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SEVEN COMMON USES FOR URETEK DEEP INJECTION PROCESS

With each application, we inject URETEK 486 STAR polymer into the foundation soils to compact and stabilize the soils. When necessary to re-align the pavement, the injection of polymer into the soils continues to lift the pavement from below the base. The pavement system (concrete, asphalt, or composite) is returned to its original construction on stiffened foundation soils.

1. Asphaltic Concrete Pavement Stabilization and Lifting
2. Composite Pavement – Stabilization at Joints and Cracks
3. Full Depth Pavement Patch – Stabilization of Foundation Soils
4. Concrete Pavement – Dips and Faulted Longitudinal & Transverse Joints
5. Drainage Systems – Repair of Leaking Joints & Compaction of Weak Soils
6. Bridge Approach/Departure Slabs
7. Concrete Pavement with Drainable Base – Stabilization and Lift

ASPHALTIC CONCRETE PAVEMENT STABILIZATION AND LIFTING

PROBLEM:

Poor foundation soils under asphaltic concrete pavement. The poor and/or uneven support can result in premature cracking, rutting, and settlement of the pavement. Insufficient soil strength may be caused by:

- Loose or un-compacted foundation soils that were untreated prior to construction of roadway.
- Water infiltration into the foundation soils through cracks in the pavement.
- Roadway was widened but proper stabilization of the foundation soils was not practical.
- A mission change for the roadway (such as in the oil/gas boom area) where the original design is now insufficient – the thicker pavement now required for the heavier loads also requires a thicker base/sub-base.

SOLUTION:

Apply the URETEK Deep Injection Process with URETEK 486 water resistant expansive polymer at a typical depth of -4'. If DCP tests show deeper problems, additional depth(s) of injection can be added as needed. This is accomplished by drilling multiple 3/4" holes through the asphaltic concrete and injecting through tubes into the foundation soils. Depending on the thickness of the asphaltic concrete pavement, this may be performed on as tight a pattern as a 3' by 3' grid or the traditional 4' by 4' grid. URETEK monitors the surface using laser monitors and/or dial indicators and knows that the pavement structure in that strata of injection has become adequately stabilized when an indication of movement is detected on the monitors. It is necessary to inject through tubes at depth because asphaltic concrete is a flexible pavement. If injected directly under the pavement or too close to the surface, the forces created by the expansion of the polymer will blister the flexible pavement and create an uneven pavement surface.

EXPECTED RESULTS:

- Compact the loose foundation soils without uneven lifting of the flexible pavement to provide sufficient support of the pavement surface.
- Continued injection into the soils can lift the pavement system if needed.

- Lifting of the rutting is NOT possible.
- Surface cracks will still need to be sealed by traditional methods to mitigate water infiltration into the system.

BENEFITS:

- Zero daytime lane closures.
- Removal of good asphaltic concrete pavement and poor foundation soils is not required – saving time and money with a sustainable solution.
- Overlay to correct rutting can be performed immediately following the polymer injection into the soils.
- Extends the life of a new overlay.
- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.

ALTERNATIVE METHODS OF REPAIR:

- Injecting a concrete slurry directly below the asphalt or at depth under the asphalt is typically not a design option as it will create a very uneven roadway surface due to the relatively high pressure at which the slurry needs to be pumped. In addition, the slurry does not migrate very far from the injection point resulting in a "mushroom" effect, creating unintended, uneven lifting.
- Injecting a polymer directly under an asphalt surface will blister the asphalt and lift unevenly resulting in a very uneven roadway surface, requiring an overlay of the pavement.
- Removal and replacement of pavement, along with the base and weak foundations soils, is extremely expensive and causes significant traffic delays.

