CS468515

Laser scanning -Enhancing Productivity & Quality in Construction Management

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Learning Objectives

- Innovative use of laser scanning for
  - Improving construction quality
  - Improve site safety
  - Getting ahead of schedule
- Laser scanning for construction progress management
- Laser scanning for inspection and approvals
  Laser scanning for quantity estimation and contactor bill approval

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Description

This class will dive deep into how laser scanning is taking construction management into a new orbit. We will use Real-life case studies to demonstrate the use of laser scanning for the following: defection monitoring of structures; virtual erection of structural elements; deviation analysis of structures and systems; leveling and alignments; coordinate extraction and as-built management; cut-out management; progress monitoring; quantity surveying; and construction inspection. Innovations in the use of laser scanning is bringing a shift in construction management. The class will discuss case studies for each of the benefits mentioned above—how it is improving quality, reducing rework, lowering costs, improve site safety and time, and dramatically improving construction quality.

Speaker

Bimal Patwari is the 1st generation Entrepreneur and founder of Pinnacle Infotech Solutions, the acknowledged Global leader in providing innovative BIM solutions. Bimal is recognized for his contribution to the innovative use of BIM technology to improve efficiency and quality, reduce costs and wastages .
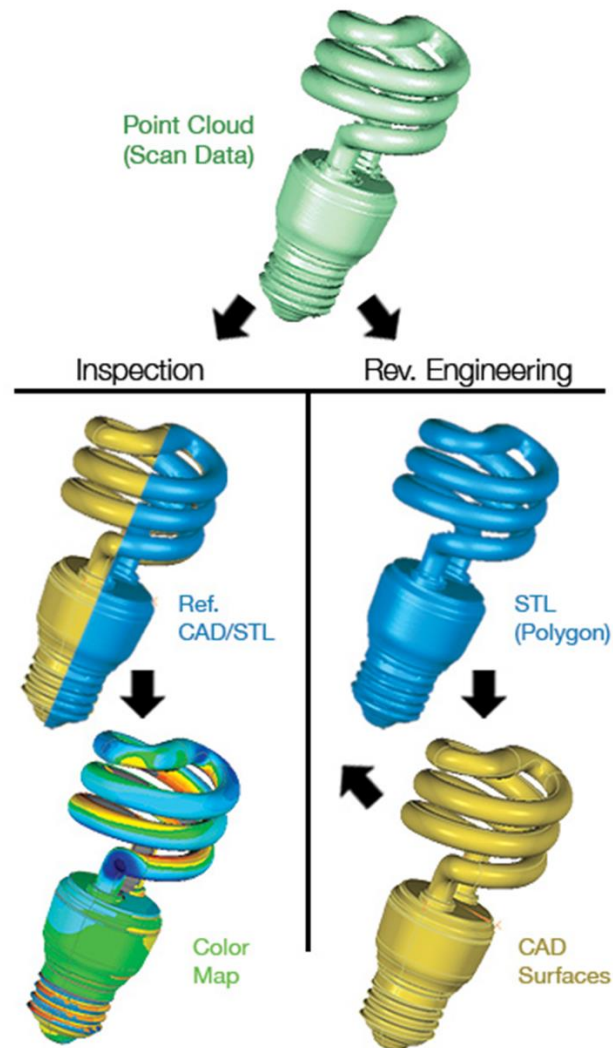He has received several awards and recognition from Government and other industry associations for his entrepreneurship and pioneering contribution to the construction industry.

Laser Scanning

3D Laser Scanning is a non-contact, non-destructive technology that digitally captures the shape of physical objects using a line of laser light.

In other words 3D laser scanning is a way to capture a physical object's exact size and shape into the computer world as a digital 3-dimensional representation.

