The URETEK Deep Injection® Process (UDI) For Roadways and Building Structures

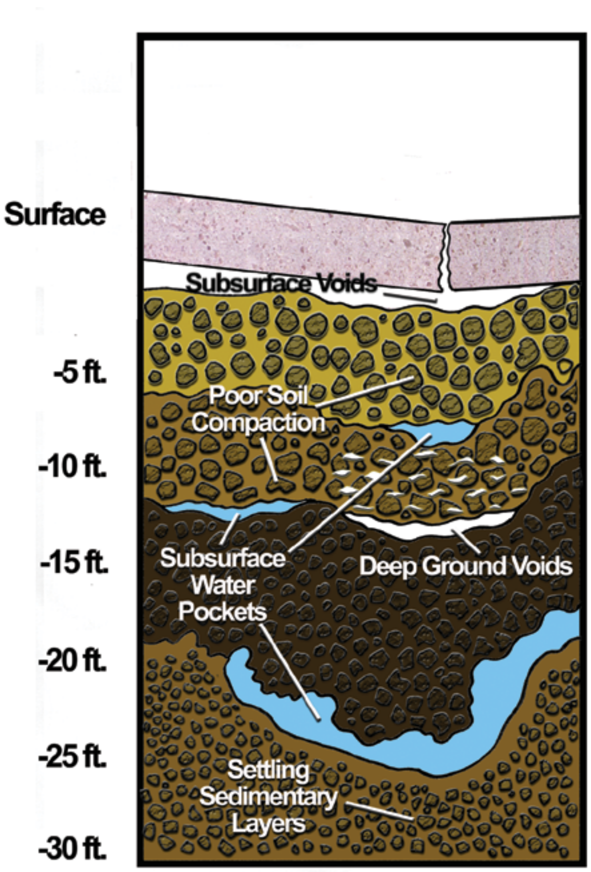
A URETEK USA/ICR White Paper
www.worldofuretek.com
888-287-3835

Introduction

Since the early days of modern civilization, road builders and building construction contractors have understood the relationship between stable ground and the roads, bridges, and structures that lie on that ground. When weather conditions produce rain, snow, or severe temperature shifts, deep underground expanses such as voids, fissures, and water pockets can be created that in turn, destabilize road surfaces, highways and building foundations. The result - cracks, potholes, and sink holes that can wreak havoc on public assets such as roadways, sewers, pipelines, bridges and overpass supports, as well as private buildings and structures (See Figure 1).

Even though work crews can seal the cracks, fill the potholes, lay down new asphalt, or rebuild the damaged infrastructures, it only masks the underlying problem, requiring that a similar round of maintenance is needed again after the next season of severe weather. The key to having quality road surfaces and public structures that last longer and require less frequent maintenance is having a stable underlying soil foundation on which these materials and components lie.

Figure 1: Elements of a Shifting/Unstable/Damaged Underground Base



The materials that are used to stabilize underground soils play an important role in offsetting problems on a permanent basis. Over the years, several materials have been introduced to fill underground spaces which have varied anywhere from seashells and wood chips, to combinations of lime, fly ash, cement, and concrete slurry. The most effective materials that stabilize an underground soil base must not only fill these remaining expanses, but more importantly, must also drive out and seal them from the entry of water into subsurface soil pockets.

Many municipalities and commercial businesses are now re-examining the role that having a stable underground base plays on the maintenance of their public and private structures, and, are placing a greater emphasis on preventative measures designed to strengthen these underground soil strata. By increasing the density of compromised sub-surface soils as part of project maintenance, repairs are longer lasting and the asset is better protected.

