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THE EFFECTS OF UHP SURFACE PREPARATION ON CONCRETE MOISTURE LEVELS USING UHP WATER JETS

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ABSTRACT

This paper documents the removal of floor coatings from concrete surfaces utilizing UHP water jet tools. Traditional methods, including shot blasting and grinding, meet the required production rates, but may fail to remove all of the invisible contaminants. They can also introduce dust into the environment. This document further illustrates the testing performed providing data, which concludes that UHP water jetting with Vacuum Recovery, does not impart moisture into the surface concrete.

Earlier versions of water jetting equipment succeeded in addressing two main limitations of grit blasting, containment of media and contaminant removal, but failed to meet required removal rates. New systems are now available that combine the advantages of UHP water jetting into a system that can meet required removal rates with a single machine. Further, many believe that UHP water jetting introduces excessive moisture into the surface concrete thereby potentially causing failure of the coating. This document will prove otherwise.

1. INTRODUCTION

Water jets have been proven to have great potential for the repair and refurbishment of concrete (1) and have been used to clean and prepare concrete surfaces for over 30 years. Older generations of water jet pumps could not generate the pressures required to effectively remove coatings from concrete. To combat this, the operators would use high flows to perform the removal. Excessive amounts of wastewater were created, greatly limiting projects where water jetting could be used. It had further concern from the coatings industry in that the high volumes of water used ultimately saturated the concrete and working environment causing concern that new coatings which were to be applied could fail prematurely due to excessive water moisture in the concrete surface.

UHP water jetting has now revolutionized the surface preparation process. Pumps with pressures to 40,000 psi (2,800 bar) can now remove almost any coating using flows as low as 3 GPM (11.4 lpm). This high pressure/low flow combination makes containing the wastewater a much easier process. Additionally, many tools have been developed that utilize vacuum recovery, making UHP water Jetting a viable concrete floor surface preparation process. In fact, the combination of UHP water with vacuum recovery tools has proven to remove coatings without increasing the surface moisture level of the concrete.

2. SHOT BLAST AND GRINDING METHODS SURFACE PREPARATION OF CONCRETE

2.1 Traditional Methods

One of the most common methods for removing floor coatings is shot blasting equipment. There are a number of variations of this type of machine, but they generally are self-propelled, electric powered machines that use paddle type devices to accelerate steel shot and direct it towards the surface to be cleaned. Once the steel shot impacts the surface, a vacuum system is employed to recover the shot in order for it to be recycled.

2.2 Problems Associated with Traditional Methods

One of the biggest problems with shot machines is the shot itself. Shot can escape at a high velocity and can roll across the floor and end up in adjacent areas where re-coating is occurring. The shot becomes encapsulated in the coating and creates a point of possible coatings failure (figure 1.).

Shot blasting and grinding/scarifying also fail to completely remove invisible contaminants from the concrete surface. These “Contamination Cells” can also lead to coating failures. In addition, grinding and scarifying create dust.

3. USING UHP WATER JETTING FOR FLOOR SURFACE PREPARATION OF CONCRETE

3.1 Advantages of Water

UHP water is an excellent method for removing floor coatings. Not only does it eliminate many of the maintenance concerns surrounding alternate methods; it more importantly eliminates many of the problems. Spent media (water) is easier to control than steel shot, and reclamation efforts are much more successful. Water jetting exposes the aggregate in the concrete, and has been proven to provide an excellent surface quality and bonding surface (2) for the new coating system (figure 2). When abrasive blasting, jack hammering, and water jetting methods of surface preparation were compared, the percentage of surface interference failure for each of the listed methods is 38%, 31%, and 7% respectively (2). In addition, UHP water has been proven to remove invisible contaminants from the surface, eliminating one of the main causes of coatings failure (3). Water jetting with UHP water does not disrupt other nearby work and it does not create dust.

3.2 Advances in the Technology

The most common systems for removing coatings from horizontal surfaces are semi-automated tools (figures 3 and 4).

The most common semi-automated systems typically resemble a lawn mower. An operator pushes the device over the surface while rotating nozzles apply the water. This rotating motion assures an even application of the water. Standoff distance (the distance between the nozzle and the surface being cleaned), traversing speed, nozzle rotation speed and nozzle size can be fine tuned to control the degree of removal. Extensive testing has shown that varying each of the above listed parameters has a specific effect on the profile created. (4).