Originally applied in the construction and maintenance of industrial plant facilities, laser scanning has since been adopted for many other uses, including building construction and building information modeling (BIM).
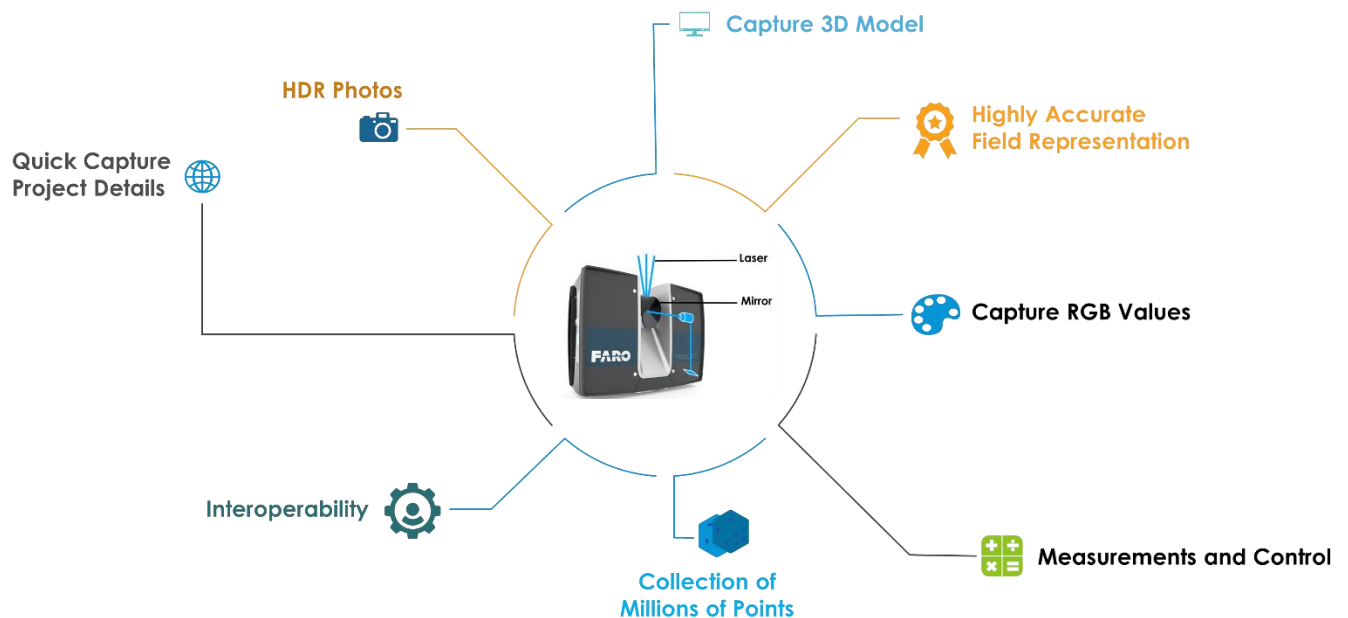

Point Cloud Processing – Image from-Laser Design

Introduction

Laser scanners advancements concerning their implementation in construction projects, it will be helpful to examine the features and capabilities that apply to conventional construction projects.

Reality capture, is one of the most prominent functions of utilizing a 3d laser scanner on your job site. Laser scanning allows you for a highly accurate field representation by collecting millions of points within a very short period of time. Those points become intelligent, as they capture the RBG values of the scene collected by the camera of the scanner.

All the below features, along with an extraordinary accuracy that a laser scanner can provide makes it a great instrument for measurement and controls in the field.

Types of Scanners

The most common type of laser scanners used in the field of construction, is the LiDAR method. LiDAR is a method for measuring distances by illuminating the target with a laser light and measuring each reflection with a sensor.

Differences in the laser returned times and wavelengths can be used for making a new digital 3d representation and usually are classified in following four main categories. Therefore LiDAR scanners can be airborne, stationary Terrestrials, mobile Terrestrials, and handheld. Each individual type is used for different purposes, needs, and range of accuracy according to the assigned task.

