WHITE PAPER

Laser Scanning Wet Concrete for Quality Control

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Adding FARO Focus^{3D} X Series Laser Scanners to a concrete pour workflow can immediately identify high and low areas which can be fixed while still wet.

Figure 1. *3D laser scanner on an elevated tripod scanning an area of newly poured concrete.*

Overview

Imagine being able to identify and locate high and low areas of wet concrete, and fixing these areas before the concrete dries. By utilizing a 3D laser scanner with fast data acquisition capabilities, combined with software which delivers quick and reliable results, a proven workflow is now possible. FARO technologies and Rithm have developed an efficient workflow that saves time and money, and is well received by field crews. Results for a 1,000 square foot concrete pour were produced in which high and low areas were identified. Measurements were given to the finishers in order to locate and fix the flawed areas, ensuring the Superintendents that the concrete pour would pass the required Floor Flatness/Floor Levelness (FF/FL) inspections. The key findings, workflow, common concerns and benefits on the business operation are described in detail below.

Key Findings

Simple hardware and software workflow – The FARO Focus^{3D} X Series Laser Scanner and SCENE Software are extremely user friendly, and do not require an engineer to operate. The workflow involves taking a single scan; meaning multiple scan alignments (or registrations) are not required. The Builder App for FARO SCENE is very intuitive, and with minimal training, the field crew can efficiently produce excellent results. Since Field Engineers are responsible for numerous tasks on a project site, spending less time learning new software systems or application workflows allows flexibility on the site. While a total station is not required, one elevation marker that the scanner can see is needed. The operator does not need to have BIM or CAD experience.

10-minute turnaround time – Results of a roughly 1,000 square foot area were produced within 10 minutes of pushing the start button on the laser scanner.

Field crew friendly – Initially, the field crew was very hesitant to use the laser scanner and did not see it as a valuable tool. The scanning team was originally told that the job had to be completed quickly and accurately, and there wasn't time to learn "new technology". Once the field crew observed the workflow and the final results, the Superintendents and Finishing Foreman agreed to the implementation of this technology across all concrete pours.

3D visualization is a powerful communication tool – Using 3D laser scanning on this project exposed a miscommunication between the Laborer, the Project Manager, and the Superintendent. One individual believed the finish should be to the height of the form, while another believed it should be just ½" higher. How did the laser scanner help solve this problem? The scan data created became a single source of truth, visually and proactively highlighting problem areas before it was too late. Getting all stakeholders on the same page allowed the team to rapidly fix problem areas that would have otherwise been discovered only after the concrete had hardened and they had potentially failed FF/FL inspections.

Too much information? – One question posed by builders regarding laser scanning technology is whether or not too much information about the concrete project is being gathered. While utilizing a laser scanner does collect a large amount of data, the analysis and distribution of the data can be managed by the builders themselves. Companies implementing this technology are in complete control of how this information is delivered to their customer. To satisfy owner requirements for FF/FL, builders can submit a basic FF/FL report using the Inspector App in FARO SCENE. For their own internal purposes, 3D laser scanning helps construction professionals identify issues before they create significant costs and provide true measurement data to use during continuous improvement conversations.

Workflow

The workflow for the FF/FL application is one of the easiest laser scanning workflows of all, and consists of easy steps:

Step 1: Establish elevations
Step 2: Scan
Step 3: Import data into FARO SCENE Software
Step 4: Elevate scan data
Step 5: Identify high/low areas using the Rithm Builder App in SCENE

These steps are explained in detail in the following paragraphs.

Step 1: Establish elevations – The first step is to establish elevations. This allows one to see the relationship between the actual elevations of the concrete versus the design elevation. A checkerboard target, which can be printed on an 8.5"x11" paper (*Figure 2*), provides a link between the 3D laser scan data and real-world elevation. For a three minute scan, the checkerboard target with known elevation should be within 60 feet of the scanner. If there is no elevation within 60 feet of the scanner, or the scanner does not have line of sight on the elevation, a builder's level can be used to easily and quickly move an elevation to a place ideal for scanning. It is best to pre-plan your possible scan locations and place elevations ahead of time so that one can be seen by each scan location, giving more time to process data in between scans. Place a checkerboard target over the elevations.