3.3 Automated Systems

Automated coating removal systems are now available and provide major advancements in productivity over previous systems (figure 5). These devices utilize UHP water and provide production rates from 250 to 3000 sq./ft per hour (76 to 914 sq. /m). These improvements in production have been made possible through a number of advancements:

3.3.1 Control of Nozzle Rotation Speed

Control of nozzle rotation has proven to be a major contributor to improved production rates. Operators are now able to speed up or slow down nozzle head RPM, which provides superior control over nozzle dwell time (the amount of time the water jet is impacting a point on the surface). This makes it possible to perform adjustments during the process and match dwell time to coating thickness.

3.3.2 Traversing Nozzle Head

The first generation of systems to utilize UHP water were simple devices that provided only a single axis of movement. New systems not only traverse backwards, but can index the nozzle array from side to side allowing for up to an 85" cleaning path (figure 6).

3.3.3 Vacuum Recovery Technology

Maintaining a positive vacuum seal is important as escaping water can create areas of excessive moisture. Advancements in vacuum seal technology have provided systems that not only gives superior seal life, but also create a vacuum seal which is unaffected by variations in the floor. Small depressions do not cause the vacuum seal to fail.

4. DOES WATER JETTING A CONCRETE SURFACE INCREASE IT'S MOISTURE CONTENT?

4.1 The problem with Water Moisture

Over the years there has been a great deal of controversy surrounding this subject. Until recently, very little testing had been accomplished attempting to prove or disprove the theory that the use of UHP tools do, or do not increase the moisture level in the concrete. Many argue that an increased moisture level may slow production rates while waiting for the concrete to dry for application of coatings. Others argue that excess moisture levels imparted by UHP water jetting can cause blistering, delaminating and other forms of coating failure.

4.2 Criteria For Testing

In order to determine if UHP water jetting tools have an impact on concrete moisture levels a controlled testing environment and procedure needed to be generated.

It was determined that the test needed to be conducted on smooth, clean concrete. It was further determined that the test needed to be conducted on a day when weather conditions dictated that neither temperature extremes nor relative humidity levels would influence the testing. Our ideal conditions then were set for a sunny day with a temperature of 75 degrees Fahrenheit and a relative humidity of 50%.

The test zones were set up into four (4) sections.

Zone 1: The first section was to be our "benchmark" or "constant" for the day, see "Figure 9". This zone was used to allow the concrete moisture content to be tracked throughout the testing time frame to verify that environmental conditions did not influence the testing as the day went on.

Zone 2: The second zone was established as our testing section for UHP water jetting with full vacuum recovery. This zone was set for 6 gallons per minute with a discharge pressure of

40,000 psi. The tool used had full vacuum recovery capabilities providing 1,000 CFM at 8” of vacuum.

Zone 3: The third zone was established as the testing section for UHP water jetting without vacuum recovery. The intent of this testing area was to determine if the water jetted surface with vacuum recovery had less moisture at the end of the test, or, to determine if it dried out more quickly.

Zone 4: The fourth zone was established as our saturation zone. In this section the concrete was saturated with running water for a three-hour period. This section was also used as a benchmark to simulate saturation from precipitation.

4.3 Moisture Measurement

For this test, we researched the available market and elected to use an instrument specifically engineered and manufactured to measure concrete surface moisture. The specific tool used works on the principle that the electrical impedance of a material varies in proportion to its moisture content. The electrical impedance is measured by creating a low frequency alternating electric field between the electrodes on the instrument. This electric field penetrates the concrete under test. The very small alternating current flowing through the field is inversely proportional to the impedance of the material. The instrument detects this current, determines its amplitude and thus derives the moisture level.

This instrument was selected; as it was determined that it was the most sensitive to “residual” surface water.

4.4 Test Results

The testing took place with environmental conditions very close to the “ideal” conditions, which had been set previously. Actual conditions were 77 degrees Fahrenheit with a relative humidity of 55%. Other conditions were sunny skies with a light to variable wind at 3 miles per hour.

A moisture test was taken on all four zones. Fortunately, the test indicated a consistent moisture level across all four zones at 3.4%. During the tests conducted on Zones 2, 3, and 4, moisture levels on Zone one were continually taken to verify that the moisture level of the concrete was not changing through the course of the test. You’ll note from “Figure 9” that the moisture level did remain constant throughout the test at 3.4%.

