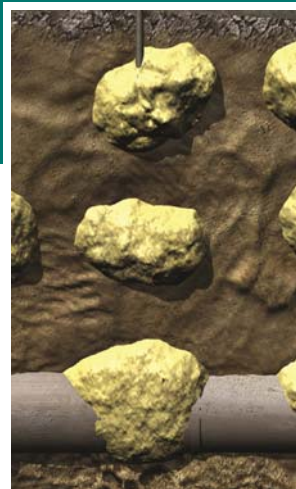
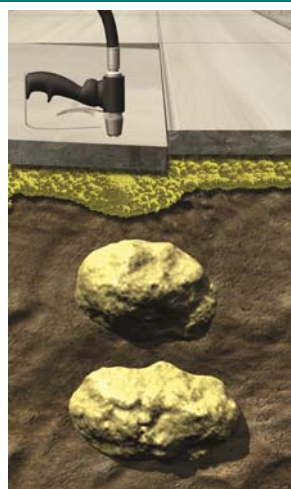
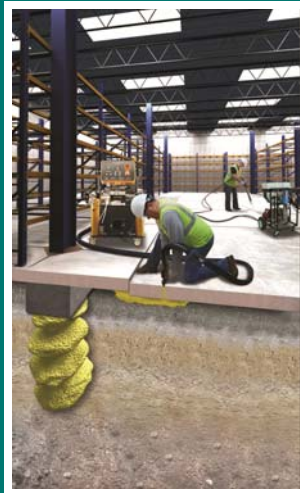


BEFORE LIFTING: Eliminate the Cause

White Paper: Contractor Productivity Series

Written: Spring 2011



Developed by **Scott Kelly**
Technical Consultant
Prime Resins, Inc.
2291 Plunkett Road
Conyers, GA 30012-3433
www.primeresins.com
800-321-7212

Introduction:

There are many things to consider when you are faced with a concrete settlement issues. The condition of the concrete is first and foremost important. If aesthetics are important and the concrete is cracked, or badly eroded with exposed aggregate you may be better off replacing the slab. On the other hand, if you have a relatively unscathed slab of concrete or if you intend to cover the slab with another floor system like carpet wood or other...you should definitely consider slab jacking.

You must also consider what has caused the settlement. You can spend a lot of money addressing the symptom which is slab settlement and never really fix the cause of the settlement. More on this later.....

There are many advantages to raising your existing concrete slab (or "Slab Jacking") versus tearing it out and replacing it.

1. The process is quick and easy. Typically you will not have to remove landscaping or existing machinery and equipment. Most slab jacking projects are completed in one day.
2. The slab jacking process will actually strengthen and stabilize the slab. Voids allow water to travel under the slab and leads to erosion. The process of raising the slab will eliminate voids and densify supporting soils.
3. Third, the cost to jack the slab should be about one third of the cost to remove and replace. This takes into consideration the cost of removal, disposal, prepping the sub-grade, actually pouring a new slab at grade, waiting for it to cure, reinstalling machinery or equipment and replacing landscaping.

All this means less mess and inconvenience and overall minimal loss of use of the slab. In manufacturing and distribution settings these factors are the true cost of performing the repair.

Polyurethane vs. Cement Slurry

Conventionally, cement based slurries have been used for slab jacking applications. In recent years advances in polyurethane chemistry and application techniques have made these products cost effective and suitable for these applications.

One of the most notable advantages of high density polyurethane foam is weight. Cement based slurries weigh between 120 and 150 lbs. per cubic foot. This additional weight on already unstable supporting soils can lead to resettlement of slabs or foundations. High density polyurethane foams used for slab jacking or soil stabilization applications weigh between 3.5 to 7 lbs. per cubic foot and are capable of generating strengths of well over 14,000 psf. The light weight of the foam places very little additional weight on supporting soils under the structure or slab.

Another major advantage of polyurethanes over cement based slurries is they do not shrink during or after cure. This helps ensure intimate contact with the slab and supporting soils remain constant, no voids form that could allow movement in the slab or water to collect leading to freeze/thaw degradation or erosion.

Material set time determines how quickly the slab can be placed back in service. High density polyurethane foams set in minutes vs. hours to days for cement based slurries.

Due to the low viscosity (flow ability) of polyurethanes you can inject the foam grout using much smaller holes (3/8") than cement based slurries (1.5" +). Smaller holes mean smaller drilling equipment, less expense and higher production. Less dust is generated which means less environmental impact, less mess and you can work easily around dust sensitive equipment.

Because the equipment and materials necessary for polyurethane injection is contained in a single unit with up to 410 feet of hose reach possible, you are able to get into small heavily populated areas with little or no disruption to normal operations.

High density polyurethane creates less waste material than conventional cement slurry grouts. Production stops when you release the trigger. Any remaining materials are kept in the spray system for the next use. Less waste equals less time cleaning equipment and disposal expense.

Environmentally speaking polyurethane foam is 100% inert after cure and poses no threat to adjacent waterways or groundwater.

Temperatures below freezing are a major limiting factor when working with cement based slurries. Polyurethanes can be used in almost any climate, due to process equipment capable of heating the components efficiently.

