White Paper

The process of raising and stabilizing concrete slabs with HMI dual component polyurethane foams.

HMI™

World Leading Manufacturer of Concrete Lifting Equipment, Training, and Material.

RR 201 RR 401 RR 401G RR 501 RR 601

The purpose of this white paper is to explain the underlying issues that cause concrete to settle and how the HMI approach to concrete raising is the best solution to remedy these issues and bring concrete back to its intended elevation.

Why does concrete settle?

The stability of a concrete slab is directly proportional to the quality of the base on which it is poured.

Poor base conditions can be attributed to:

Poor or improper compaction of the base: Failure to properly compact base materials before pouring can lead to hastened settling. The weight of the slab will further compact the base after curing, and settlement can happen quickly.

Climate: The freeze and thaw cycle experienced in many regions causes the ground underneath the slab to expand when frost is present. This in turn will cause slabs to heave or raise. When the frost melts the slabs will settle and most often not to their original elevation. Slabs may become uneven resulting in trip spots. Drought often causes soil, such as expansive clays to shrink causing settling issues for concrete slabs. When expansive clay soils encounter wet conditions, they may swell leading to shifting concrete that needs leveling.

Erosion: Many different factors can lead to eroded base materials under concrete. Damaged water lines or sewer lines can lead to washout of base materials causing slabs to settle. Improperly placed downspouts can cause pooling of water, which can lead to erosion.

Machine/Traffic Vibrations: Concrete slabs may move or settle in industrial/highway settings where movement and heavy loads are present. The vibrations from the machinery and passing traffic can lead to the base compacting and the slabs settling or slab movement.

Slab Curl/Rocking Slabs: Slab curl occurs when a relatively large section of concrete is poured. During the curing process, the top of the slab may cure slightly faster. This leads to slabs that curl and may rock and become unstable. Vibration may also cause slabs to eventually settle.

What can be done with settled concrete?

Nothing: Settled concrete is an issue that needs to be addressed, not only from an aesthetic standpoint, but most importantly from a liability standpoint. The Americans with Disabilities Act (ADA) of 1990, defines a 'trip hazard' as any vertical change of over 1/4 inch or more at any joint or crack. Since the ADA demands strict compliance, trip hazards represent a legal liability to clients. Cities, school districts, hospitals, private communities, shopping malls, universities, apartment complexes, and other property owners are all extremely concerned with this liability.

Grinding: This is an inexpensive option that is unattractive. Grinding exposes aggregate in the concrete which makes this unappealing. The integrity and strength of the slab is also compromised when using this method. Slabs that continue to settle after grinding cannot be raise back to original levels.

Replacement: This option is the most expensive option. It is also very time consuming. This method may lead to downtime for businesses, loss of productivity, and lost revenues. The fnished colors of the new slab will not match existing adjacent concrete.

Raising & Stabilizing: This may be done with traditional mudjacking or cementitous grouting. This process utilizes a hydraulically powered pump to install a slurry mix under the slab with enough pressure to compact weak soil underneath and raise the slab. Water, fly ash, top soil, sand, clay, agricultural lime, and cement are materials used to create these slurries. This method, when used on subgrade that has already settled, adds excessive weight and may lead to resettling.

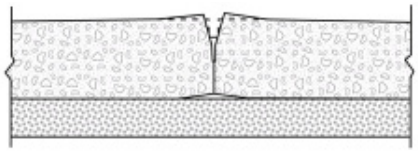
Raising and Stabilizing-Polyurethane Foam: With HMI polyurethane, the HMI method for concrete raising utilizes the slab itself as a means of delivering raising, void filling, and stabilizing foam. A 5/8" hole is drilled through the slab into the subgrade. A tapered delivery port is then installed in the 5/8"hole. The injection equipment, which delivers the dual component polyurethane material, is then connected to the port. Material is then injected through the port and under the slab. Expansion of the material occurs within seconds, compressing loose soils and raising concrete.