REFERENCE DOCUMENTS:

1. **MODOT Carroll County Project Report:** Contains pre-injection and post-injection Falling Weight Deflectometer (FWD) test results and analysis performed by MODOT. Results were extremely favorable and engineer remains satisfied with the project. Read Report

2. **Penn State University Demonstration:** Summarizes the demonstration URETEK performed in 2012 at the request of PennDOT. View Demonstration.
3. **TXDOT SPID Asphalt Stabilization Project in 2001, Corpus Christi, TX:** Stabilization at -4' of an unstable asphalt pavement prior to overlay, the project was a success and 13 years later continues to provide the required pavement support. View video

COMPOSITE PAVEMENT - STABILIZATION AT JOINTS & CRACKS

PROBLEM:

For composite pavement, the lack of a stable base and foundation soils beneath existing joints and cracks in concrete pavement is one of the causes of premature failure of the asphaltic concrete overlay. The unstable soils beneath the concrete cause the pavement to deflect as traffic loads are inefficiently transferred from one slab to another beneath the asphalt overly. In short order, the constant movement causes reflective cracking of the asphaltic concrete overlay. This reflective cracking then leads to water infiltration at the joints and cracks and even weaker pavement support. The continual movement of the pavement causes spalling of the asphalt overlay and significantly reduces the life of the overlay.

SOLUTION:

Prior to the overlay, apply the URETEK Deep Injection Process with URETEK 486 water resistant expansive polymer to one row of injections on the approach and leave side of each joint and crack. Inject through tubes, to a depth of approximately 3' into the foundation soils by drilling 3/4" holes through the concrete and injecting through tubes into the soils. This is typically accomplished on a 4' grid pattern. URETEK monitors the surface using laser monitors and/or dial indicators and knows that the roadway has become adequately supported when an indication of movement is detected on the monitors.

EXPECTED RESULTS:

- Decreased deflections at the joints and cracks.
- Increased Load Transfer Efficiencies (LTE's) at the joints and cracks.
- Extends the life of the overlay.

BENEFITS:

- Zero daytime lane closures.
- Multi-lane mile projects are accomplished with up to four production trucks and stay ahead of the prime contractor performing the mill/overlay.

- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.

ALTERNATIVE METHODS OF REPAIR:

- Injecting a polymer directly under a composite pavement to stabilize the joints/cracks will likely cause delamination of the asphalt and concrete as material travels up through the joints and cracks to get into the interface between the concrete and asphalt. This causes removal of the entire asphalt layer, increasing the time to complete and the cost of the project. Additionally this alternate does not address the problem of weak supporting soils and will likely result in premature failure of the asphalt overlay if the foundation soils allow deflection of the pavement.

- Removal and replacement of the entire pavement system (pavement and the weak foundation soils) is extremely expensive and results in significant traffic delays.

REFERENCE DOCUMENTS:

1. **VDOT I-81 Projects:** Three projects were completed on I-81 between 2009 and 2012; 35 lane miles with over 8,000 transverse cracks and pumping joints. Photos include reflective cracking prior to the project, URETEK injecting at night in 2009, and a photo from 2014 (five years later). VDOT detailed the work areas in late 2014 and identified less than 50 reflective cracks out of the 8000 injected cracks/joints (fewer than 1%) with the cause of these reflective cracks yet to be determined. View Photos

2. **TXDOT Beaumont Project Report:** Contains pre-injection and post-injection Falling Weight Deflectometer (FWD) test results and analysis performed by TXDOT on jointed concrete pavement. This report demonstrates the benefits of our process with significant decrease in deflections and significant increase in LTE at the joints. View Report

3. **PennDOT Pilot Project Report I-80 (2012):** Contains pre-injection and post-injection Falling Weight Deflectometer (FWD) test results and analysis performed by PennDOT on a jointed concrete pavement system. This report demonstrates the benefits of our process with significant decrease in deflections and significant increase in LTE at the joints. View Report

FULL DEPTH PAVEMENT PATCH - STABILIZATION OF FOUNDATION SOILS

PROBLEM:

Stabilization of areas of roadways where full depth repair is to be done to minimize the need for additional cutout of poor base/sub-base/sub-grade once the roadway surface has been removed. The failure of the pavement surface is often caused by weak or insufficient support in the foundation soils. Ignoring this problem leads to premature failure of the patched pavement. Tearing out the base/sub-base/sub-grade is costly and causes significant lane closure time including daytime lane closures. The replacement of the foundation soils is often ineffective due to the inherent difficulty to compact the new soils in a small area. Adjacent panels can be negatively affected by disturbing their foundation soils during the repair.