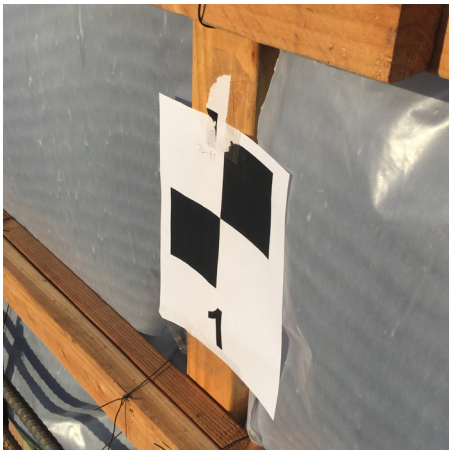

Figure 2. *Checkerboard target placed over a known elevation.*

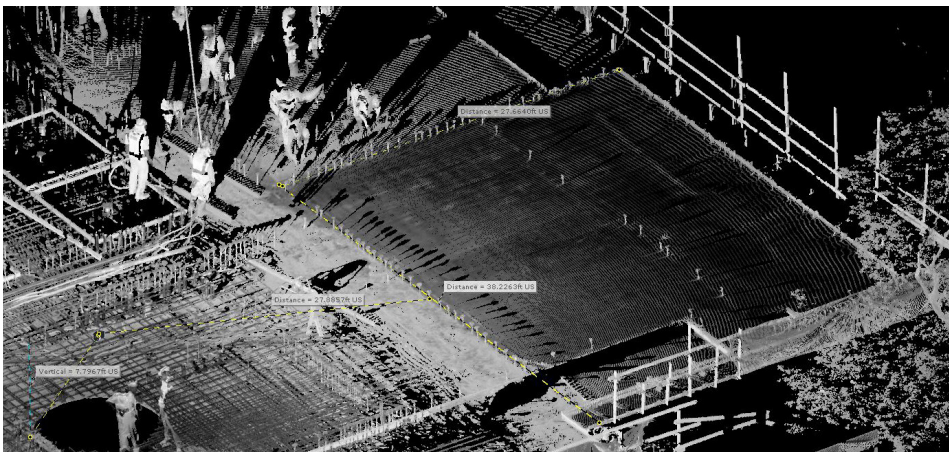

Figure 3. *Diagram of scanner placement and size of wet concrete area evaluated.*

Step 2: Scan – Using a FARO Focus^{3D} X 330, select the appropriate resolution which can collect points with 1/4" spacing at 30 feet away. For those familiar with the Focus^{3D} interface, this is a 1/5 resolution and 3x quality scan with no pictures, resulting in a three minute and 17 second scan. Using a standard tripod with the scanner elevated about 6 feet off the ground, you can collect data (*Figure 3*) up to 70 feet from the scanner that is dense enough to identify high/low areas as well as calculate FF/FL numbers. An elevated tripod can be used to increase the height of the scanner, which will result in capturing usable data at greater distances. The scanner can be accessed remotely by smartphone or tablet if it is elevated beyond reach using the built in Wi-Fi.

Step 3: Import data into FARO SCENE Software – Once the scan is complete, remove the SD card and insert it into the laptop. Open SCENE software and create a new project, drag and drop the scan into the project and save the project. Right click on the scan - then click on **Operations – Preprocessing – Preprocess scan**. Make sure only the boxes shown in *Figure 4* are checked to enable the software to automatically detect the checkerboard targets placed over the known elevations.

Step 4: Elevate scan data – Open up the **Quick View** by double clicking on the scan. Right click on the checkerboard and select **Properties Panel.** Find the Z elevation and copy and paste it into an Excel sheet. Find the difference between the desired elevation and the current elevation. Apply the transformation by right clicking on the scans cluster and selecting **Properties Panel**. Paste the transformation into the box for the Z transformation, as the picture in Figure 5 shows. Now the point cloud is correctly elevated. This can be verified if there is another known elevation that was captured in the scan. Mark a point at that elevation and go to Properties and ensure that it is at the correct elevation. Now right click on the scan and select "**Operation – Point Cloud Tools – Create Scan Point Cloud**".