Test #1 The first test was conducted on Zone 4. This zone was saturated with water for a period of 3 hours. At the end of this period moisture readings were taken as indicated on “Figure 9”. You’ll note that in this case, the saturated concrete surface was back to its previous moisture level of 3.4% after 35 minutes. In this case the light to variable wind combined with stable humidity and sunlight enabled the concrete to drop back to its original condition.

Test #2 The second test was conducted on Zone 3. This zone was water jetted using 6 gallons per minute at 40,000 psi. The tool used, known as a “SpinJet” passed over the surface, completely cleaning the surface within a time frame of approximately 7 seconds. No vacuum recovery was used. You will note from “Figure 9” that the test section dropped to 6% moisture content after 20 minutes and finally, back to it’s original condition of 3.3% after 25 minuets. You can see from “Figure 9” that while the surface was cleaned, the residual latent material is still present.

Test #3: The third test was conducted on Zone 2. This zone was water jetted using 6 gallons per minute at 40,000 psi. Full vacuum recovery was employed. Again, the “SpinJet” completely cleaned the surface within a time frame of approximately 7 seconds. You will note from “Figure 9” that the test section which originally had a moisture measurement of 3.4% had raised to 4.5% immediately after cleaning. After 1 minute the moisture dropped to 3.0%, and after 2 minutes, the reading dropped to 2.9% where it stabilized.

The results from Test #3 on Zone #2 raised questions regarding the original moisture content of 3.4% and the resultant test results of 2.9%. After a lengthy conversation with technical support engineering from the manufacturer of the concrete moisture meter we found our answer. The slight amount of “Iron” deposits which were present on the original concrete acted as a slight “conductor” for the tool.

Understanding this result, it was determined that the test should be conducted once again. This time, the “SpinJet” was to be passed over the clean surface area with no iron deposits present. Test #3 listed previously was repeated over the same surface area. The beginning moisture level was measured and documented at 2.9%. Once the test was completed, the concrete was immediately measured at 4.5% moisture content. After 1 minute the moisture had dropped to 3.1%, and after 2 minutes the moisture had returned to its original level of 2.9%.

5. OTHER APPLICATIONS

While floor coating removal has proven to be the largest application for systems of this type to date, there are a number of other potential applications. The same systems can be used for non-skid removal from steel ship decks, as well to perform light to heavy scarification of concrete surfaces (figure 7). Epoxies as well as rubber type waterproofing compounds and membranes (figure 8) can easily be removed at higher production rates than multiple shot blasting machines, eliminating multiple operators and the need for clean-up.

6. CONCLUSION

Advancements in water jetting technology, including increased operating pressures, traversing techniques and vacuum seal design have addressed many of the limitations of the first generation systems. These new tools have evolved to point that they can provide a viable solution for coating removal and surface preparation.

Further, it was determined that a water jetted surface using a vacuum recovery devise providing 6 gallons per minute at 40,000 psi does not impart any measurable increase in moisture levels into the concrete. In most cases, a water jetted surface may be coated immediately after cleaning has been done.

7. REFERENCES

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8. GRAPHICS

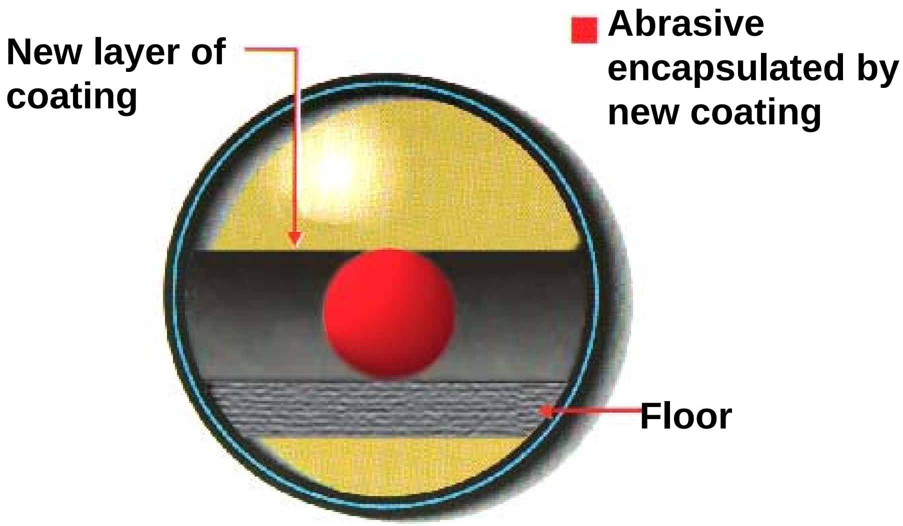


Figure 1. The abrasive material that remains on the floor compromises the new coating.