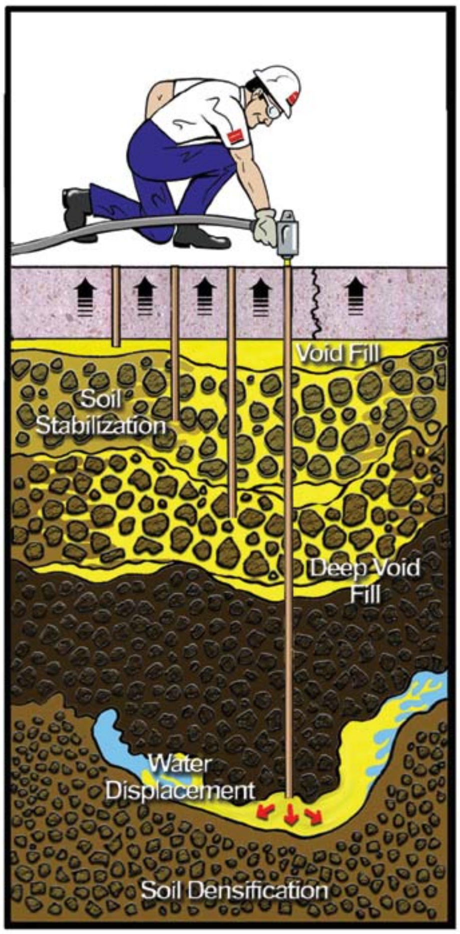
URETEK USA products and services, including the URETEK patented Deep Injection™ Process and the revolutionary URETEK 486 polymer material provides the industry's most cost effective, expedient and safest solution to stabilizing underground soils. The process is ideal for a host of public and private assets with settlement problems that are the result of unstable soil conditions.

About the URETEK 486 Polymer Material

The objective of the patented URETEK Deep Injection Process is to guarantee significant increase in the bearing capacity of the ground. To accomplish this, URETEK USA utilizes the most advanced technologies and injection techniques in the industry.

Key to the URETEK Deep Injection Process is the application of the URETEK 486 polymer material. This high density expanding resin offers superior advantages over less effective traditional materials. The URETEK 486 polymer fills, densifies, and stabilizes low-density compressible soils to depths of 30 feet and beyond. It is ideal for highways, bridge approaches/departure slabs as well as taxiways, runways and tunnels that have settlement problems caused by a poor sub-base and soil compaction. The URETEK 486 polyurethane is also specially formulated to be fast acting and hydro-insensitive, ensuring that it is unaffected by any water or wet soil that may lie under the surface pavement (See Figure 2).

Figure 2: The URETEK 486 Material Reconstitutes the Underground Base



Benefits of the URETEK 486 material include:

1. Longevity - The URETEK 486 polymer is a specially formulated polyurethane material that is guaranteed for ten years against any loss of dimensional stability and deterioration.

2. Fast Acting - With the URETEK 486 material, time requirements for the UDI process are reduced to hours instead of the days or weeks required for other techniques. As a result, the time needed for project completion is dramatically reduced.

3. Hydro-Insensitive - The unique nature of the URETEK 486 polymer material pushes out and displaces water[1]. The polymer chemistry prevents weak cross-linking at the time of injection. When complete this process prevents further water infiltration. The strong link that is created prevents any material breakdown from occurring when the polymer is exposed to subsequent amounts of water. The material can also be used to seal underground pipes by surrounding the leaking joint.

4. Expansive - Because of its unique expansive capabilities, the URETEK 486 material has the ability to fill all voids or fissures while further compressing and densifying the soils.

5. Lightweight - The URETEK 486 polymer material is extremely lightweight, weighing less than 5% of a comparable quantity of cement/concrete based grouts. As a result, a minimal amount of additional overburden weight is introduced into the already distressed sub-grade soil environment.

6. Safe - The cured polymer material is inert, environmentally neutral, and does not contribute to soil or water contamination, leaching, or pollution.

In comparison, other soil densification procedures such as cementicious compaction grouting utilizing heavy suspension grouts, adds a significant amount of weight that can contribute to additional soil and ground problems over time.

1- The time necessary to push out any remaining water may vary depending upon the soil conditions

The Details Behind the URETEK Deep Injection Process

The URETEK 486 polymer is used as part of a multi-phased, deep injection soil densification process that takes place at a variety of soil depths. In this section, we discuss each phase of the Deep Injection Process in greater detail, and show how this process and material plays a critical role in yielding higher levels of soil densification.

Investigative Phase - The Penetrometer Test

Prior to any material injection, a series of preliminary tests are conducted to identify and determine the specific areas that have a weaker soil stratum, and to find the specific locations where the expanding polymer material is needed.

The tests are performed using a dynamic cone-penetrometer, a metal rod that is driven into the ground to measure the density of the ground soil. The rod is marked in 10-centimeter increments and is used as an indication of the density of the soil.

This density measurement process is accomplished through a series of "blow counts" that are administered by dropping a specific weight from a certain distance onto the top of a penetrometer rod to drive it into the ground. The number of blows that are necessary to send the rod 10 centimeters into the ground are counted and measured. For example, a high number of blows would be indicative of a more dense soil, while a lower number of blows would indicate a weaker soil condition. Typically soils register a low value, typically 1 to 5 blows, while denser soils register a higher blow count above 10, 20 or higher.