Step 5: Identify high/low areas using the Rithm Builder App in SCENE – Open up the 3D View and create a clipping box to isolate just the area of concrete that will be evaluated as shown in *Figure 6*. Right click the **Clipping Box Tool** and deselect **Visible**. Open up the Builder App and click on the **Surface Wizard** button. It will walk you through how to apply a filter and create a cut/fill heatmap. The filter will get rid of noisy data along with any debris or trash that might be on the concrete as shown in *Figure 7*.

One can then create quick down-and-out measurements from an easily identifiable point for the finishers to locate the high and low areas so they can fix the concrete while still being wet. This enables the user to disregard the XY orientation of the scan data, all that is needed is one Z elevation as shown in *Figure 8-9*. The entire process of importing the data and using the Rithm Builder App takes approximately 5 minutes.

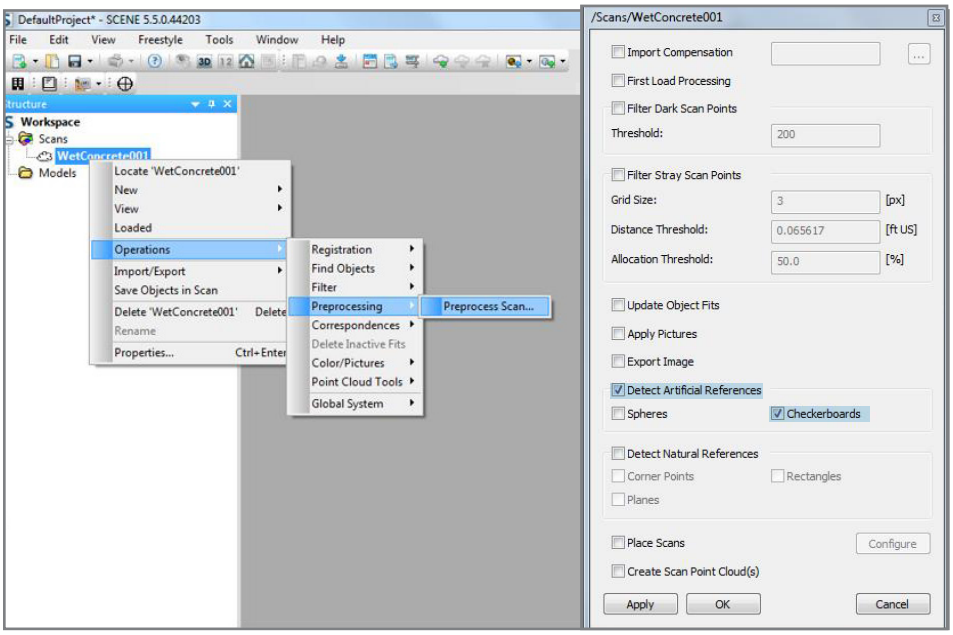

Figure 4. *Preprocessing settings.*

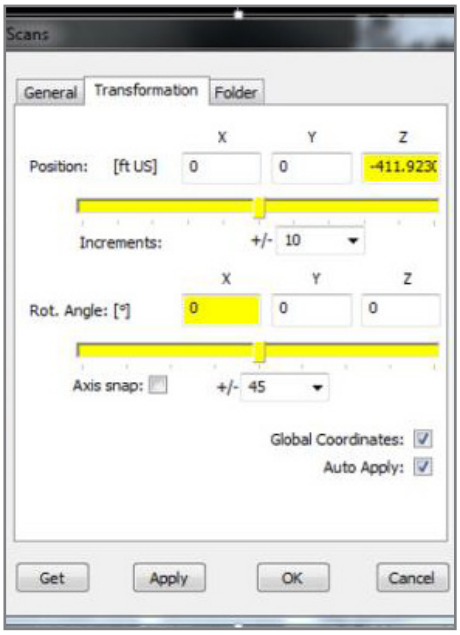

Figure 5. *Transforming point cloud to correct elevation according to targets.*

Addressing Common Concerns