You can achieve precise control with high density polyurethane foams due to their rapid expansion and set times. Through metered interval injection techniques the slab is raised slowly and in complete control of the installer.

Comparison Table: Cement Slurry Vs. Polyurethane

Comparisons:	Cementitious	Precision Lift
Unit Weight	150 PCF	3.5 – 7.0 PCF
Material Set Time	Hours to days	Less than an hour
Impact on Existing Subsoil	Increases overburden stress	Minimal stress
Size of Injection Hole	2" +	3/8"
Preparation of Material Onsite	Mortar mixers, dust control	Material stored in trailer
Clean Out	Wash-out area on site	None required
Shrinkage	Yes (Relative to water)	None
Groundwater	Affects grout composition	Not affected
Equipment	Multiple large trucks and machinery, additional trucks for transporting raw materials.	Single self contained unit houses materials, hoses and equipment.
Mobility	Multiple large trucks and machinery, additional trucks for transporting raw materials.	Up to 410 feet of hose with standard equipment.
Waste Material	Mixers, pumps and hoses have to be flushed with water. Left over material has to be disposed of.	Minimal waste material. Pumps and hoses remain charged with material safely until next use.
Environmental Impact	Dust Noise from large machinery	Inert after cure Less waste

Comparisons:	Cementitious	Precision Lift
	Waste Disposal	Does not generate dust
Temperature	Limited use below 32 degrees	No limits –Can be installed in almost any climate
Precise Control	Less control of lift can lead to slab fracturing or over lift. Inconsistency from one batch to the next.	Precision control to within 1/8 inch. Consistent production.
Less Intrusion	Work can take days/ months. Dust sensitive equipment must be protected or removed.	Work completed in hours/ days. Dust sensitive computers and equipment can be left in place.

Stabilize Before Lifting – Causes of Settlement

Settlement destroys the integrity of concrete slabs and foundations. The root causes are often poor compaction of fill materials, erosion, high water content (shrink and swell cycles), decaying organic materials or freeze thaw cycles.

Soil Types – Engineering

Geotechnical engineers classify soils according to their engineering properties. It is best to consult a local geotechnical engineer who is familiar with the area, soil types, and characteristics.

Classification systems predict properties & behaviors of soils. Geotechnical Engineers employ soil boring or sampling techniques, penetrometer testing, moisture analysis, and sieve analysis to determine the properties of soils.

Unified Soil Classification System is used in engineering and geology disciplines to describe the texture and grain size of a soil.

Symbol	Definition
G	Gravel
S	Sand
M	Silt
C	Clay
O	Organic

Letter	Definition
P	Poorly graded (uniform particle sizes)
W	Well graded (diversified particle sizes)
H	High plasticity (Easily changes shape)
L	Low plasticity

For example: GW = Well graded gravel.

Types of Soil Stabilization Grouting

Permeation Grouting / Sandy Soils or Permeable Soils

Permeation grouting is typically defined as the flow of a low-viscosity grout into the pores of the soil without displacing or changing the soil structure. The characteristics of the ground are modified with the hardening or gelling of the grout. Permeation grouting serves two purposes, to increase the strength and cohesion of granular soils, and to decrease the permeability of the soil.

Prime Flex 910, Prime Flex 920, and Prime Flex Hydro Gel are ideal for permeation grouting applications. Permeation grouting is done by driving small diameter pipes or “probes” into the ground to a predetermined depth. The chemical grout is then injected in predetermined volumes as the pipe is raised or jacked out through the zone of influence. Spacing the probes is determined by the permeability of the soils, the moisture content, void content and the desired load carrying requirements for the zone. Probes are normally laid out in a grid, one row offset to the adjacent row to form a triangular pattern.

Types of Polyurethanes for Permeation Grouting

Single Component Polyurethane foam.

Prime Flex 910

Prime Flex 910 is an ultra low viscosity single component hydrophobic polyurethane injection resin. This resin requires a catalyst before injection. The amount of catalyst regulates reaction time & expansion. Permeation grouting applications normally use very low catalyst amounts to extend the fluid state during injection which increases penetrations into soils.

Ground water or moisture activates the chemical reaction and initiates stage two of the process in which the chemical grout expands encapsulating more soil and finally curing into a solid mass.

The influenced soils are effectively glued together in non-permeable closed cell foam mass and generate strengths of over 600 psi.

Prime Flex 910 is suitable for the following applications:

- Permeation grouting
- Void filling
- Slab under-seal
- Cutting off gushing leaks
- Curtain wall grouting

Single Component Polyurethane Gel

Prime Flex Hydro Gel SX

Prime Flex Hydro Gel is injected with up to 10 parts water to 1 part resin. This mixture creates a low viscosity non-expansive mixture that permeates loose soils.

Soil particles engulfed by this mixture are immobilized after cure.

Common applications:

- Curtain-wall grouting to cut off ground water movement.
- Permeation grouting to immobilize fill materials adjacent to excavations.
- Sealing leaks in below grade structures, particularly brick structures with multiple mortar joints.