Preparation Phase - Drilling the Injection Pattern and Injection Holes

Once the penetrometer tests have been completed, the specific locations and depths of weaker soil strata are logged. Using this information, special probe drills are used to measure and drill an injection pattern that includes a series of ½" to ¾" holes encompassing the entire identified area. The injection grid is designed to strength the soil directly underneath the structure as well as the surrounding area. To enforce the target areas, injection holes are drilled at a variety of depths depending on the soil condition.

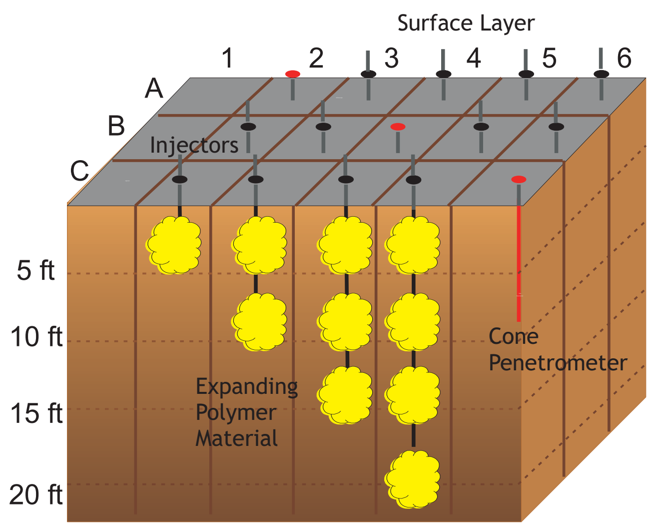
Primary Injection Phase - Polymer is injected into the Shallower Locations

Once all of the injection holes are drilled, a length of tubing is placed into each hole to accurately place the URETEK 486 material. The polymer, which is based on a combination of two different chemicals, is warmed prior to its injection into the ground to facilitate the injection process.

The area where the polyurethane material is injected is referred to as the "sphere of influence". The weaker locations closest to the surface, comprising depths between 3 to 9 feet receive the first injection. When the injection has been completed, the polymer material reaches its maximum density very rapidly. Expansion of the polymer is over within one minute reaching 90 percent of its strength within 15 minutes (see Figure 3).

The URETEK 486 synthetic polymer material is placed in upper areas of weak soil resistance, where it quickly expands. As it does so, soils are compacted and nearby fissures and voids are filled. Since the polymer is hydro-insensitive, any ground water in this expansion path is pushed aside. This property allows for deep injections to occur under any type of ground condition, including heavily saturated soils.

3: Deep Injection Process Using the Patented URETEK 486 Polymer Material



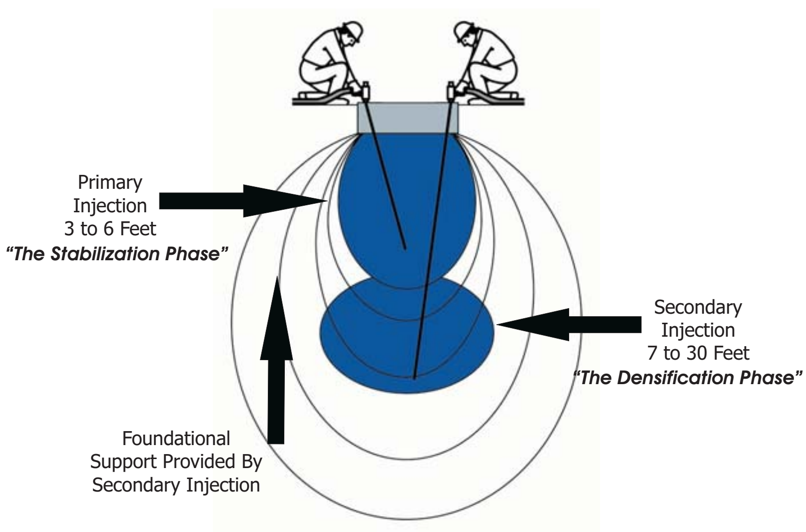
Secondary Injection Phase - Polymer is injected into the Deeper Locations

Once the upper stratum is densified, lower levels can be addressed. Depending on the condition of the underground soil, and the depths that are required, there can be additional deep injection locations.