Implementing workflow in the field and office – A common perception in the industry is that a laser scanning workflow can be difficult to implement in the field and office, and has a steep learning curve. If one plans on doing Building Information Modeling (BIM) coordination and modeling from scan data, a Virtual Design and Construction (VDC) Engineer is needed who is familiar with BIM. However, the laser scanner can be used for much more than just BIM coordination and modeling. The workflow described here has demonstrated that a field worker can operate the laser scanner and the software. With a single scan, the registration and Quality Control (QC) processes are easily accomplished. The Rithm Apps are designed to be intuitive and easy to use for both engineers and field personnel. This easy, step-by-step process enables a user to essentially bring the office to the field and drastically reduce turnaround time.

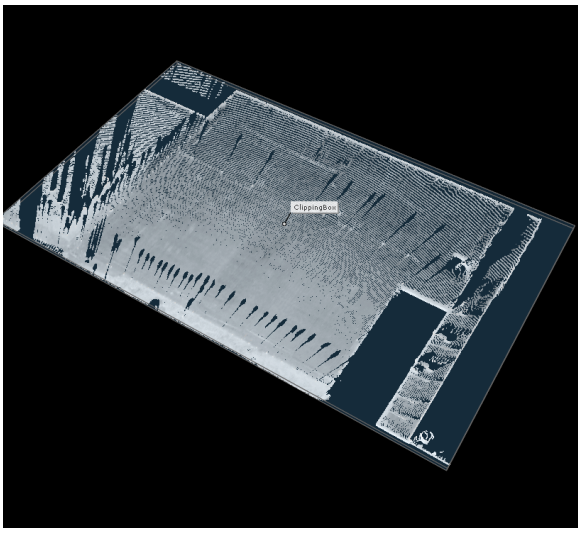

Figure 6. *Create clipping box to isolate area of interest. Hides everything outside of it.*

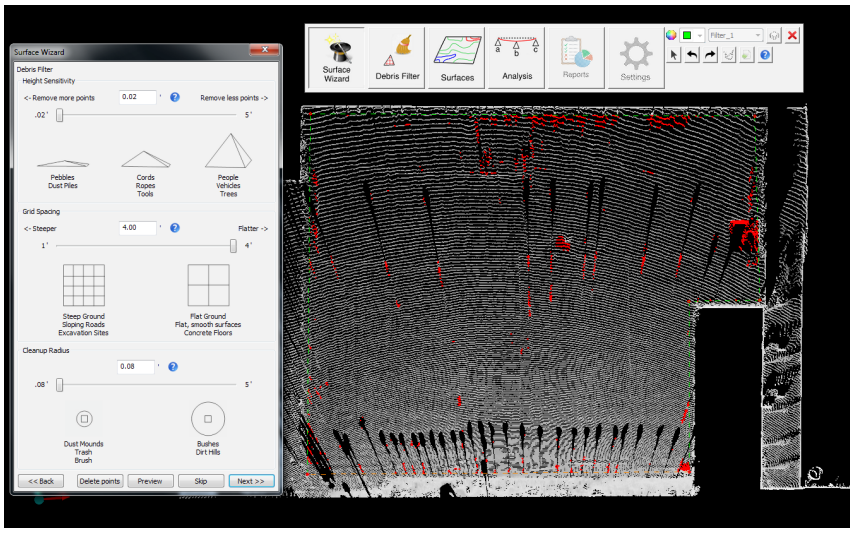

Figure 7. *Debris filter. Filter that can be used to get rid of things like dirt and chords on a job floor. Parameters are easy to understand and change.*