	Airborne Laser Scanner	Stationary Terrestrial Laser Scanner	Mobile Terrestrial Laser Scanner	Handheld (Industrial)
Ideal Usage	Exterior mapping Long/Linear Projects Large scale mapping	Interior high-density high accuracy scans (MEP, architectural, structural, facilities management, and forensics)	Exterior high accuracy longer range scans (Architectural reconstruction, surveying, engineering, planning, forensics)	Top-quality, high-precision Its suitable for indoor scans
Accuracy and Range	Accuracy +/- 10 CM, depending on conditions Range 3.000 feet (typically flown at about 3,000 FT)	Accuracy +/- 2MM Range 60 to 120 meters, depending on conditions	Accuracy +/-2MM Range 150 to 330 meters, depending on conditions	Accuracy +/- 0.5mm Range up to 110 meters, depending on conditions
Scanners				

Benefits for General Contractors

- 3D laser scanning enables a fast and accurate means of collecting millions of measurable data points in seconds to provide pinpoint accuracy, every time.

- For general contractors, this insight is the single largest benefit of laser scanning. Laser scanning helps lower contractor risks by ensuring as-built drawings are accurate and by exposing any inaccuracies early in the process, before they turn into change orders during construction.

- Datasets are dimensionally accurate, measurable, and shareable, so you can eliminate any guesswork back at the office.

- For detailed MEP installations, you need a high level of accuracy. If your project is complex, involves retrofits, or requires refurbishment, you can capture precise data over the full measurement range.

- The benefits of laser scanning do not stop at preconstruction coordination. Scanning progressively during construction to compare with as-designed models and drawings, provide archival records, and document critical milestones provides tremendous value throughout the construction process as well as to the owner as the building is managed, maintained and renovated.

Laser Scanning Across A Project's Lifecycle

Design - When it comes to site design, 3D laser scanning is a starting point even sometimes before BIM. Many professionals today are adopting a scan-to-BIM method of design to capture detailed information to kick off and manage the process early.

Construction - Construction coordination, specifically in avoiding conflicts between different systems (i.e., HVAC, electrical, plumbing). Data can also be shared between parties to help with any remote coordination.

Operations - Scanning isn't just performed at the beginning of a project either; it can be done at various other points along the timeline to better document milestones, reduce the necessity of change orders and pass off work to other trades professionals.
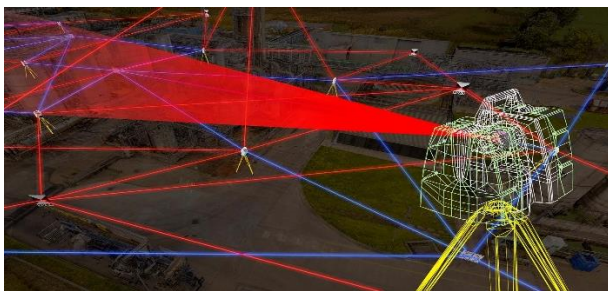
Retrofits & Renovations - Laser scanning captures a very high level of detail, and this helps create a permanent as-built record for both owners and facility managers. In the end, this data can help with building operations, renovations and future building additions and even demolitions.
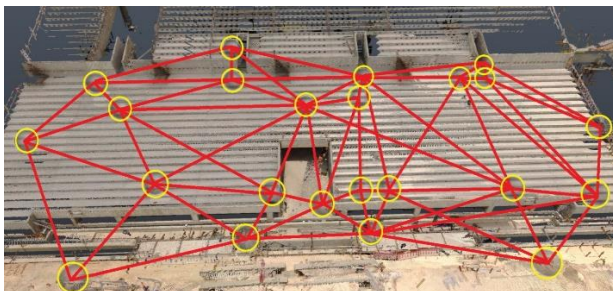
Laser Scan Registration

Registration is the process of aligning multiple scans in a parent coordinate system using reference positions common between scans. References are common points between scans that are used to create a "best-fit" alignment.
The X,Y,Z coordinate and point name are created on positions like the center of a sphere or planar scan target.
The purpose of pairwise registration is to find a common contact surface and optimally align one of the scans relative to another. There are many algorithms for registration of two geometric surfaces that are the alternatives of the well-known Iterative Closest Point (ICP) algorithm
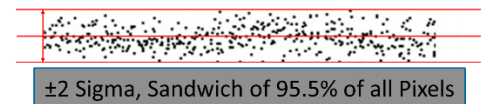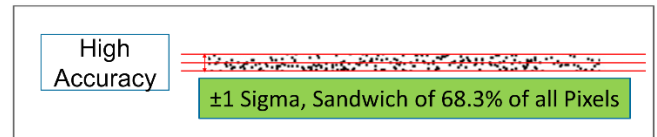