These deeper injections encompass the entire soil support area necessary for the overbearing structural load. Each injection continues up to a point of minimum lift registered at the surface, indicating the sufficiency of densification. This assures a sufficient radial compaction from each point of injection (see Figure 4).

As this final portion of polymer expands, the surrounding sphere of influence compacts and densifies the soil to affect a controlled lift of the bearing loads. These movements are precisely monitored and controlled by the laser level measuring devices on the surface. By proceeding in this manner, these injections guarantee an adequate increase of the bearing capacity of the entire underground foundation. This soil densification is easily verified by comparative measurements taken before and after using the dynamic cone penetrometer. The bearing loads are subsequently distributed on both the plane surface as well as in the compacted sub-grade ground/resin stratums.

Figure 4: The Deep Injection Procedure



Once this final injection phase has been completed, the road or structure can be returned to normal operation within 15 minutes. This results in dramatically reduced costs and minimizes the downtime for use of the asset.

Validation and Testing Phase - Ensuring Success

Given the variances that are inherent with any underground environment, it becomes imperative to test the reinforced area after the injections have been applied to ensure that the polymer material has accomplished its densification goals.

After the injection phases have been completed, a series of post-injection penetrometer tests are completed in close proximity to the injection locations. These tests are similar in nature to the pre-injection tests that were performed at the start of the project. Proof of specific soil strata strength is accomplished and logged.

A report is generated and given to the client to validate the changes that have taken place in the ground density and show the improvements that have been made in restoring the surface elevation, and also increasing the bearing capacity of the foundation soils.

Summary

Densification of sub-surface base soils is an important repair option to stabilize and reinforce pavements, foundations, and structures. When the URETEK 486 high-density polyurethane material is injected deep into the ground to stabilize a sub-base soil stratum it leads to longer lasting and less frequently maintained projects.

The URETEK Deep Injection Process provides a cost effective, fast, and safe solution to soil stabilization. As a pioneer in applying the latest technologies to solving complex soil stabilization problems, URETEK delivers a "no disruption" cure for highways, bridge approaches, runways and building foundation repair problems as well as deep soil densification, and sealing underground leaks. With the UDI process, many of today's state, county, and municipal governments as well as engineers and contractors can make the most cost effective use of limited budget resources while dramatically improving the quality and longevity of their existing infrastructure investments.

To summarize, the URETEK Deep Injection Process provides the following advantages:

1. Efficient - The resolution of highways, roads, bridge and foundation problems should rarely require, if ever, extensive downtime. URETEK brings a "no disruption' solution to pavement lifting, infrastructure services, runways, and soil stabilization.

2. Low Cost - Deep Injection is a highly effective, low-cost alternative to more traditional excavation repair methods. Infrastructures, roadways, bridge approaches, building foundations and tunnels are put back on solid ground, without the need for costly reconstruction. Equipment, labor, and materials costs are significantly reduced. Since there is no need to take the asset out of service, minimal interruptions occur leading to additional cost savings. Since the issue is solved at the source, any additional or related problems do not recur or require future maintenance.

3. Fast with Minimal Disruption - With the URETEK Deep Injection Process, most repairs can be completed in a matter of hours as opposed to days or weeks. Work is often accomplished during off-peak nighttime hours. Since there is a rapid cure time associated with the URETEK 486 polymer material, work crews can re-open traffic lanes as they finish each section of the project repair area.

4. Quiet and Safe - The URETEK Deep Injection Process is the most quiet and safest soil stabilization process in the world. Through advanced technologies and state-of-the-art equipment, this process has the least noise of any alternative method. In addition, all URETEK employees and affiliates undergo rigorous training, ensuring the safest, most predictable, and most efficient worksite available. All materials are 100% environmentally safe and inert, preventing any pollution of the environment or surrounding groundwater.

5. Proven and Successful - URETEK has successfully completed more than 75,000 projects, worldwide. The URETEK Deep Injection Process prolongs the life of your public infrastructures, highways, roads/bridges, airport runways/taxiways, and industrial, commercial, and residential structures.

13900 Humble Road
Tomball, TX. 77377
www.worldofuretek.com
888-287-3835

URETEK CASE STUDIES

Case Study #1: The URETEK Deep Injection Process on a Public Roadway (Page 7)

Customer Profile:
A Utility Board in a Major Tennessee Metropolitan Area.