Figure 2. Water jetting exposes the aggregate in the concrete, proving an excellent bonding surface for the new coating system.

Figure 3. Semi-automated tools are the most popular for performing coating removal from concrete.

Figure 4. A second variation of the semi-automated tool is a crawler type device. This system has the added advantage of being able to do work on vertical surfaces.

Figure 5. Second generation coating removal systems combine the advantages of the original systems with new features that improve productivity.

Figure 6. Second generation systems not only traverse backwards, but can index the nozzle array from side to side allowing for up to an 85" cleaning path.

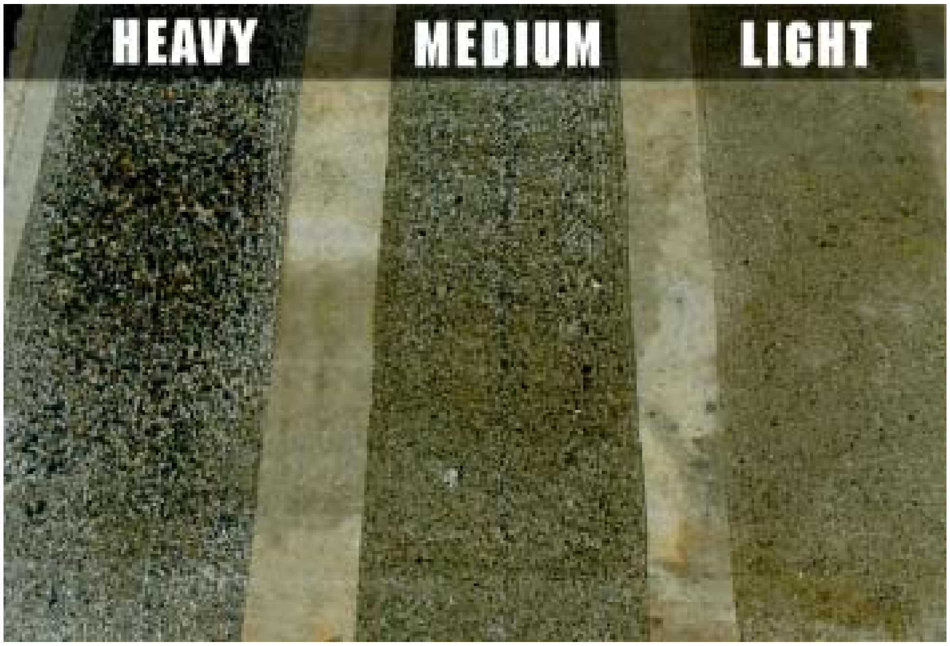


Figure 7. Additional applications include various levels of concrete scarification.

Figure 8. Membrane removal from a concrete surface.

Time In Minutes	ZONE #1 Base Concrete (% Moisture)	ZONE #2 SpinJet With / Vacuum Recovery (% Moisture)	ZONE #3 Spin Jet Without Vacuum Recovery (% Moisture)	ZONE #4 Water Saturation (% Moisture)	ZONE #2 RETEST SpinJet With Vacuum Recovery (% Moisture)
0	3.4	3.4	3.4	3.4	2.9
0.5	3.4	3.5	6.1	6.1	3.4
1	3.4	3.3	6.1	6.1	3.1
2	3.4	2.9	6.1	6.1	2.9
3	3.4	2.9	6.1	6.1	2.9
4	3.4	2.9	6.1	6.1	2.9
5	3.4	2.9	6.1	6.1	2.9
6	3.4	2.9	6.1	6.1	2.9
7	3.4	2.9	6.1	6.1	2.9
8	3.4	2.9	6.1	6.1	2.9
9	3.4	2.9	6.1	6.1	2.9
10	3.4	2.9	6.1	6.1	2.9
15	3.4	2.9	6.1	6.1	2.9
20	3.4	2.9	5.9	6.0	2.9
25	3.4	2.9	3.3	4.2	2.9
30	3.4	2.9	3.3	3.7	2.9
35	3.4	2.9	3.3	3.4	2.9

Figure 9. Concrete moisture test results, proving that UHP water jetting does not add moisture to jetted concrete surfaces

TEST ZONE #2 SpinJet with Vacuum Recovery – Pre-Test Moisture Reading Of 3.4% H2O.