SOLUTION:

Utilize URETEK Deep Injection Process to stabilize the foundation soils prior to replacement of the failed pavement section. This is accomplished by drilling multiple 3/4" holes through the existing pavement and injecting polymer through tubes, placed at minus 3' to minus 4' from the pavement surface. This is usually done on a 4' grid pattern. URETEK monitors the surface using laser monitors and/or dial indicators and knows that the roadway has become adequately supported when an indication of movement is detected on the monitors. Injection is also performed one row in front and in back of the failed section. The pavement can then be removed and new pavement placed on a sufficiently strong base/sub-base.

EXPECTED RESULTS:

- Foundation soils are sufficiently stiffened to support the load on the new patch.
- Extends the life of the full-depth patch.

BENEFITS:

- Zero daytime lane closures.
- Injection is accomplished sufficiently ahead of the patching crew so that the patching process can take full advantage of the lane closure time frame.
- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.
- No disruption to utilities.

ALTERNATIVE METHODS OF REPAIR:

- Complete removal of the weak foundation soils. Compaction of the new soils is difficult in the small area of a patch and often leads to pre-mature failure just as quickly as if the foundation soils had not been replaced. Weather can cause delays as removal of foundation soils will be postponed if inclement weather is threatening. High cost, high risk, minimal effectiveness.

- Ignore the weak foundation soils due to high cost and minimal effectiveness of traditional replacement methods. Presumably the weak foundation soils caused the premature failure of the pavement and the cycle will likely be repeated.

REFERENCE DOCUMENTS:

1. **VDOT I-81 Projects:** As part of the stabilization of joints and cracks on I-80, over 2000 LF of foundation soils under the pavement has been injected prior to replacement and installation of the patch. This was a change order on one project for 1000 LF. View Memo

2. **ADR Forensic Photos:** The entire premise of this research project for the Navy was to stabilize the un-compacted fill in 20' Diameter bomb craters. While you do not have bomb craters on your roadways, there are certainly patches of failed concrete caused by weak foundation soils. View Photos

3. **NAVFAC Press release:** Navy was satisfied with the foundation support the URETEK Deep Injection Method provided to the concrete patches on their runways. View Press Release

4. **Penn State University Demonstration:** Summarizes the demonstration URETEK performed in 2012 at the request of PennDOT. View Demonstration

CONCRETE PAVEMENT - DIPS & FAULTED LONGITUDINAL & TRANSVERSE JOINTS

PROBLEM:

Concrete pavement settlement, whether settlement of several panels across all lanes to form a dip or one lane with settled panel(s) causing a faulted longitudinal joint or multiple panels in succession with faulted transverse joints, is most often caused by weak foundation soils insufficient to support the heavy tractor trailer loads or the increased truck traffic counts. Once the pavement begins to settle, the pavement system typically is more susceptible to water intrusion, exacerbating the situation.

SOLUTION:

Roadway surfaces that have settled can be stabilized and lifted by injecting polymer through tubes at multiple elevations, strengthening the weak sub-grade soils. This is accomplished by taking DCP tests before the injection process to determine the elevation(s) where the injections will be done; then drilling multiple 3/4" holes through the concrete and injecting polymer through tubes placed at the level(s) of the weak area(s) into the foundation soils. This is usually done on a 4' grid pattern in 4' elevations. URETEK monitors the surface using laser monitors and/or dial indicators and knows that the roadway has become adequately supported when an indication of movement is detected on the monitors. Injection is continued into the soils to lift the pavement to grade - returning the pavement to original construction, concrete on base on stiffened sub-base/subgrade. If the faulted joint experiences aggregate lock prior to completing the lift, the joint may require full depth saw cut or if minor can be touched up with diamond grinding.

