STRUCTURAL STEEL AND CONCRETE ANALYSIS THROUGH 3D SCANNING



Joshua Engelbrecht
VDC Engineer



Philip Lorenzo
Software Developer

Summary

- Current State of the Industry
- Why Scan during Construction?
- Best Practice Workflows
  - Capture
  - Compute
  - Create
- Benefits, Values
- Code Compliance
- How you can contribute

Class summary

As a General Contractor McCarthy has integrated laser scanning as a Quality Control measure to ensure that we are providing the best client experience possible. In this presentation we will be covering what laser scanning is, why the construction industry is starting to utilize it's power, and how McCarthy is using this derived information & innovating what it means to capture real-time reality. By carrying out laser scanning deliverables we are have the opportunity to expedite field inspections, eliminate/mitigate rework, create a sustainable O&M process, and increase our efficiency for self-perform work.

The workflow of Laser Scanning data analysis and output has been compacted into a more user friendly and client focused process. From field scanning best practices to point cloud registration, we will be exploring how facilitating Laser Scanning deliverables pertaining to Steel Beam and Concrete Floor Flatness Monitoring are impacting the construction industry.

The data compiled over McCarthy's initiation of implementing laser scanning is truly making waves in the standardization of these workflows. From initially being used as an inventive method of capturing real-time reality, to being used as in-house quality control measure, laser scanning is now an international standard for ASTM, AISC, and ACI building codes.

Key learning objectives

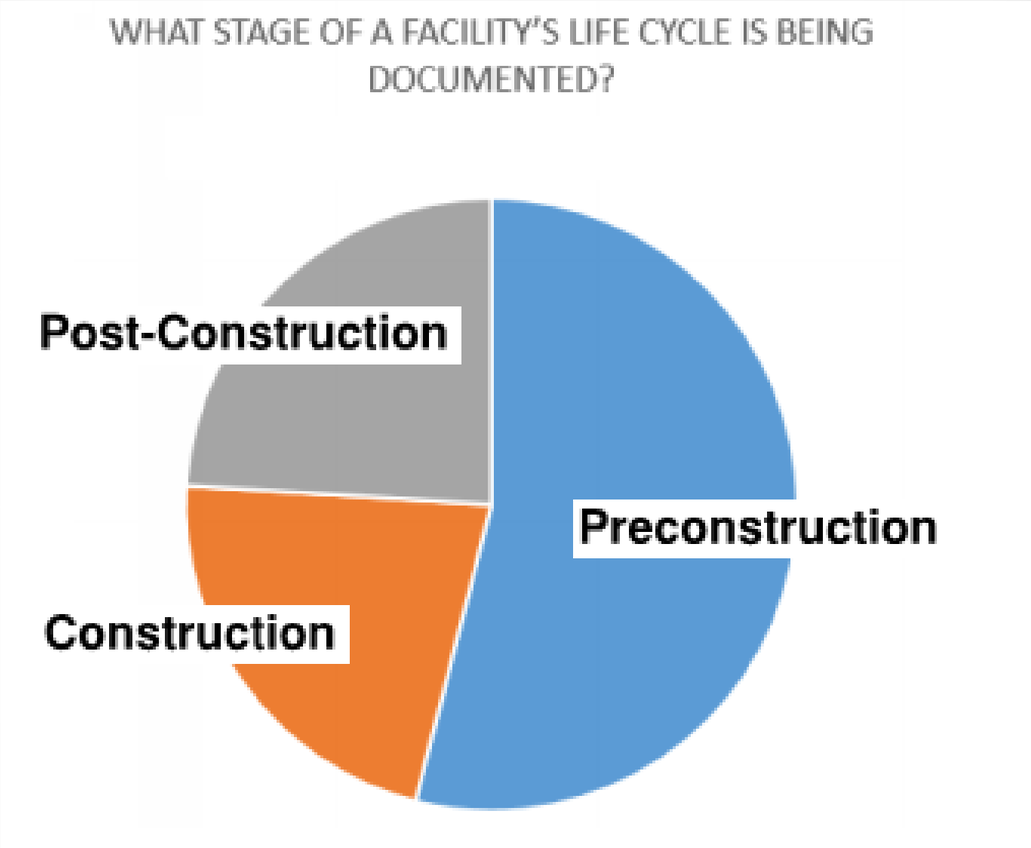
At the end of this class, you will be able to:

- Logistically Analyze How to Carry Out Field Scanning
- Understand Field & Office Best Practices for Laser Scanning Workflows
- Apply Expedited Data Analysis Workflows for:
  - Steel Monitoring
  - Concrete Topography
  - Concrete Monitoring
- Grasp the Benefits of Using Laser Scanning from Client & Management Perspectives

When are people typically scanning?