Raising concrete with polyurethane foam is done with controlled incremental injections. Lifting foam will fully expand within 10-15 seconds. This allows the applicator to monitor the raise and prevents over raising the slab. HMI suggests using air purged equipment to deliver foam under the slab. This equipment will keep the injection port open between injections, allowing for the installer to wait for foam to fully expand before injecting more material.

Injection Equipment: HMI patented EliteONE injection gun has revolutionized concrete raising with foam. This patented design allows the applicator to install material into a delivery port multiple times. This eliminates the need for excessive hole drilling and saves time. The EliteONE merges mechanical and air purged technology, it is the first ever injection tool designed specifically for concrete raising by HMI.

Void Filling: Concrete settling is not the only issue that HMI Foam can solve. Voids under slabs are often present in areas where wash out or excessive settling can occur. HMI material will weigh on average 15-25 times less than a traditional mudjacking or cementitious grout mix. This lightweight material will put less stress on an already failed subgrade. The process of drilling, port installation, and injecting the material is the same as the raising process. All dual component polyurethane foams create heat when installed. Void fills must be done in a layering method to allow heat to dissipate safely. HMI issues a Stewardship manual to all dual component polyurethane customers. This manual covers safety precautions that must be observed when injecting dual component polyurethane foams.

Joint/Slab Stabilization: Slab stabilization is often required when slabs lack support, but may or may not be settled. Slabs can crack when loads exceeding its capacity are applied . Slab/joint stabilization applications require the voids be filled to eliminate slab movement and offer support.



HMI foam specifically designed for joint/slab stabilization has a very long reaction time and minimal expansion strength. It will take longer to expand, allowing for better coverage under the slab or down a void along a joint.

The process of raising concrete with HMI foam is inexpensive when compared to replacement. It is also exponentially faster than the replacement method. Repaired areas are ready within minutes to be utilized, as they were intended to be. Ease of process, material and clean up are advantages over traditional mudjacking repairs made with grout.

HMI Concrete Raising Material

Why is HMI foam different? HMI is the ONLY company that makes polyurethane foam from recycled material. HMI manufactures an environmentally friendly, dual component polyurethane foam for raising and stabilizing concrete. Our patented materials (U.S. Provisional Patent Application No. 61/583,295) are made from recycled components, making it the "greenest" polyurethane foam on the market. Available in 2, 4, 5 and 6 lbs. per cubic foot density (free spray). HMI has developed this revolutionary new foam that is setting new standards in polyurethane foam quality. ASTM tested, this recycled material is the best foam available for raising and stabilizing concrete. Each foam is specifically designed for applications such as lifting, high density lifting, stabilization, and undersealing. Formulating with recycled foam, offers the advantage of using super charged raw materials that have already been quality foam. Recycled foam provides benefits like fast tact free time and a high compressive strength skin that avoids concrete adhesion and adds strength. Fast and aggressive expansion for lifting concrete, along with a 15 minute final cure time, allows for slab manipulation while adjusting for the perfect lift.

Fact: It takes less than 7 PSI to raise a standard slab of concrete. The PSI reported in ASTM D1621 for compressive strength is equivalent to the PSI force applied when the foam expands.

RR201 is a 2.5 lb. per cubic foot density foam that was developed to have a fast reaction time and good spread. This offers more control when lifting slabs of concrete. Designed to mimic the speed of traditional hydraulic mudjacking material/process, this is the first HMI foam specifically for residential polyurethane concrete raising.

RR 201

Density ASTM D1622	
Average (lbs./ft³)	2.50 – 2.99

Compression Properties ASTM D1621	
Modulus (psi)	525
Proportional Stress (psi)	20.9
Proportional Elongation (%)	4.3
Crushing Strength Stress Avg. (psi)	32.4
Crushing Strength Elongation (%)	16.2

Tensile Properties ASTM D1623	
Modulus (psi)	1147
Breaking Strength Stress Avg. (psi)	42.4
Breaking Strength Elongation (%)	5.2

Shear Properties ASTM C273	
Modulus (psi)	147
Proportional Stress (psi)	8.7
Proportional Elongation (%)	6.9
Breaking Strength Stress Avg. (psi)	11.0
Breaking Strength Elongation (%)	15.3