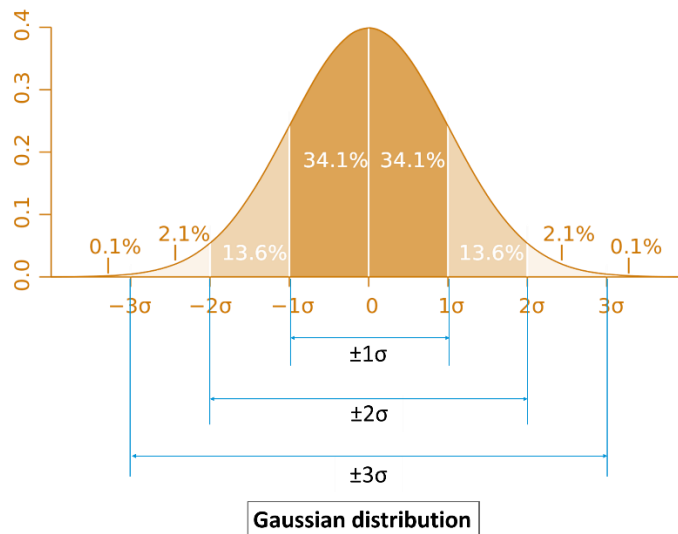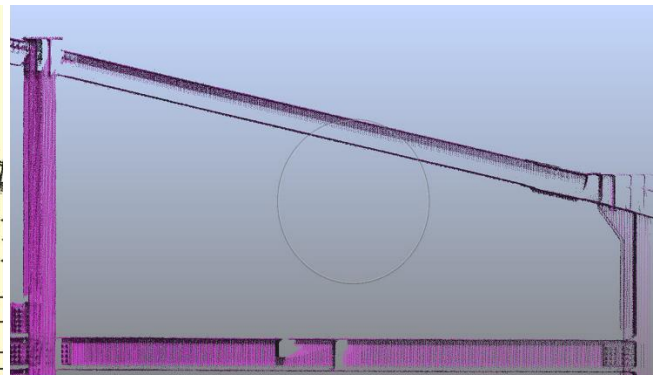Concept of Registration

Actual Registration

Registered Output

Laser Scanning Accuracy

The difference of each single range measurement to the mean range-value is specified by the Range Noise.
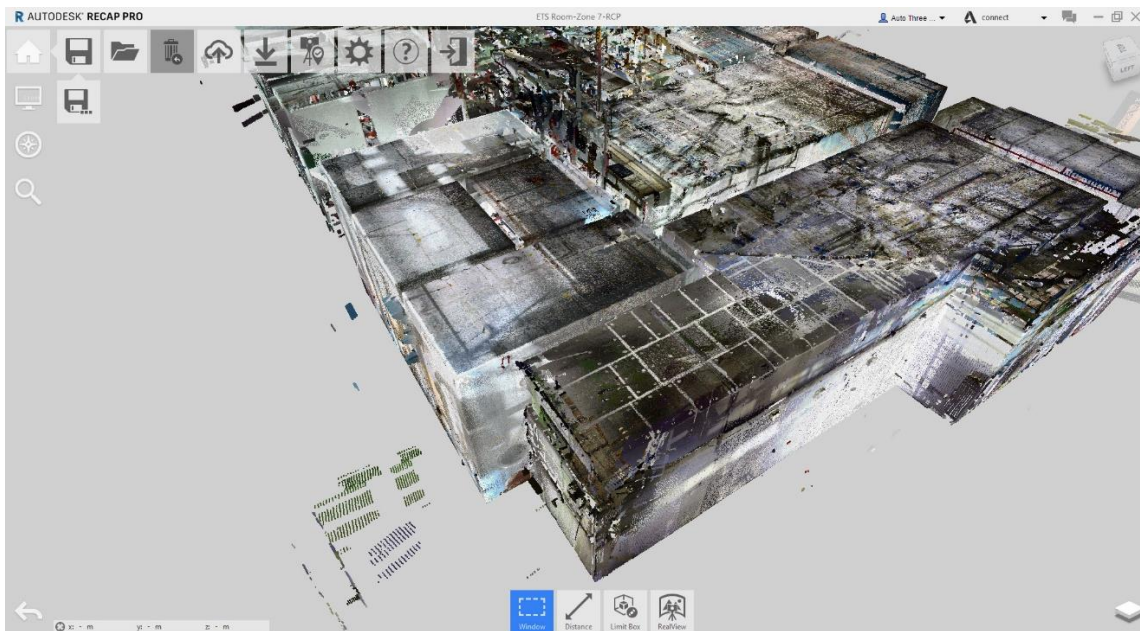