EXPECTED RESULTS:

- Foundation soils will be sufficiently stiffened to support the load and mitigate future settlement.
- Deflections will be reduced and Load Transfer Efficiencies improved.

BENEFITS:

- Zero daytime lane closures.
- Pavement life extended with proper support of the pavement.
- Safety hazard eliminated.

- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.

ALTERNATIVE METHODS OF REPAIR:

- Utilization of concrete slurry directly under slab has many weaknesses:
    - Difficult to control the lift.
    - Material setup time is long and material can travel far beyond the point of installation – often times requiring significant additional material and/or causing environmental concern.
    - Vibration from traffic in adjacent lanes can cause water separation and thus a poor end product.
    - Does not have the tensile strength to hold up under the vibration of traffic
    - If a blow-out occurs– there is a significant delay while the material hardens before injection can continue.
    - While cement slurry is often used to fill large voids, it is ineffective where there are small pockets of void or weak soils as it is difficult to identify exactly where those voids or weak soils are and should be injected.
- Polyurethane injection directly beneath the concrete to fill voids and lift has many weaknesses:
    - Foundation soils that cause the settlement are not repaired.
    - While the polyurethane material by itself performs well on the Repeated Load, Permanent Deformation Testing, it does not have sufficient Resilient Modulus strength. The composite of the material injected into an aggregate, combines both Resilient Modulus strength with great resistance to permanent deformation.

REFERENCE DOCUMENTS:

1. **TXDOT Beaumont Project Report**: Contains pre-injection and post-injection Falling Weight Deflectometer (FWD) test results and analysis performed by TXDOT on a jointed concrete pavement system. This report demonstrates the benefits of our process with significant decrease in deflections and significant increase in LTE at the joints. View Report

2. **PennDOT Pilot Project Report I-80 (2012):** Contains pre-injection and post-injection Falling Weight Deflectometer (FWD) test results and analysis performed by PennDOT on a jointed concrete pavement system. This report demonstrates the benefits of our process with significant decrease in deflections and significant increase in LTE at the joints. View Report

3. **Executive Report Rev 1 (Boudreau):** Summarizes the results of material testing research performed by Rick Boudreau doing Resilient Modulus and Repeated Load Permanent Deformation Testing. The testing looked at samples of various aggregates and our polyurethane by themselves and then the same aggregates after injection with polyurethane. View Report

DRAINAGE SYSTEMS - REPAIR OF LEAKING JOINTS & COMPACTION OF WEAK SOILS

PROBLEM:

Leaking joints in drainage box culverts or pipes allow foundation soils to be removed from the pavement system. The soils are carried out with the water that moves through the pavement system and out though the leaking joints. This causes loss of support for the pavement system – causing settlement and premature cracking of the pavement.

This can also cause voids around the culvert or within the pavement system that can lead to sudden movement in the pavement and at times catastrophic failures. Some drainage system joints are intact but simply have poor compaction over the culvert or pipe that need stabilization.

SOLUTION:

Apply the URETEK Deep Injection Process with URETEK 486 water resistant expansive polymer into the foundation soils beneath the pavement system at various elevations to compact loose soils to properly support the roadway. Continue injection into the soils as needed to raise the pavement to grade. Inject the polymer around leaking joints to fill voids and compact the soils around the drainage system and to allow material to enter the leaking joints while expanding to provide a positive encasement seal of the joint.

EXPECTED RESULTS:

- Compact the loose soils around and above the drainage system to provide sufficient support for the roadway.
- Seal any leaking joints in the culverts or pipes to prevent foundation soils from leaving the area via the drainage system.
- Continued injection into the soils can lift the pavement system if needed.

BENEFITS:

- Zero daytime lane closures.
- Complete reconstruction of the drainage system is not required.
- Tear out and replacement of the pavement and support soils to excavate to the drainage system is not required.
- Tremendous dollar savings over replacement.

- Injection to seal the leaking joints in the drainage system can be easily controlled to prevent filling of the pipe and waste of material.

- Yearly re-sealing of the drainage system joints from the inside is not required as is often the case with traditional methods.

- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.

ALTERNATIVE METHODS OF REPAIR:

- Removal and replacement of pavement, weak foundations soils and culvert or drainage pipe is extremely expensive and causes significant traffic delays.

- Spot repair of the leaking joint requires expensive and time consuming removal of the pavement and foundation soils in order to reach the drainage system to make the repair. Following spot repair and testing, the foundation soils must be installed and compacted and new pavement placed. Compaction of the soils is difficult and often results in pavement settlement in near future.

- Traditional patching of the pipe joint from inside can prematurely fail as it is not a positive seal – water will continue to try to enter the joint from the voids around the pipe. Since this alternate does not address the voids around the pipe, the pipe can easily flex and break the new seal at the joint. Additionally the voids around the pipe can continue to allow water flow along the pipe during a rain event keeping the possibility open for catastrophic failure. These voids also allow for the pavement foundations soils to settle into the voids around the pipe, causing premature cracking and settlement of the pavement.

REFERENCE DOCUMENTS:

1. **Classic Culvert Failure:** This four minute video demonstrates what can happen when the soils around culverts are not compacted against the culvert – the opening is available for a catastrophic failure. View video

2. **Damage Control:** View Video

BRIDGE APPROACH/DEPARTURE SLABS

PROBLEM:

Bridge approach and departure slabs often settle several inches or more causing potential unsafe driving conditions. The settled approach slab and highway pavement are impacted by cracking and stresses that either reduce the pavement life or require additional maintenance costs. Additionally the bridge itself is subjected to increased impact loading which is damaging to the structure. The settlement is most often caused by loose or poorly compacted foundation soils. The settlement can also be caused by water penetration under the slab and out under the abutment wall or wing walls, carrying soils out from under the slab.

SOLUTION:

Perform Dynamic Cone Penetrometer (DCP) tests to determine the depth(s) of the weak soils. Bridge approach slabs that have sleeper support slabs shall have all drill holes fully sleeved by tubes into the base soils to prevent any injection of material between the sleeper slab and the pavement. To stabilize the sleeper slab, injection tubes shall be inserted to a minimum depth of 5' (minimum of 2' below the bottom of the sleeper slab) and then typically at a second elevation approximately 10' below the pavement surface. Material shall be injected in each tube until the soils are stabilized as evident when movement of the pavement is detected. After the soil is stabilized beneath the sleeper slab, injection may be continued to lift the sleeper slab and pavement to original grade. Based upon the DCP tests, additional levels of injections may be required to provide adequate stabilization. Stabilization of the soils will provide proper support for the heavy sleeper slab to mitigate any future movement. If there is any concern over loss of soil beneath the abutment wall, a row of injection tubes shall be inserted to the proper depth(s) and material injected to stabilize the soils and to close off any pathways for water to travel that were carrying soils out from under the abutment wall.

EXPECTED RESULTS:

- Foundation soils are sufficiently stiffened to support the load and mitigate future settlement.
- Sleeper slab, approach slab and pavement raised to grade.
- Impact loading from launching trucks onto the bridge eliminated.

BENEFITS:

- Zero daytime lane closures.
- Sleeper slab is properly supported.
- Approach slab and roadway are not lifted off the sleeper slab.
- Pathways for water to travel through the system are cut off so soils remain within the pavement system
- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.

ALTERNATIVE METHODS OF REPAIR:

- Utilization of concrete slurry directly under slab has many weaknesses:
    - Difficult to control the lift.
    - Material setup time is long and material can travel far beyond the point of installation – often times requiring significant additional material and/or causing environmental concern.
    - Vibration from traffic in adjacent lanes can cause water separation and thus a poor end product.
    - Does not have the tensile strength to hold up under the vibration of traffic.
    - Difficult to control – if there is a blow-out – there is a significant delay while the material hardens before injection can continue.
    - While cement slurry is often used to fill large voids, it is ineffective where there are small pockets of void or weak soils as it is difficult to identify exactly where those voids or weak soils are and should be injected.
- Polyurethane injection directly beneath the concrete to fill voids and lift has many weaknesses:
    - Material can easily travel from under the sleeper slab and lift the approach or pavement off the sleeper slab – leaving the sleeper slab down. This places polyurethane material between the concrete roadway and the concrete sleeper slab which will eventually crush, causing re-settlement.
    - Foundation soils that cause the settlement are not repaired.