USIBD™
U.S. Institute of BUILDING DOCUMENTATION™

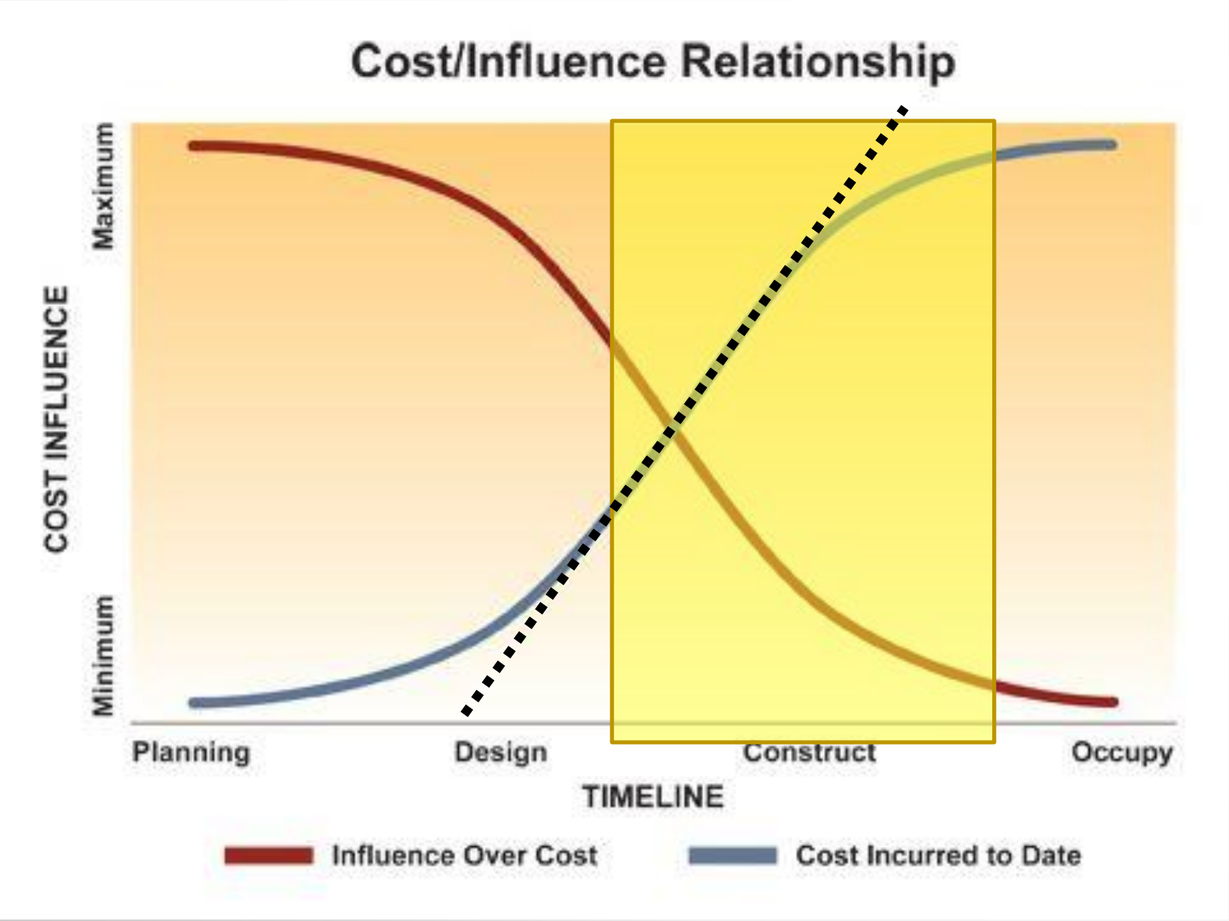
CORNERSTONE™ REPORT



August 2015

Why scan during construction?

As opposed to many who scan during preconstruction as-built modeling



- Margin for Error ↓
- Cost of Mistakes ↑
- Costs of Delays ↑

- Overall Quality ↑
- Overall Value ↑

What are we scanning for?

- Beam Camber Monitoring (Pre vs. Post Pour)
- Floor Flatness
- Steel Placement Elevation Verification
- As-built Modeling
- In-Wall & Over-Head Utilities



Why do we scan?

- Increased Efficiency
- Quality Enhancement
- Risk Management
- Waste Reduction

Why does McCarthy scan in-house?