Gaussian distribution

High Accuracy — ±1 Sigma, Sandwich of 68.3% of all Pixels

±2 Sigma, Sandwich of 95.5% of all Pixels

Nominal Accuracy — ±3 Sigma, Sandwich of 99.7% of all Pixels
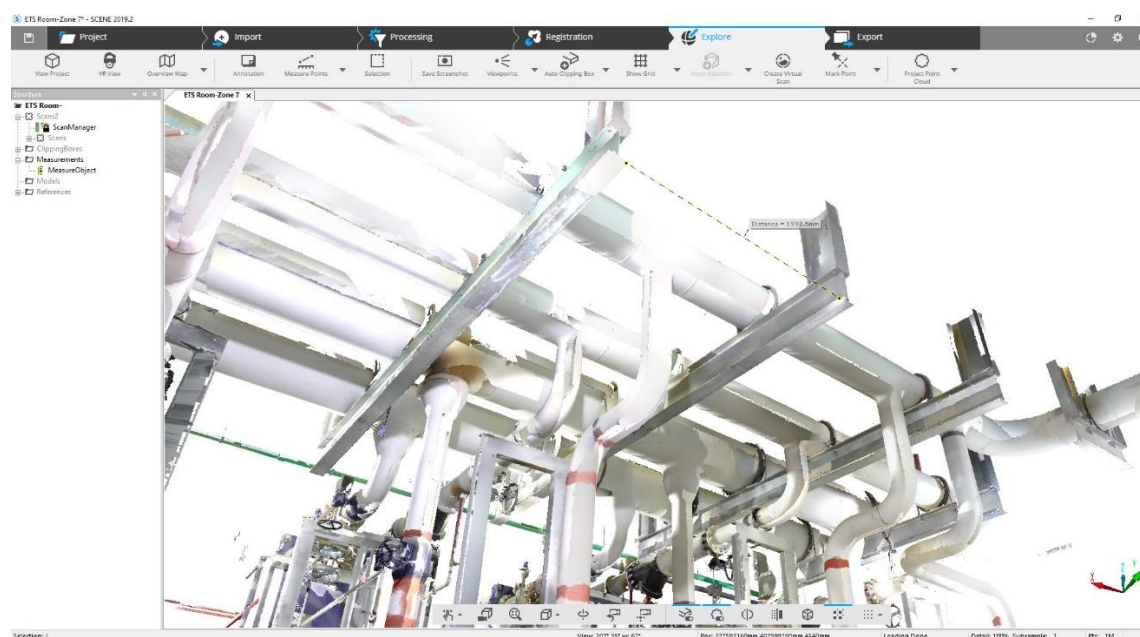

±3σ Sandwich(99.7% of all pixels)   ±1σ Sandwich(68.3% of all pixels)

Point Cloud Processing Software

The processing software should be capable to register the number of laser scans at a time with a great accuracy. The noise elimination tools must be incorporated with the software which will help to remove the noise to combine the processed data very accurately