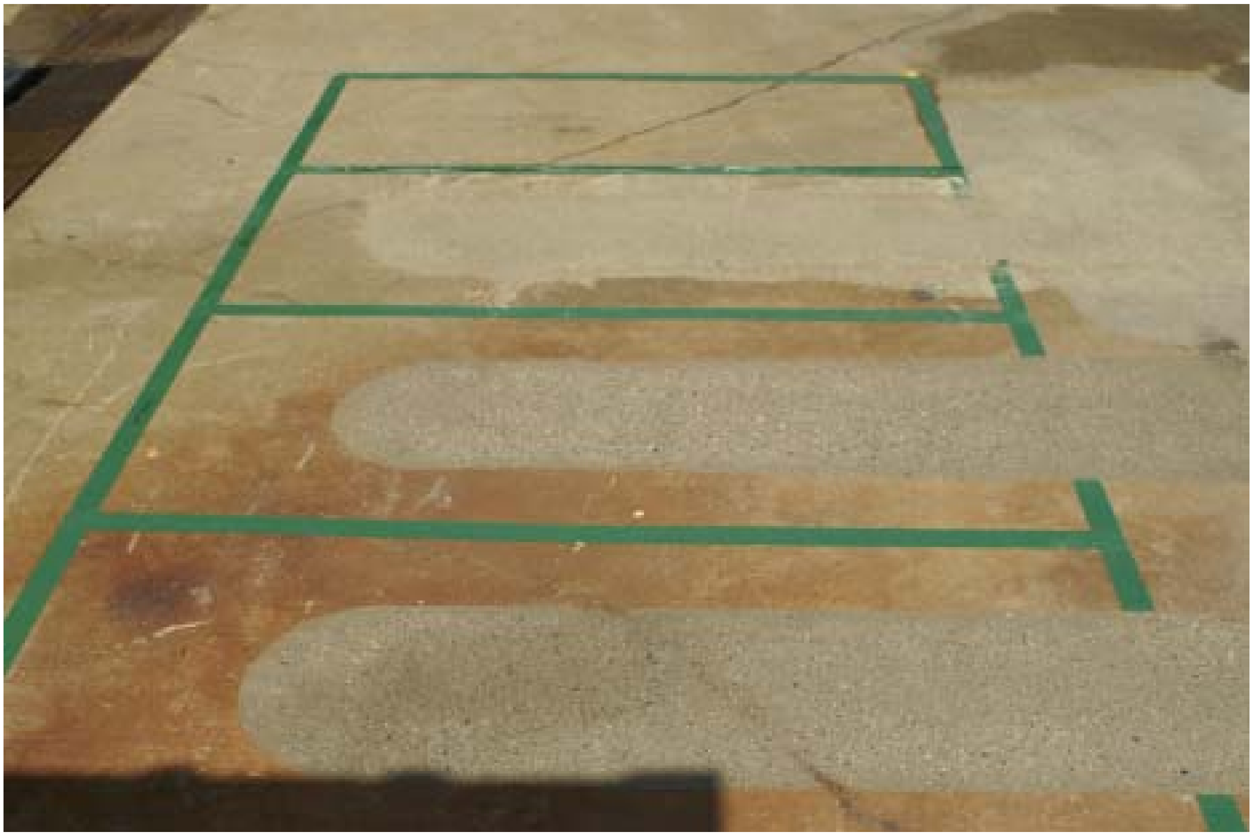
TEST ZONE #2 SpinJet with Vacuum Recovery –Moisture Reading at five seconds after jetting: 4.4% H20.

TEST ZONE #2 SpinJet with Vacuum Recovery – Moisture Reading at one Minute after jetting: 3.3% H20.

Test Zone #2 SpinJet with Vacuum Recovery – Moisture Reading at two minutes after jetting: 2.9% H20.

TEST ZONE #2 SpinJet with Vacuum Recovery – Clean Surface, no dust, No dirt, no moisture, of and kind.

TEST ZONE #2 and #3 Pull Test The Vacuum Recovery SpinJet leaves A clean surface (on left)



View of the overall test area. Zone #1 at the bottom of the photo working upward to Zone #4 at the top of the photo.