Customer Environment:
A pavement settlement problem around a sanitary sewer manhole at a busy river front section of the city.

Customer Situation:
An abandoned sewer pipe weakened the area presenting a potentially significant traffic problem.

Case Study #2: The URETEK Deep Injection Process on a Building Structure (Page 9)

Customer Profile:
A Major Kentucky-based Dairy Foods Producer

Customer Environment:
A 50,000-gallon production tank located within the food processing plant.

Customer Situation:
The foundation of the food processing facility had settlement issues causing a problem with a 50,000-gallon liquid storage tank.

Case Study #1: The URETEK Deep Injection Process on a Public Roadway

Customer Profile: A Utility Board in a Major Tennessee Metropolitan Area

Customer Environment: A pavement settlement problem around a sanitary sewer manhole at a busy river front section of the city.

Customer Situation: An abandoned sewer pipe weakened the area presenting a potentially significant traffic problem.

Background: A case involving asphalt settlement in a major metropolitan area of Tennessee was brought to the attention of URETEK USA during June 2001.

The city had patched around the manhole two times before notifying the Utility Board that there may be a problem with the site. Upon investigation by the Utility Board, they found a broken 8-inch sanitary sewer line entering the manhole at approximately 25-feet from the surface. A miniature camera had revealed that the pipe was blocked and broken approximately 3-feet outside of the manhole wall. While the brick manhole was structurally sound, it was also quite susceptible to water and soil infiltration through the gaps in the deteriorated mortar joints at random locations along the barrel of the manhole.

The Metropolitan Utility Board contracted with URETEK USA in July of 2001 to accomplish three tasks that were deemed necessary to solve the manhole problem. First, the soils surrounding the manhole needed to be stabilized. Secondly, the entry of the 8-inch broken pipe into the manhole was to be sealed.

Methodology: The URETEK Deep Injection Process employed a series of injections forming a grid pattern design that provided a precise, uniform, and sequential layout of injection probe placements. The pattern was determined by the results of penetrometer testing as well as soil information that the Utility Board supplied. The initial penetrometer test was taken approximately 3-feet south of the edge of the manhole. The test revealed a 33-inch void directly under the asphalt pavement. The soils were so weak that the penetrometer rods dropped under their own weight to a depth of 22-feet! This penetrometer test revealed just how extensive and weak the soils strata had become. A collapse of the manhole, the possibility of subsequent backup and possible flow of sewage into the adjacent river, the loss of sewer services, as well as delays and interruptions needed for a massive excavation could have cost the Utility Board many times the cost of the URETEK repair.

The soil and structural problems, indicated by the penetrometer testing, dictated the spacing and depth of the injection pattern. The relative weakness of the soils determined the volume of the resin consumption. The weaker the soil, the greater the amount of material consumption would be necessary to achieve an adequate level of soil densification in order to stabilize the problem and support the load on the pavement.

Budgetary constraints, test data and common sense were used to guide the sequence of injections to the areas that had the highest need for the URETEK 486 polymer material. In this particular case, URETEK designed a pattern around the manhole starting with the deepest points first, then radiated outward and upward in a shallower pattern of densifying injections.

Based on the contract proposal discussions and an analysis of the original area covering both the slow and passing lanes of traffic, a pattern made up of 20 injection points, covering an area of 18-feet by 15-feet was devised. This injection plan called for four depths of injections, at 17, 13, 9, and 5 feet respectively. The points closest to and surrounding the manhole received injections at all four depths. The penetrometer hole (P1) was also treated as an injection point receiving three depths of injected polymer material to fill and densify the void under the asphalt pavement (see Figure 6).

All work performed by URETEK was completed during evening and early morning hours over the course of five nights, allowing the roadway to be used each day during peak traffic periods. As a result, there was no disruption to the flow of traffic either entering or exiting the city each day during the entire project.

Validation: A post penetrometer test was completed within 2-feet of the original test location (P1). This second test, when compared to the first test, shows an improvement in the densification of the soil. It is used to determine if additional injections are needed to gain further densification. In this case the test results were satisfactory that the soils had been densified to support the load on the pavement. The manhole was sealed against further soil infiltration as evidenced by polymer penetration throughout the interior mortar joints.