Autodesk Recap Pro

Faro Scene

Benefits of Laser Scanning-

Construction Quality Management

Processing of millions of closely spaced points helps in capturing actual level and member orientation. Feedback from deviation analysis extracted by point cloud facilitates erection and minimize the overall tolerance of combine structure during the erection stage. It improves coordination and collaboration on jobsite, leading to faster and better decision-making.
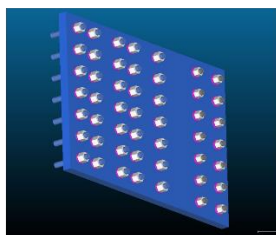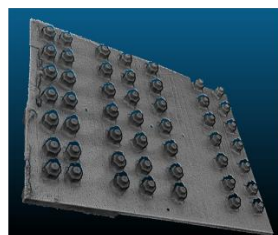

Deviation Analysis

Inspection and Approvals

The overlay of the LOD 400 models versus the collected point cloud creates a composite model that clearly reflect the deviations between the as-designed and as-built stage.
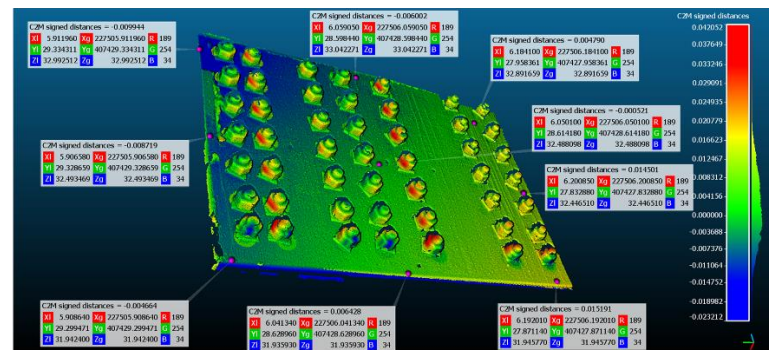
Inspection of Embedded Plates

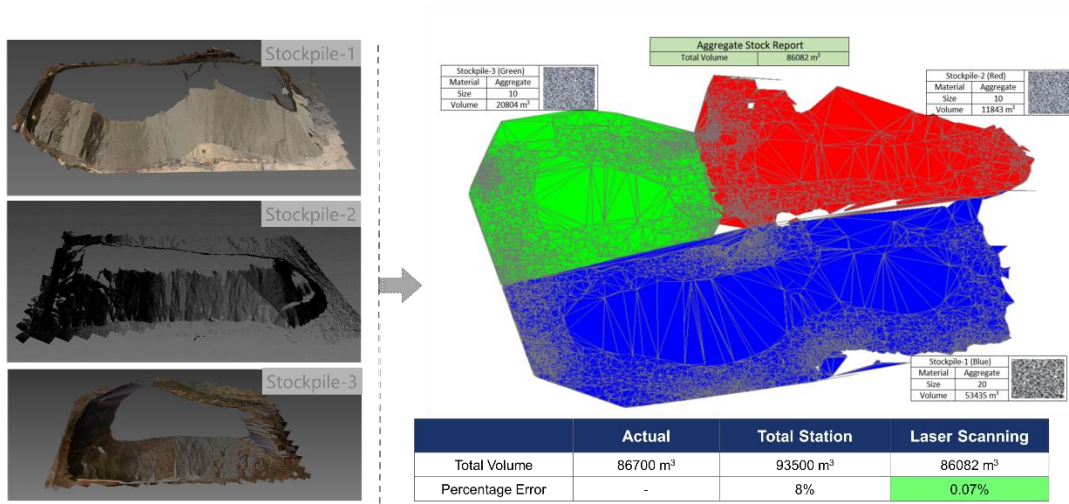On-Site Scanning of Steel Part   Point Cloud Model