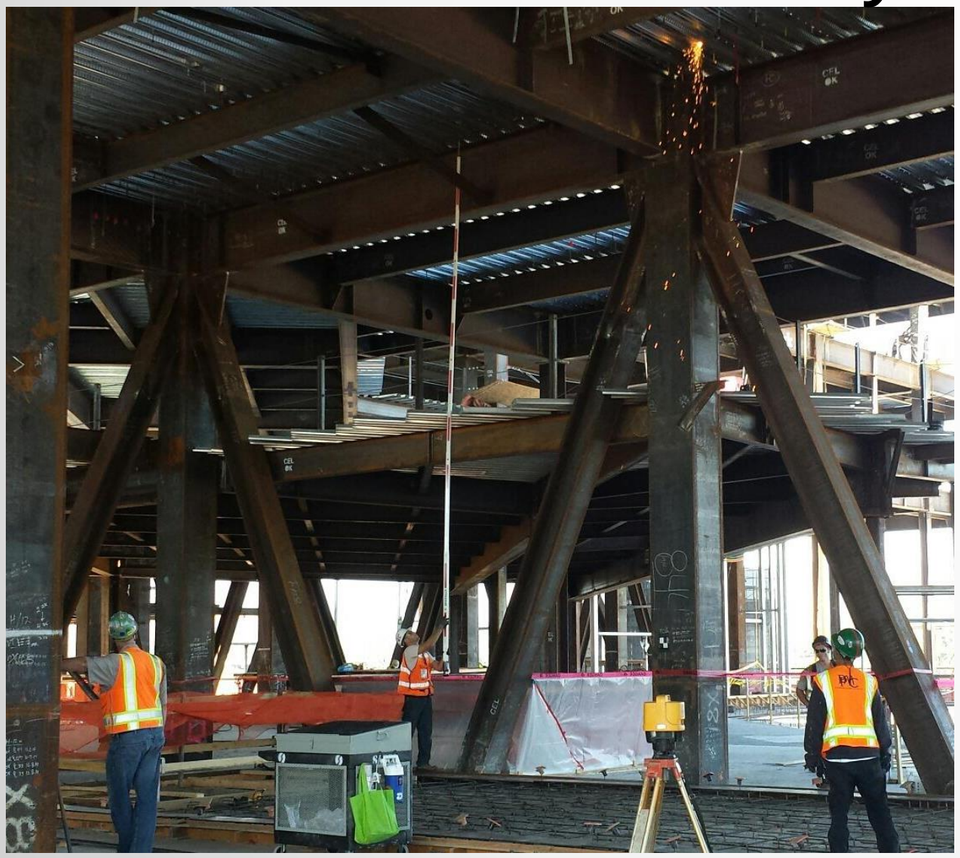
- Better understanding of required deliverables
- Better control over Schedule
- Better integration with BIM processes (local coordinates)
- Competition and Standardization



Laser Scanning vs. Conventional Survey Methods
(Then vs. Now)