Compaction Grouting

Compaction grouting is a process by which rapidly expanding polyurethane foam (fully expanded in 30-60 seconds) is injected into the ground. The foam fills voids in the immediate area and compacts the surrounding soil using expansive pressure. The bearing capacity of the soil is increased as a result of the placement of the high strength foam.

Fracture Grouting

Injection pump pressure and the expansive forces of the expanding polyurethane grout fractures zones in the soil and forms intertwined lenses or fingers of grout resulting in improved bearing capacity. Compaction grouting with polyurethane grout foam usually results in fracture grouting.

Dual Component High Density Foam

Precision Lift 3.5 lb. = 60 psi

Precision Lift 4.75 lb. = 100 psi

Dual component high density polyurethane foams are available in various formulations and can yield strengths up to 10,000 psi. These foams are not reliant on water to initiate the chemical reaction. They consist of an “A” component or “Isocyanate” and a “B” component or polyurethane.

Variations in the formulation can expedite the reaction time to under ten seconds for slab jacking applications or slow the reaction for void fill and stabilizations applications where lifting is not desirable.

Dual component high density foams are classified typically by their weight per cubic foot of unrestricted foam. Example: Precision Lift 3.5 # foam weighs 3.5 lbs. per cubic foot when it is allowed to expand without restriction.

Steps to Slab Jacking

Once you have stabilized and consolidated the sub-grade, it is time for the Precision Lift process. Rapidly expanding foam is injected through small diameter holes directly beneath the slab in short bursts. By speeding up the reaction with heat and by controlling the amount of material that goes in beneath the slab, you are able to precisely control how much the slab is lifted. This procedure requires specialized equipment and a well trained technician. Precision Lift products are designed specifically for this task.

Preparatory steps to Slab Jacking with Polyurethane

1. Locate buried utilities

Any time you are working below grade it is a must to know precisely where any buried utilities are. Drilling through buried electrical lines or gas lines can yield catastrophic results and death. Drilling into buried sewer or water lines can result in foam filling and plugging those lines.

2. Protection of Adjacent Structures

A quick application of lightweight plastic can save hours of needless cleanup.

3. Material preparation

One benefit of working with polyurethane equipment is the ability to precondition or heat your materials on the way to the job site. This is possible due to all of the equipment being strategically housed in a single mobile unit.

4. Check for obstructions

You must ensure that the slab you intend to raise is free and independent from adjacent slabs or foundations.

5. Saw cut joints – If necessary

If obstructions are located you must saw cut or remove the obstruction.

6. Drill 3/8" hole patterns

Your hole pattern is dependent on the amount of amount of lift necessary and the thickness of the slab. Thin profile slabs require more frequent holes to increase the lift over the maximum amount of square inches. This helps prevent overstressing the slab which can lead to cracking. Thicker heavily reinforced slabs can be lifted with fewer holes due to the additional strength of the thicker concrete profile and steel reinforcement.

7. You are ready to begin injection.

Detailed Instructions

1. Beginning at the lowest point of the slab, inject polyurethane in 5 – 10 second shots, longer shots may be necessary for larger voids. The idea is to fill the void in the immediate area of your injection hole. The pause between shots should not exceed 5 seconds. Your objective with pausing is to allow for the foam to partially expand and fill void so that subsequent shots are restricted and the hydraulic effect of the expanding foam is expedited.
2. Once voids are filled beneath the slab the expanding foam will form a hydraulic lift and begin to raise the slab. Think of this as building layers of a cake. Each layer compresses the supporting soils and produces more lift to the slab. As the slab is raised shorter injection shots can be used and shorter intervals to fine tune the slab to the perfect elevation.
3. Use multiple injection points to evenly distribute the lift. Thinner slabs require more frequent injection holes and less lift from each hole to reduce stress to the slab.
4. It may be necessary to inject holes multiple times. Raise the slab in short increments and reuse existing holes.
5. Holes previously injected will have to be re-drilled. Be sure to penetrate the foam layer under the slab. You must make sure you have an open pathway to the interface between the soil and the last layer of foam.

Packaging

Single component polyurethanes for permeation grouting are available in 5 gallon pails, 50 gallon drums and 300 gallon totes. High density polyurethane foams are available in 100 gallon drum sets or 660 gallon tote sets.

Necessary Equipment

- Self Contained Trailer or Truck Mounted Rig
- Air Compressor 20 – 35 cfm
- Generator 20kw – 60kw
- Proportioner - PMC Classic GH25
- Heated Hoses
- Air drying system
- Impingement Gun
- Transfer pumps
- Hammer Drill and Bits
- Laser Level & String Lines
- Concrete Saw
- Dial Indicator

Safety Considerations

Personal

Personal protective clothing and equipment are a must when working with any material injected under pressure. These personal protection items are not extraordinary to other common construction process.

Eye Protection –safety glasses and full face shield.

Clothing that covers sensitive skin.

Boots

Gloves

Property

Sensitive equipment or surfaces should be draped in light weight polyurethane plastic. This is a sure fire issue of a little prevention will save hours of cleanup should you have an accidental spray of foam or should foam escape rapidly (known as refusal) during injection.