Figure 5: Injection Grid Diagram of Riverfront Street (Top View)

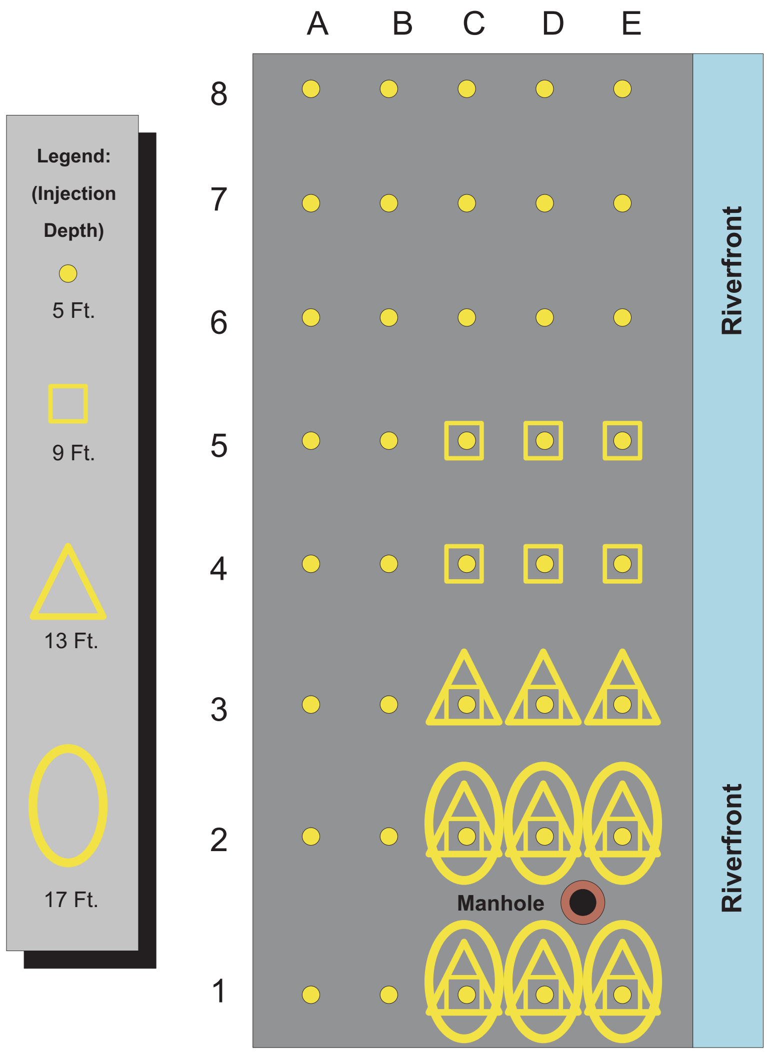
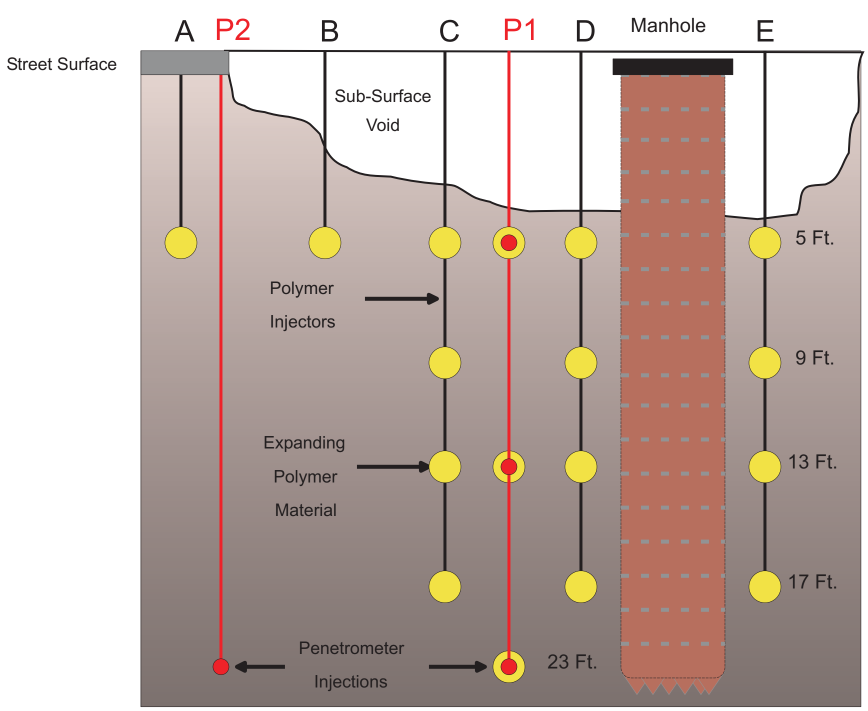


Figure 6: Depth Diagram of Injections (Side View)



Case Study #2: The URETEK Deep Injection Process on a Building Structure

Customer Profile: A Major Kentucky-based Dairy Foods Producer

Customer Environment: A 50,000-gallon production tank located within the food processing plant.