Steel Monitoring

Conventional Survey



Laser Scanning



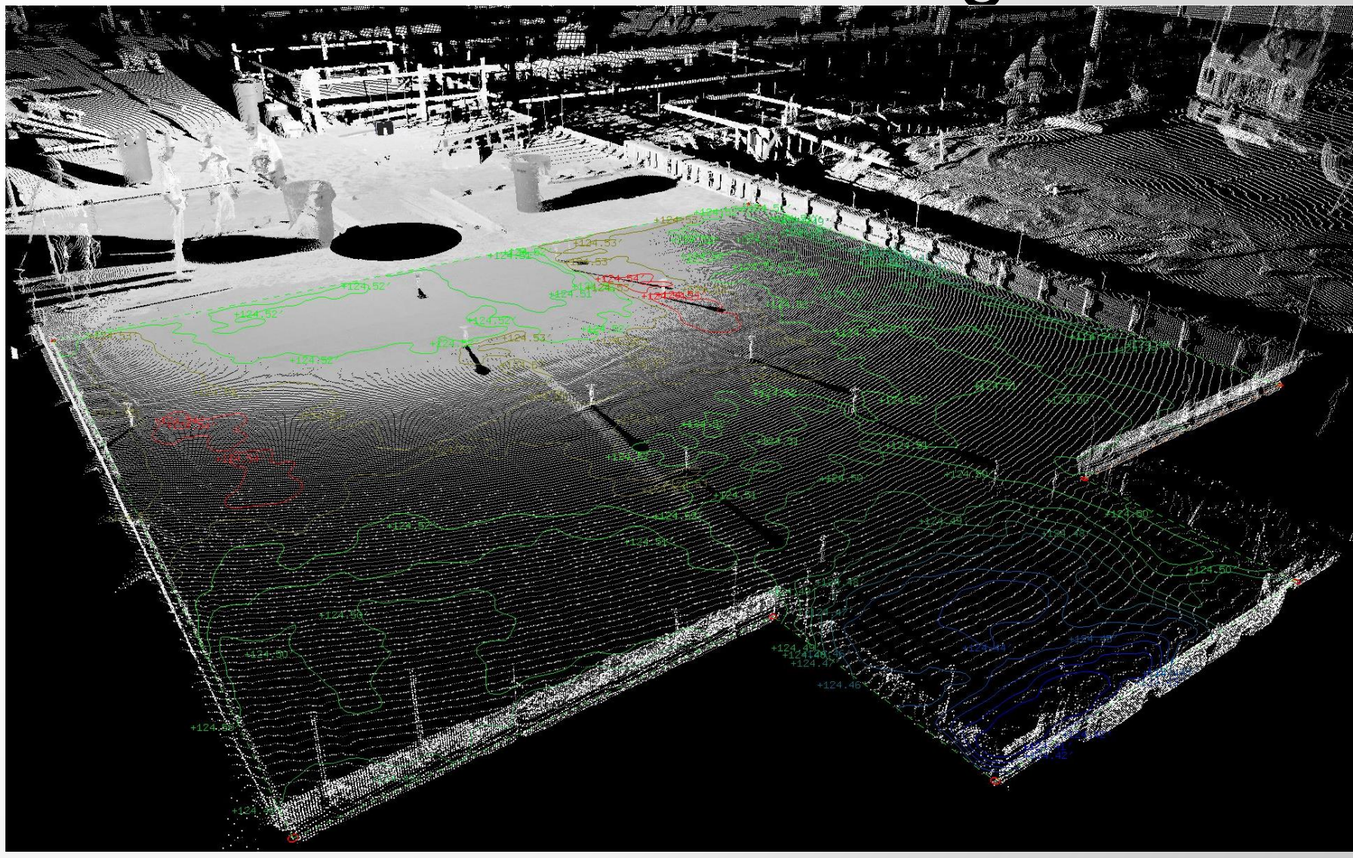
Laser Scanning vs. Conventional Survey Methods
(Then vs. Now)