Open Cell Content ASTM D2856	
Closed Cell Content (%)	86.18

HMI Testing	
Time at Reaction (mm:sec)	00:10
Peak Exotherm (°F)	247
Time at Peak Exotherm (mm:sec)	00:24
Time at Tack Free (mm:sec)	00:18
Time at Peak Expansion (mm:sec)	00:32

Water Absorption ASTM D2842	
Water Absorption (Vol. Basis) (%)	0.8
Water Absorption (Area Basis) (lb/ft²)	0.026
Water Absorption (Weight Basis) (%)	11.3

RR401 is a 4 lb per cubic foot foam that was developed to be .a stronger foam with the ability to lift large slabs. Perfect for highway/ roadway slabs and factory floors. The durability of this foam will stand up to heavy loads and high traffic areas. RR401 meets and exceeds specifications required by DOTs for lifting highway slabs and bridge approaches.

RR 401

Density ASTM D1622

Average (lbs./ft³)	4 – 4.5

Compression Properties ASTM D1621

Modulus (psi)	2300
Proportional Stress (psi)	100
Proportional Elongation (%)	6.0
Crushing Strength Stress Avg. (psi)	121
Crushing Strength Elongation (%)	9.2

Tensile Properties ASTM D1623

Modulus (PSI)	5680
Proportional Stress (psi)	208
Proportional Elongation (%)	5.4

Shear Properties ASTM C273

Modulus (PSI)	343
Proportional Stress (psi)	29.6
Proportional Elongation (%)	20.7
Breaking Strength Stress Avg. (psi)	39.4
Breaking Strength Elongation (%)	44.4

Open Cell Content ASTM D2856

Closed Cell Content (%)	>90

HMI Testing

Time at Reaction (mm:sec)	00:19
Peak Exotherm (°F)	273
Time at Peak Exotherm (mm:sec)	00:29
Time at Tack Free (mm:sec)	00:27
Time at Peak Expansion (mm:sec)	00:35

Water Absorption ASTM D2842

Water Absorption (Vol. Basis) (%)	0.55
Water Absorption (Area Basis) (lb/ft²)	0.13
Water Absorption (Weight Basis) (%)	6.4

Response to Thermal and Humid Aging ASTM D2126

Change from Initial Volume (%)	0.30

HMI's RR401G is a gas blown version of the RR401 that is a 4 lb. per cubic foot density foam. It has hydro-insensitive qualities, making it ideal for use in wet conditions. RR401G uses gas as a blowing agent instead of water, allowing the presence of water in the soil to not affect the foam reaction, cure time or performance.

USDA CERTIFIED BIOBASED PRODUCT
PRODUCT 46%

Hydraulic Mudpumps, Inc. (HMI) Earns USDA Certified Biobased Product Certification and Label

Manitowoc, WI. (May 10,2016) — Hydraulic Mudpumps, Inc. (HMI) has earned the USDA Certified Biobased Product Label for its RR 401GB. The USDA Certified Biobased Product Label verifies that the product or product family's amount of renewable biobased ingredients meets or exceeds levels set by USDA. Biobased products are finished or intermediate materials composed in whole or in significant part of agricultural, forestry, or marine ingredients.

RR 401G

Density ASTM D1622

Average (lbs./ft³)	4 – 4.5

Compression Properties ASTM D1621

Modulus (psi)	1982
Proportional Stress (psi)	92
Proportional Elongation (%)	6.8
Crushing Strength Stress Avg. (psi)	121
Crushing Strength Elongation (%)	15.5

Tensile Properties ASTM D1623

Modulus (PSI)	5322
Proportional Stress (psi)	307
Proportional Elongation (%)	4.3

Shear Properties ASTM C273

Modulus (PSI)	494
Proportional Stress (psi)	25.3
Proportional Elongation (%)	20.0
Breaking Strength Stress Avg. (psi)	49.4
Breaking Strength Elongation (%)	64.0