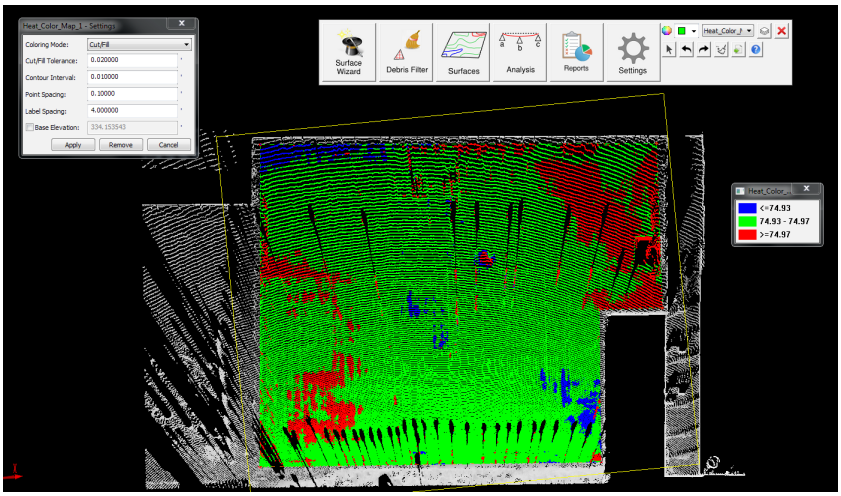

Figure 8. *Cut/fill map of wet concrete. Shows areas outside user defined tolerance. Blue is low, red is high.*

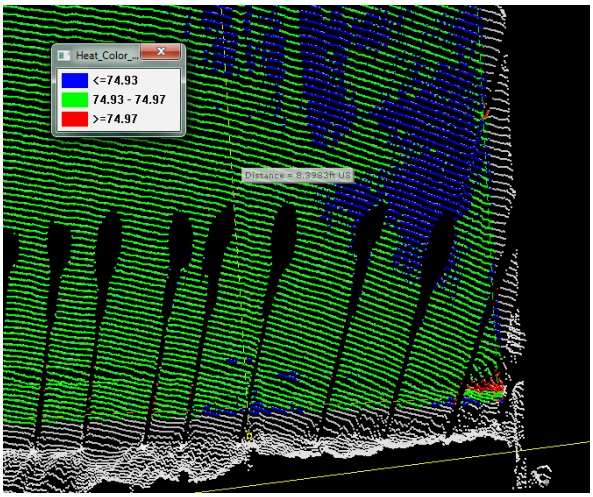

Figure 9. *Measurements to locate problem areas. Based of easily recognizable features like rebar, forms. Do not need to put in total station since field crew just used tape measure to locate.*

Control – A common difficulty when scanning on a hectic job site can be establishing sufficient control points to geo-reference scan data. When laser scanning wet concrete, the perceived difficulty is amplified since there are no solid concrete or columns constructed. However, one does not need these control points for laser scanning wet concrete. One elevation point that can be seen from the laser scanner is all that is required. As mentioned before, these elevations can be easily moved around by a builder's level, which is easier, faster and less expensive than using a total station.

How Does This Help My Business?

Implementing this workflow into every concrete pour will not only demonstrate that a company is innovative and at the forefront of technology integration for the construction industry, but it will also prove to be beneficial in other ways. Laser scanning concrete platforms and being able to fix high and low areas will help ensure that the project will pass FF/FL inspections, give companies a favorable reputation, and save money that would be spent going back and grinding high spots and filling low spots. It also helps mitigate risks associated with grinding down concrete and possibly grinding too low. The data can be archived and referred to in the future if a dispute arises to prove that the concrete was delivered within tolerance at the time of the pour.

Conclusion

Working with Morley Builders, FARO and Rithm have developed a workflow that overcomes many common concerns and proves that a laser scanner is more than just an as-built tool. It is a tool that can be utilized in the field to provide value in many different ways. High and low areas of a 1,000 sq. ft. pour were identified within 10 minutes so that the concrete could be fixed while still wet. The field crew was extremely pleased with the easy workflow and the quick turnaround time, and was confident that they would be able to use the laser scanner as a valuable tool for future concrete pours. Implementing this workflow produces a unique opportunity for progressive companies to separate themselves and be on the leading edge of this technology integration into the architecture engineering construction industry.

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