Floor Flatness/Floor Leveling

Conventional Survey



Laser Scanning



Our Tools



AutoCAD

Rithm

BUILDER

International Building Code

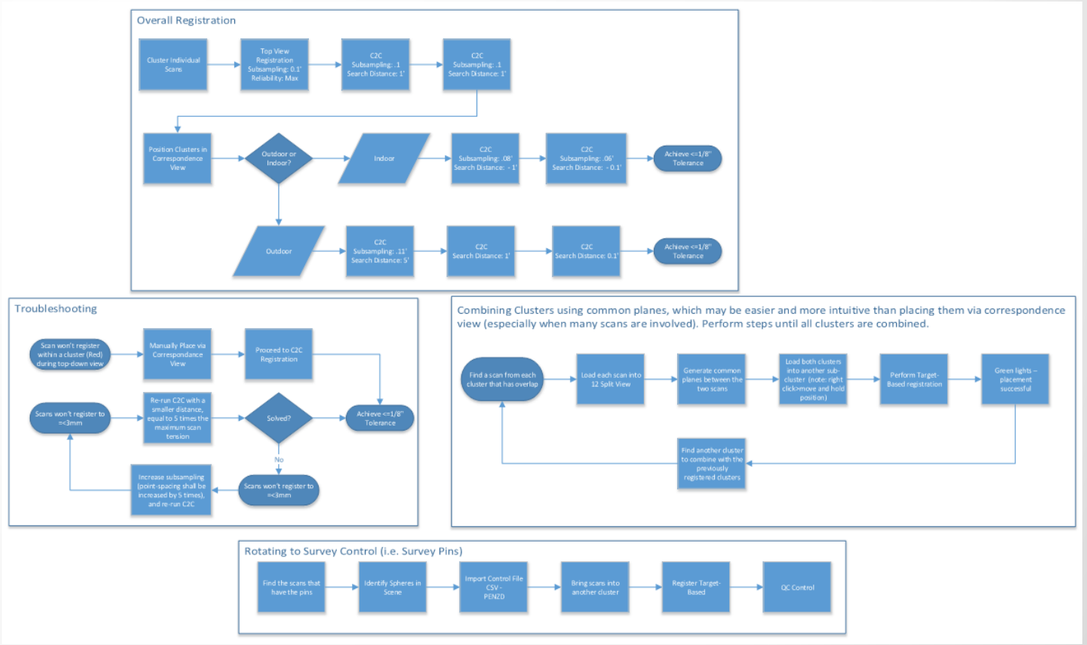
INSPECTOR

Our Strategy – Minimum Viable Workflow

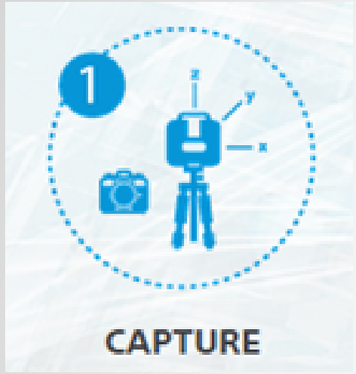
Constantly work together to minimize the amount of steps and clicks from scan to deliverable, WITHOUT compromising on quality and accuracy

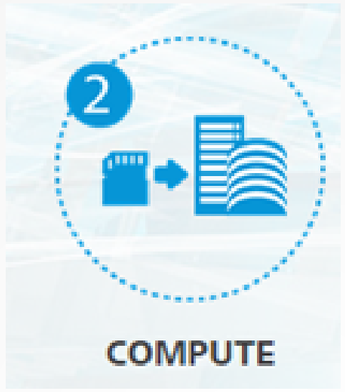
Benefits:

- Trainability ↑
- Repeatability ↑
- Scalability ↑
- Risk/Uncertainty ↓
- Bottlenecks ↓
- Costs ↓