HMI Testing

Time at Reaction (mm:sec)	00:16
Peak Exotherm (°F)	257
Time at Peak Exotherm (mm:sec)	00:25
Time at Tack Free (mm:sec)	00:26
Time at Peak Expansion (mm:sec)	00:27

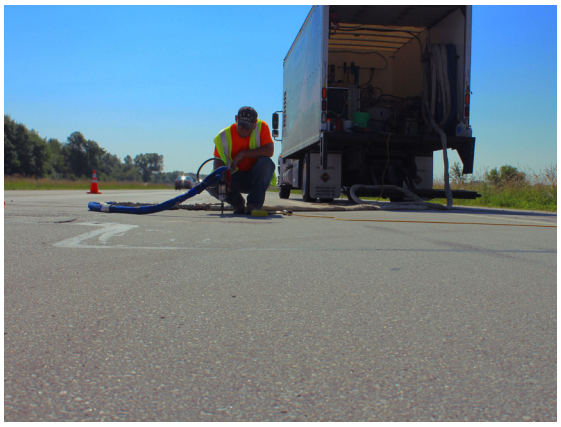
Water Absorption ASTM D2842

Water Absorption (Vol. Basis) (%)	0.39
Water Absorption (Area Basis) (lb/ft²)	0.09
Water Absorption (Weight Basis) (%)	3.9

Response to Thermal and Humid Aging ASTM D2126

Change from Initial Volume (%)	0.46

RR501 is a 5 lb. per cubic foot density foam. It was developed to have a slower reaction time to allow the material to spread further. Because of the distance the material can travel, RR501 is ideal for undersealing and stabilizing joints on rocking slabs. The foam is formulated for stabilization, not lifting.



RR 501

Density ASTM D1622

Average (lbs./ft³)	5

Compression Properties ASTM D1621

Modulus (psi)	3489
Proportional Stress (psi)	78.7
Proportional Elongation (%)	2.5
Crushing Strength Stress Avg. (psi)	112.4
Crushing Strength Stress Peak (psi)	114.9
Crushing Strength Elongation (%)	5.1

Tensile Properties ASTM D1623

Modulus (PSI)	5025
Proportional Stress (psi)	123.6
Proportional Elongation (%)	3.0
Breaking Strength Stress Avg. (psi)	123.6
Breaking Strength Elongation (%)	3.0

Open Cell Content ASTM D2856

Closed Cell Content	86.1 ± 1.1%

Shear Properties ASTM C273

Modulus (PSI)	254
Proportional Stress (psi)	44.3
Proportional Elongation (%)	17.6
Breaking Strength Stress Avg. (psi)	82.5
Breaking Strength Elongation (%)	62.7

HMI Testing

Time at Reaction (mm:sec)	00:53
Peak Exotherm (°F)	302
Time at Peak Exotherm (mm:sec)	01:26
Time at Tack Free (mm:sec)	01:21
Time at Peak Expansion (mm:sec)	01:45

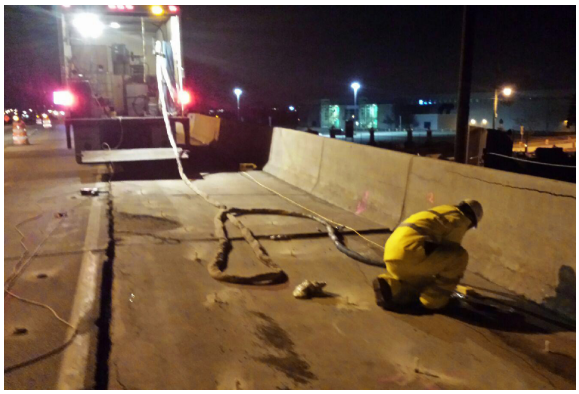
Water Absorption ASTM D2842

Absorption by Volume (%)	0.06

Volume Change ASTM D2126

Change from Initial Volume (%)	-1.47

RR601 is a 6 lb. per cubic foot density foam. It has been developed for infrastructure repair. The increased compressive strength of the foam is suitable for heavy loads and high traffic areas. This foam was formulated per request from DOT engineers for specialty applications.



