement engineering terminology and state of the practice with pavement overlay technology. In addition, a separate editorial review is also provided to complement this review.

- Proper steel reinforcement design to claim that some flexural strength can be achieved would likely require significant amounts of steel. It is suggested to play down this benefit and focus more on the benefit of keeping cracks tight providing structural integrity and the additional pavement section provided with the overlay.
- Bonded concrete overlay design and construction guidelines are now available such as those developed by the Iowa CP Tech Center[1]. We suggest a thorough review of these guidelines to incorporate any applicable recommendations to the design/construction methodology. A summary of these guidelines is provided in the next section of this Tech Memo.
- The report needs to differentiate between plastic shrinkage cracking (PSC) and Drying shrinkage cracking. PSC is a result of excessive evaporation of bleeding water during the plastic state of concrete and is due to a combination of wind, ambient temperature, PCC temperature and relative humidity that results in short and closely spaced cracks that are typically superficial. Drying shrinkage cracking is cracking that occurs in the hardened state of concrete and is related to the ambient wetting and drying cycles that over time result in a reduction of moisture in the concrete and lead to concrete shrinkage that, if excessive, may result in partial or full depth cracking of the pavement and possible debonding. On the other hand, temperature plays a roll primarily in contraction and expansion of the concrete. In turn, temperature and moisture changes in the concrete generate gradients that can lead to curling and warping movements and stresses, that if excessive, may result in cracking, and possible debonding[2,3,4].
- The coefficient of thermal expansion of the aggregate for the concrete overlay plays an important roll in potential cracking and debonding as well. Typically, aggregates with a low CTE such as limestone help reduce temperature related cracking and debonding.

Recommendations on OPR method

Based on the results of the pavement evaluation report, and although it has reported a high success rehabilitation rate, a few recommendations to further increase the success rate and performance of this solution are discussed below:

- It is highly recommended that the OPR solution be considered as a rehabilitation alternative within limited effectiveness on badly deteriorated concrete that would be more suitable for a full reconstruction.
- We suggest developing a list of conditions that shall be identified to determine whether the OPR solution is suitable for a given project or if pre-overlay repairs are needed including the following:
    - It is highly recommended to identify the potential vertical rise (PVR) threshold due to soil shrink/swell movements that is suitable for implementation of the OPR solution, based on observed performance on previous projects.
    - Existing concrete pavements shall be properly prepared and any HMA overlay material shall be removed to ensure adequate bond and to ensure that the overlay works monolithically with the existing pavement.
    - This rehabilitation method may not be suitable for projects with substantial amount of failed pavement areas.
    - Existing pavement with working cracks or joints exhibiting significant movement when moving loads are applied.
- We suggest developing pre-overlay repair and preparation guidelines listing conditions that shall be addressed prior to overlay construction including recommendations on the following:
    - Remove and replace of failed areas (or leveling).
    - Controlling the speed of milling to reduce the potential of fracturing of the existing concrete that could compromise the bond to the overlay.
    - Consider the use of micromilling equipment if available.
    - Consider the use of shot blasting or high-pressure water blasting
- Develop guidelines on construction materials and methods such as the following:
    - Prevent the use of siliceous river gravel or aggregates with known high CTE or at a minimum, ensure compatibility exists between aggregates in the existing PCC pavement and overlay.
    - Consider sawcutting the overlay directly on top of existing joints to mitigate reflective cracking and associated maintenance.
    - Consider intermediate sawcutting of the overlay to reduce curling and warping stresses.
    - Sawcut overlay directly above existing joints and working cracks to minimize reflective cracking and associated maintenance costs.
    - Provide guidelines on sawcutting depth (typically it is suggested to use overlay depth (T) plus 0.5 inches for transverse joints and T/2 for longitudinal joints.
    - Provide a sawcut width slightly larger than existing crack widths.
    - Emphasize the importance of curing timeliness (apply curing within 30 minutes of overlay placement) and thoroughness (apply curing at twice the standard rate and

  ensure full coverage). Thin overlay jobs are significantly more susceptible to drying shrinkage due to the high surface-area-to-volume ratio.
  - Account for the reduced sawcutting window of thin overlays.
  - Consider the use of additional reinforcement over existing non-working cracks (use crack cages) to prevent reflective cracking.
  - Consider grout injection when voids are detected under existing pavement.
  - Remove asphalt patches and replace with PCC patches or fill with concrete during overlay placement.

References

1. Guide to Concrete Overlays, Dale Harringon and Gary Fick, National Center for Pavement Technology Center, Third Edition, 2014.
2. Ruiz, J. Mauricio, et al. Computer-Based Guidelines for Concrete Pavements, Volume II: Design and Construction Guidelines and HIPERPAV® II User's Manual, Publication No. FHWA-HRT-04-122, McLean, VA, February 2005.
3. Ruiz, J. Mauricio, et al. Validation of Bond Prediction Models as a System: JPCP. Unpublished Report for Contract DTFH61-00-P-00312, Federal Highway Administration, Washington, December 2001.
4. Ruiz, J. Mauricio, et al. Bonded Concrete Overlay: Behavior Prediction Model Enhancement and Calibration for CRCP. Unpublished Report for Contract DTFH61-00-P-00318, Federal Highway Administration, Washington, December 2001.