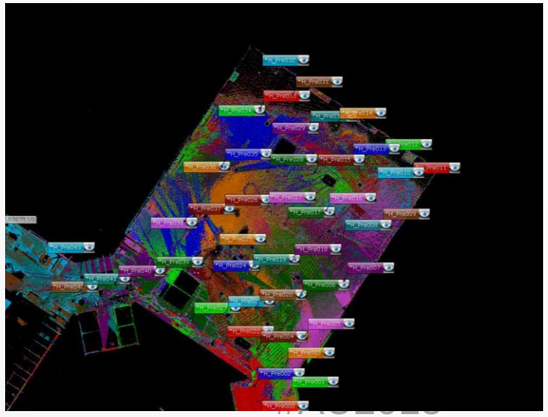
Best Practice Workflows

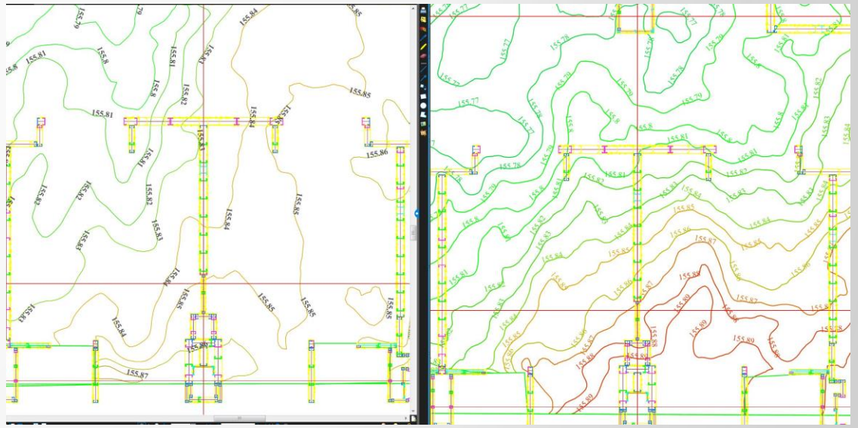






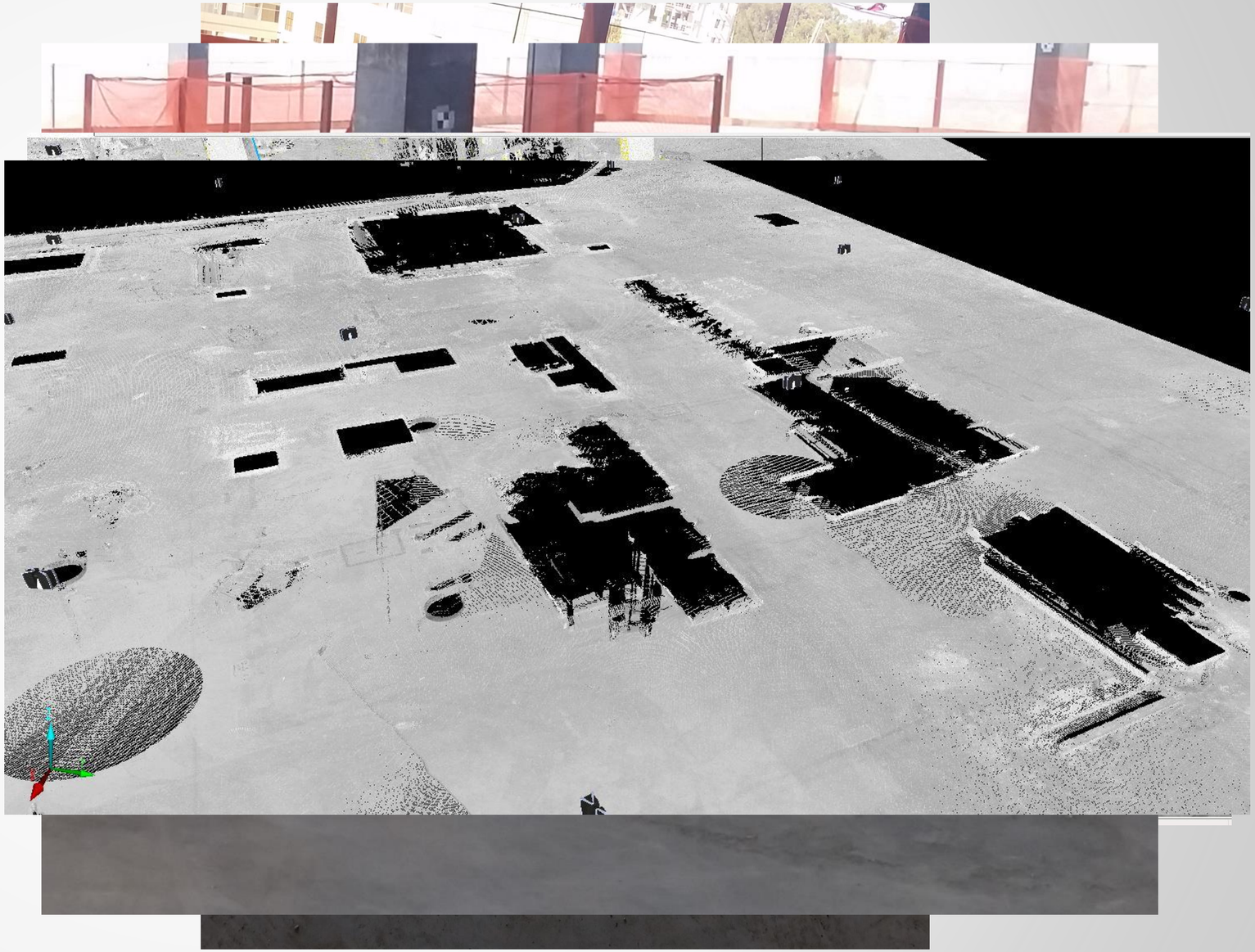






Field Scanning – What to look for?

Jobsite Conditions



For Optimal Data Collection:

- Dry conditions (NO WATER)
- Minimal Debris
- Pallets & Material Clear
- Clear Line of Sight
- Correct Job-phase (i.e. For steel, cannot be fireproofed)
- Minimal Foot Traffic
- No Rain or Airborne Dust

Why is it important?

- Maximize ROI/$$$ of scans
- Avoid Scanning Rework

Field Scanning – What to look for?

Scheduling (Job-Site Phases)





Mobilizations vs. Essential Data

- Capture FF/FL & Overhead Steel Simultaneously
- Deck Pour Sequencing

Timing

- FF/FL Scanning ASAP
- Monitoring Based on Design Timeline
- Post Pour Camber Based on Fireproofing Schedule

Field Scanning – What to look for?