Customer Situation: The foundation of the food processing facility had settlement issues causing a problem with a 50,000-gallon liquid storage tank.

Background: A case involving a settlement problem with the foundation pad underneath a sinking 50,000 gallon production tank at a major foods processing plant in Kentucky was brought to the attention of the URETEK ICR Division in July 2000.

Just three months prior, the tank had been installed at the plant's storage facility and almost immediately began to exhibit settlement problems of approximately ½ to ¾ of an inch. The weight of the tank and the regular loading and unloading of its liquid cargo had contributed to the settlement problems and to the adjacent building foundations that were in close proximity to the storage area. If left unchecked, serious and costly problems could impact both the storage tank, as well as the adjacent foundations.

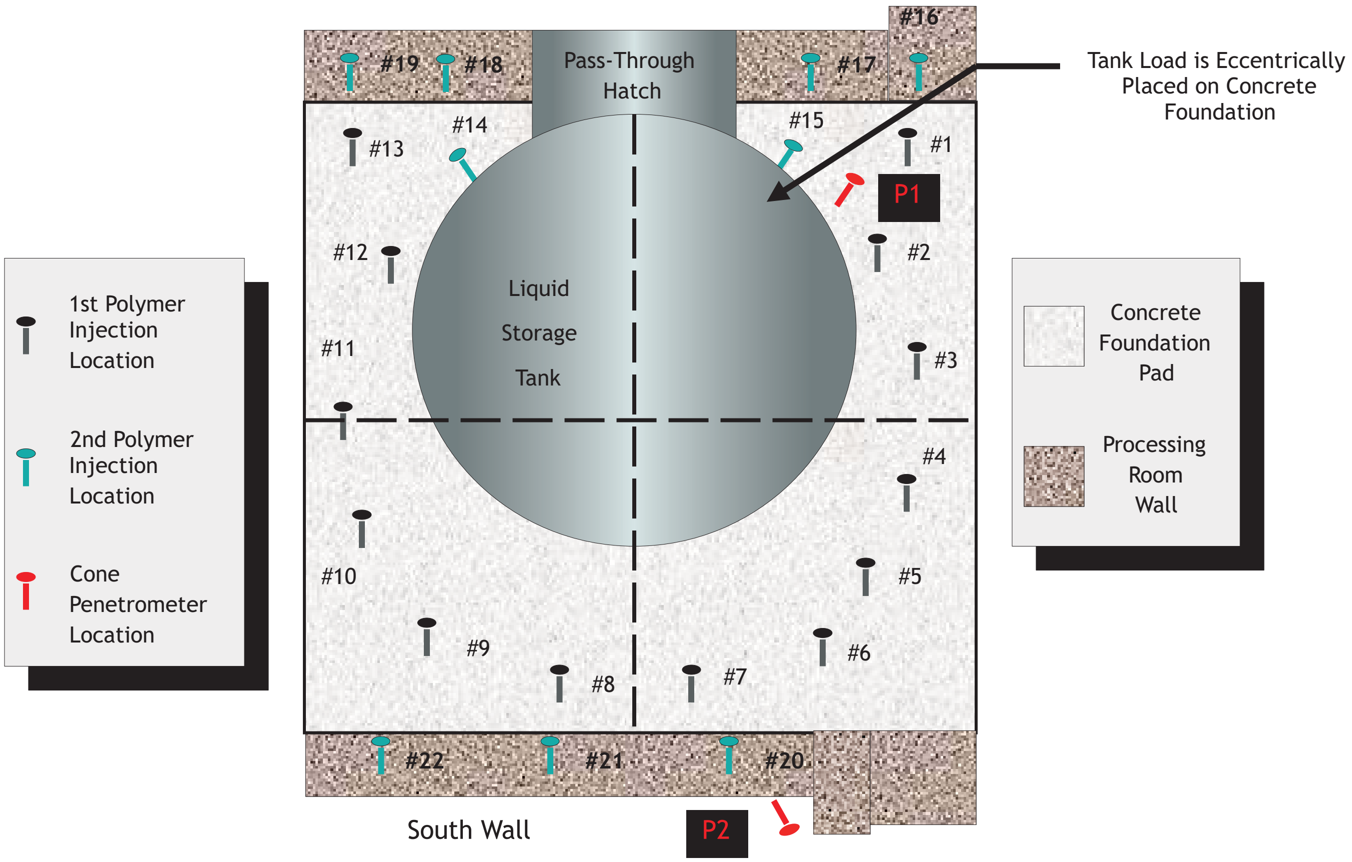
Once work began, an inspection of the soils underneath the foundation pad revealed an initial layer of highly compressible, saturated and weak, silty soils situated over a second denser layer of these same soils that were located approximately 8 to 9-feet down. The entire plant facility was supported on this more compact layer of silty soils. URETEK believed that the tank could be supported if the intervening saturated layer was stabilized down to this denser layer. The plant's use of the tank while stabilization occurred was considered beneficial, as the continued loading and unloading of the liquid weight would assist in the densification process.