Deviation Analysis of As-Built Model Vs LOD 400 Model

Quantity Estimation

Measuring quantity and maintaining the volume of stockpiles, cut & fill in heavy earthwork industries is difficult. Traditional survey methods are inaccurate and measure up to 80% of original volumes. Measuring a stockpile volume using 3D Laser Scanning is by far the fastest and safest method available.
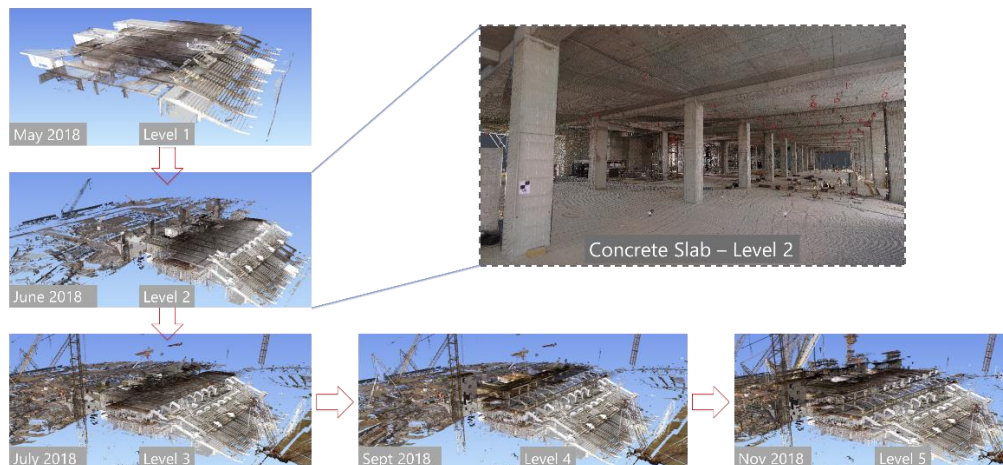
Stockpile Quantification & Management

	Actual	Total Station	Laser Scanning
Total Volume	86700 m³	93500 m³	86082 m³
Percentage Error	-	8%	0.07%

Progress Monitoring

Creation of construction progress model on timely basis is now easier with laser scanning. It creates a point cloud of each element of site. The progress models from every span of time create a clear vision of construction headways.

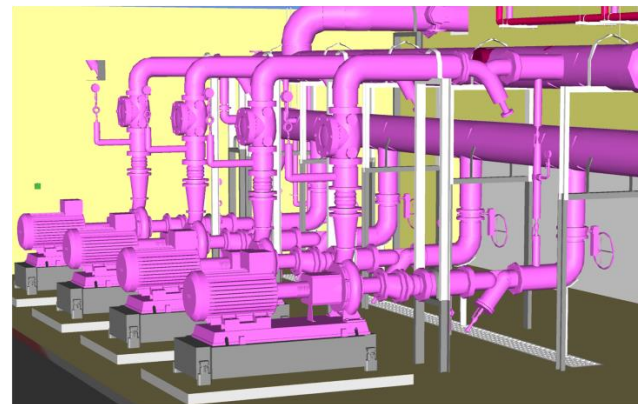**Concrete Structure Monitoring**

![Autodesk University logo]
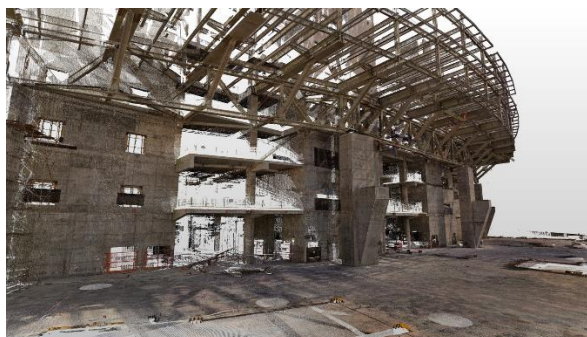
As Built Preparation

The practice of creating a digital representation of existing conditions of the building with its physical and functional characteristics in BIM. The point cloud need to import into a 3D BIM software (Autodesk's Revit, Graphisoft's ArchiCAD, etc.) in order to create accurate as-built models

Scan ⟹ BIM

Pump Room Point Cloud Model

Pump Room BIM Model

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Concrete & Steel Structure Monitoring