- Channels for water to travel through the foundation soils are not eliminated.
- Polyurethane material has a very high R value (no impact when mixed with soils). If several inches of polyurethane material is between the concrete and the foundations soils, the bridge approach panel is now susceptible to icing faster than it is not isolated from mother earth. When the bridge approach re-settles, that icing situation will present an additional safety problem.

REFERENCE DOCUMENTS:

1. **ADR Forensic Photos:** The entire premise of this research project for the Navy was to stabilize the un-compacted fill in 20' Diameter bomb craters. The photos demonstrate how the injection process will lock up and compact the loose soils beneath a bridge approach and provide sufficient support for the heavy sleeper slab. View Photos
2. **NAVFAC Press Release:** Confirms the success of the URETEK Deep Injection Process to stabilize un-compacted fill to support pavement. View Press Release
3. **URETEK R-Value Testing:** Provides information on the insulating characteristics of the polyurethane by itself and when injected into soils. View Report

CONCRETE PAVEMENT WITH A DRAINABLE BASE - STABILIZATION & LIFTING

PROBLEM:

Pavement system has lost foundation support. The poor and/or uneven support can result in premature cracking of the concrete, spalling or corner breaks, and settlement at the joints and dips in the pavement. Insufficient support strength may be caused by:

- Loose or un-compacted foundation soils that were untreated prior to construction of roadway
- Loose soil or sand in the sub-base or subgrade below the drainable base migrate into the drainable base and is carried out of the system as the water flows through the drainable base. This allows the drainable base to drop into the sub-base/subgrade, causing loss of support for the concrete pavement.

SOLUTION:

Apply the URETEK Deep Injection Process with URETEK 486 water resistant expansive polymer injected through tubes at a typical depth of 12" to 24" below the drainable base to repair foundation soils and then continue injection into the soils if needed to lift the concrete pavement to grade. If DCP tests show deeper problems, additional depth(s) of injection can be added as needed. This is accomplished by drilling multiple 3/4" holes through the concrete and injecting through tubes into the foundation soils. This is usually done on a 4' grid pattern. URETEK monitors the surface using laser monitors and/or dial indicators and knows that the roadway has become adequately supported when an indication of movement is detected on the monitors. This stabilizes the foundation soils, compressing the drainable base back up against the bottom of the pavement without filling the drainable base with polymer.

EXPECTED RESULTS:

- Compact the loose foundation soils and compact the loose drainable base back up to the bottom of the concrete slabs.
- No fouling of the drainable base with polymer – preserving the drainable base while not wasting limited maintenance money on filling the drainable base with polymer.
- Continued injection into the soils through tubes can lift the pavement system if needed, without fouling the drainable base.

BENEFITS:

- Zero daytime lane closures
- Pavement can be lifted without the expense of filling the drainable base and without further fouling of the drainable base
- Injection can be accomplished in wet soil conditions as the URETEK 486 STAR hydro-insensitive polymer will form a dimensionally stabile polymer even when injecting into saturated soils. The expansion process will also drive the water out of the soil system.
- Injecting a concrete "mud jacking" slurry or a polymer directly under the surface of the concrete to lift the pavement will first fill the drainable base, making it impervious to water, permanently fouling the drainable base. This process will also use significant additional material to fill the drainable base before the material will begin to lift the roadway, forcing the client to pay for a negative. The concrete mud-jacking material has very little tensile strength and will not hold up to the vibration of traffic. While the polymer will certainly lock up the drainable base and has great tensile strength – the foundation soils will not be repaired.
- Removal and Replacement of pavement, drainable base and the weak foundations soils is extremely expensive and causes significant traffic delays.