Methodology: Two pre-injection penetrometer soil density tests were taken at the storage facility location, the first one (P1) was located at the northeast location of the floor pad, and the second (P2) was approximately three feet inside the receiving room door. Both were driven into the ground at an angled position and were driven to a depth of 6-meters. The blow count readings at both locations ranged anywhere from 0 to 7 blows, representing very weak soil densities.

The initial injection plan called for injection locations to surround the storage tank, starting first on the south side to create a stable bench within the foundation soils, and also to support the tank when the north side bond with the processing wall was released. All sides including the west and east sides were injected at the 6-foot depth.

By the end of the first day, a total of 13 of the 15-tank foundation pad injection probes had been injected to the six-foot depth. Once completed, it became immediately apparent that the soft soils would accept a considerably larger amount of material than originally calculated for the project. After a subsequent planning meeting, it was decided to continue with the original injection plan anticipating that the next round of injections at the 9-foot depths would require less polymer material since it would be socketed into the medium dense layer of supporting soil. And indeed, this proved to be the case as the injection process continued (See Figure 7).

Figure 7: Food Storage Tank Injection Pattern (Top View)



On the following day, injection probes were placed at the 9-foot depth, but URETEK was forced to back off to an 8-foot depth when hard resistance was encountered. This was a positive sign for the project. While injecting the last holes at the northeast corner of the pad, the monitoring laser levels showed a 2mm lift on the processing room wall and the north pad, and a corresponding 2mm drop on the receiving room wall, indicating a fulcrum moment shift of the load.

Then the crew installed injection probes (#'s 20, 21, and 22) that were angled under the receiving room's south wall to a depth of six-feet. Even though the underlying sands and gravels were very loose and wet at that depth, the receiving room wall cracks were soon closed during this injection sequence.

Validation: The following day, the post penetrometer test (P2) was conducted under the receiving room wall, close to the original test location. The post P2 test was terminated at 1.5 meters (5 feet) with blow counts registering 350 blows per 10cm[2]! The preliminary test had shown single digit blow counts to this same area.

The post-injection (P1) penetrometer test at the northeast corner of the tank pad was conducted with similar results. The test was terminated at 1.9 meters (6.2 feet) with blow counts of 347 blows per 10cm. The preliminary tests originally conducted over the same area showed counts of 6 and 7 blows per 10cm at this depth. These post penetrometer tests showed a dramatic increase in the density of the foundation bearing soils. At this point URETEK considered the deep injection project to be complete.

The client has continuously monitored the tank structure levels over the last four years. No further settlement has occurred.

2 - A normal post-injection penetrometer reading would register from 30 to 50 blows

About URETEK

URETEK puts customers in control of their pavement lifting and soil stabilization problems, reducing repair cost, time, and disruption, through proprietary, safe, predictable products, people, and methods. Since 1989, with over 75,000 successful worldwide jobs, URETEK focuses on resolving complex concrete lifting and soil stabilization projects.

For more information about URETEK and the URETEK Deep Injection Method, please visit our website at www.worldofuretek.com or call 1-888-287-3835.

URETEK

13900 Humble Road
Tomball, TX. 77377
www.worldofuretek.com
888-287-3835