RR 601

Density ASTM D1622

Average (lbs./ft³)	6.0-6.5

Compression Properties ASTM D1621

Modulus (psi)	2207
Proportional Stress (psi)	145.7
Proportional Elongation (%)	6.7
Crushing Strength Stress Avg. (psi)	193.6
Crushing Strength Stress Peak (psi)	292.1
Crushing Strength Elongation (%)	16.4

Tensile Properties ASTM D1623

Modulus (PSI) Proportional Stress	5072
(psi) Proportional Elongation (%)	138.4
Breaking Strength Stress Avg. (psi)	4.0
Breaking Strength Elongation (%)	138.4

Open Cell Content ASTM D2856

Closed Cell Content	89.7 ± 1.6%

HMI Testing

Time at Reaction (mm:sec)	00:15
Peak Exotherm (°F)	270
Time at Peak Exotherm (mm:sec)	00:25
Time at Tack Free (mm:sec)	00:23
Time at Peak Expansion (mm:sec)	00:23

Water Absorption ASTM D2842

Absorption by Volume (%)	0.04

Volume Change ASTM D2126

Change from Initial Volume (%)	+0.28

Liquid Resin Density

RR 601B #Gallon at Room Temperature	9.4
RR A #Gallon at Room Temperature	10.3
RR 601B #/Gallon at 100° F	9.2
RR A #/Gallon at 100° F	10.2

Material Characteristics

	Density ASTM 1622 (lbs./ft3)	Peak Compressive Strength ASTM 1621 (PSI)	Tensile Strength ASTM D1623 (PSI)	Time at Reaction (mm:sec)	Peak Exotherm (F °)	Time at Peak Expansion (mm:sec)	Time at Tack Free (mm:sec)	Time at Peak Expansion (mm:sec)
RR 201	2.5	43.2	63.8	0:10	255	0:24	0:18	0:32
RR 401	4	112.2	115.9	0:16	270	0:25	0:26	0:27
RR 401G	4	90	85	0:19	257	0:29	0:27	0:35
RR 501	5	114.9	123.6	0:53	208	1:26	1:21	1:45
RR 601	6.5	292.1	138.4	0:15	270	0:25	0:23	0:23

A Foam For Every Application

- Residential
- Factory/Warehouse
- Highway

Special Project? If you have a special application that requires a different reaction profile than the foams mentioned, please contact us at 800-626-2464. Our lab can work with you to create a foam for your special needs.

Did you Know?

HMI does not use Toxic Chemicals
Major toxic chemicals, often associated with some types of polyurethanes, such as some blowing agents, formaldehyde, benzene and toluene are NOT used in HMI foams.
Most of what is warned against on the Internet pertains to these chemicals.

As Safe as the Cushions you sit on!
The foam we install under ground is like the foam in your mattress and or in your couch. Instead of it being built in a factory, we make the foam directly under the slab. Instead of being light and fluffy it is firm and strong.

DIRECTLY FROM THE EPA
The EPA states that cured polyurethane is safe unless burned or ground into a fine dust.

ABOUT HMI – HMI, founded in 1974 is the world leader in: manufacturing equipment, system development and polyurethane material formulation for lifting and leveling concrete. HMI prides itself on training and provides unmatched customer support.
For more information visit www.hmicompany.com

Summary

HMI's process and material will provide long lasting repair to sunken or moving concrete slabs in need of lifting and/or stabilization. Our repair method has proven to be more cost effective for the customer and saves them time in completing their repairs. Time is of the essence, when considering commercial projects where productivity could be lost replacing slabs as opposed to the HMI process of raising them with polyurethane foam.

HMI has been providing quality concrete raising equipment and material since 1974. Our customers and our own contracting division, have performed hundreds of thousands of projects over the course of 40 years for satisfied customers. These encompass residential, commercial, industrial, and government projects involving small walk way slabs, factory floors, airport runways and highways. Over 40 years of concrete raising experience, gives HMI the insight to develop innovative products assisting those wishing to remedy concrete problems with polyurethane foam and equipment .

For more information about HMI's materials, equipment, and processes, please visit our website:

www.HMICompany.com

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