Fireproofing Scheduling Issue

New Stanford Hospital Project *Palo Alto, CA*

Level 1 Overhead Steel:

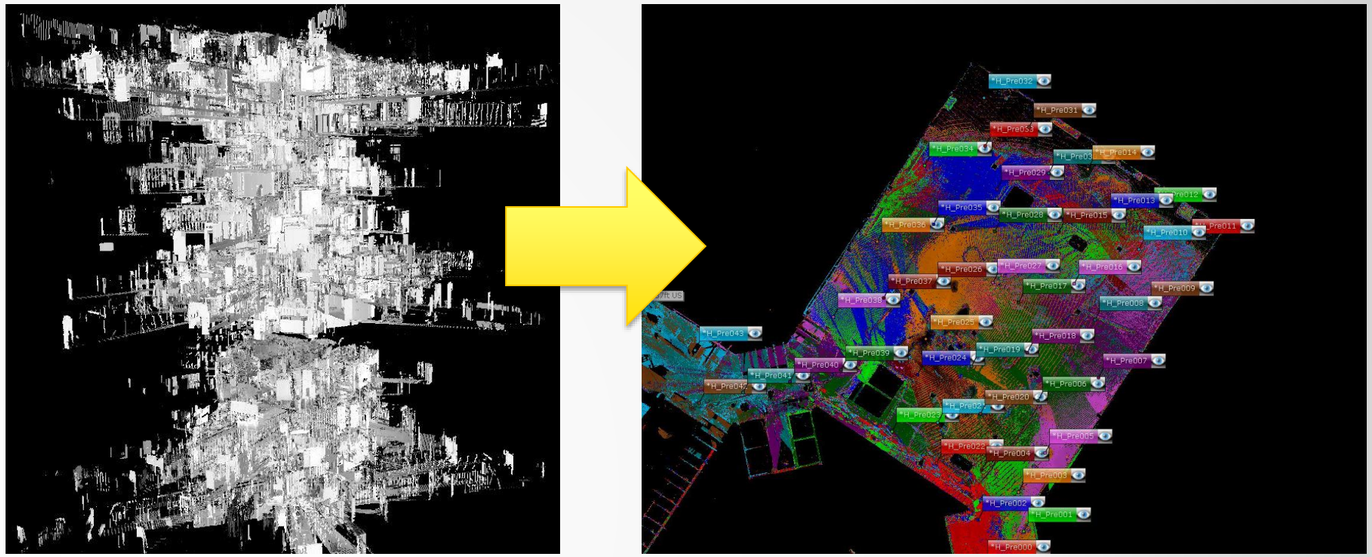
- 178,313 ft^2 & 11,326 LF Main Steel
- Fireproofing carried out before Post-Pour Camber scanning
- Had to poke through fireproofing & shoot elevations with Total Station
- 2 Man Crew (Chief Surveyor & Rodman)
- 334 Main Beams x3 (Shots/Beam) = 1,002 Shots
- 7 Mobilizations Over Span of 2 Weeks (112 In-Field Man-hours)
- Constantly battling line of sight between prism & Total Station (plethora of obstacles)



Target-Less Registration (Cloud to Cloud)

Benefits:

- Easier to Train
- More Free Time
  - Tracking/Planning
  - Simultaneous Scan/Registration



Pro-tips:

- >50% overlap each
- Scan at a faster rate (lower resolution), shorter distances
- Don’t go back to your old ways (higher resolution)
- Clustering/Grouping

80/20 Rule:
Field Scanning drives 80% of the results
Office Registration makes up 20%

Field Capture to Office Registration Ratio
1:2 → 1:1

Aligning Scan Data to Model Coordinates

Method 1: Survey Control ("Best Practice" or "The Divine Privilage")

Benefits:

- Potentially easier (with experience)
- Global Accuracy

Challenges:

- Potentially painful (in-experienced surveyor)
- Time/Schedule
- Expensive





Aligning Scan Data to Model Coordinates

Method 2: Field Grid Offsets and Benchmarks

Considerations:

- May not always be available

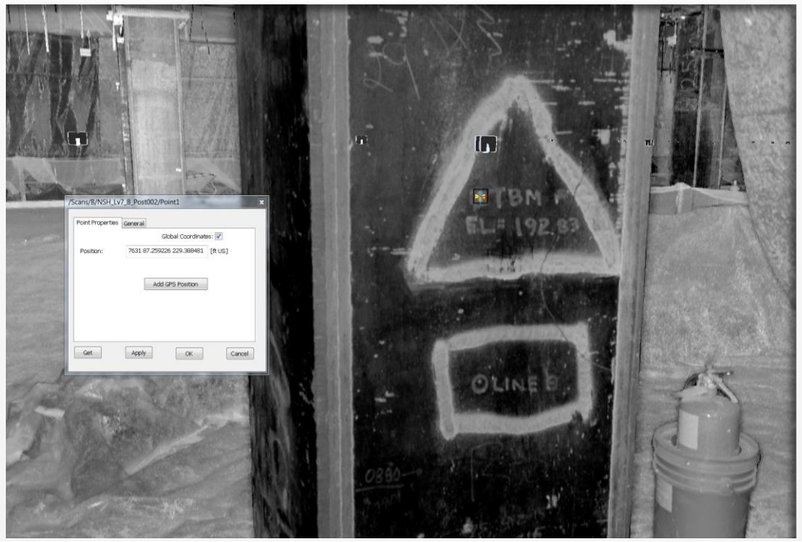
Benefits:

- No need for robotic Total Station
- $1200-$2000 cost savings per mobilization
- Prevent 1-3 days of delay



X

Y



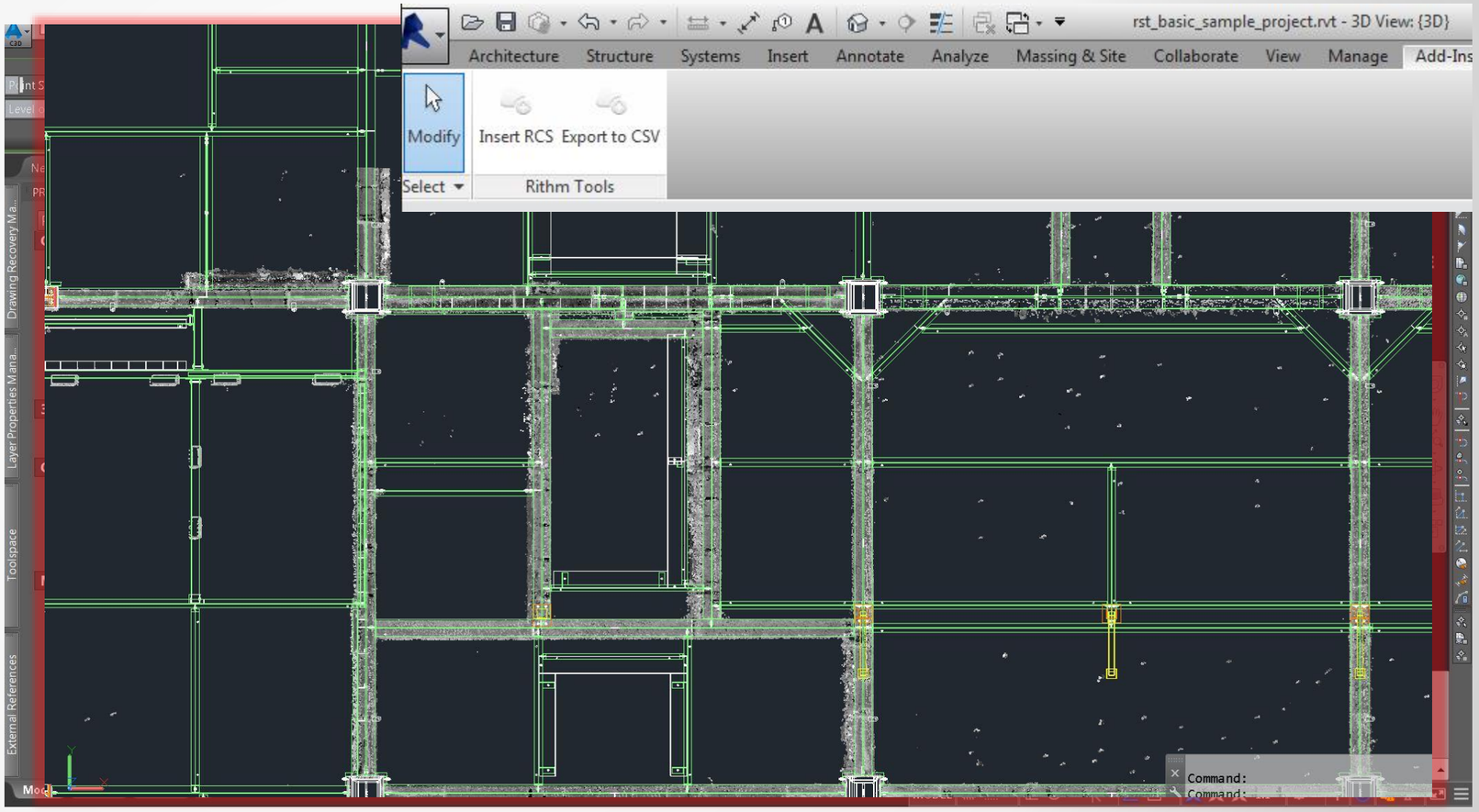
Z

Aligning Scan Data to Model Coordinates

Method 3: Model "Best Fit"

Considerations:

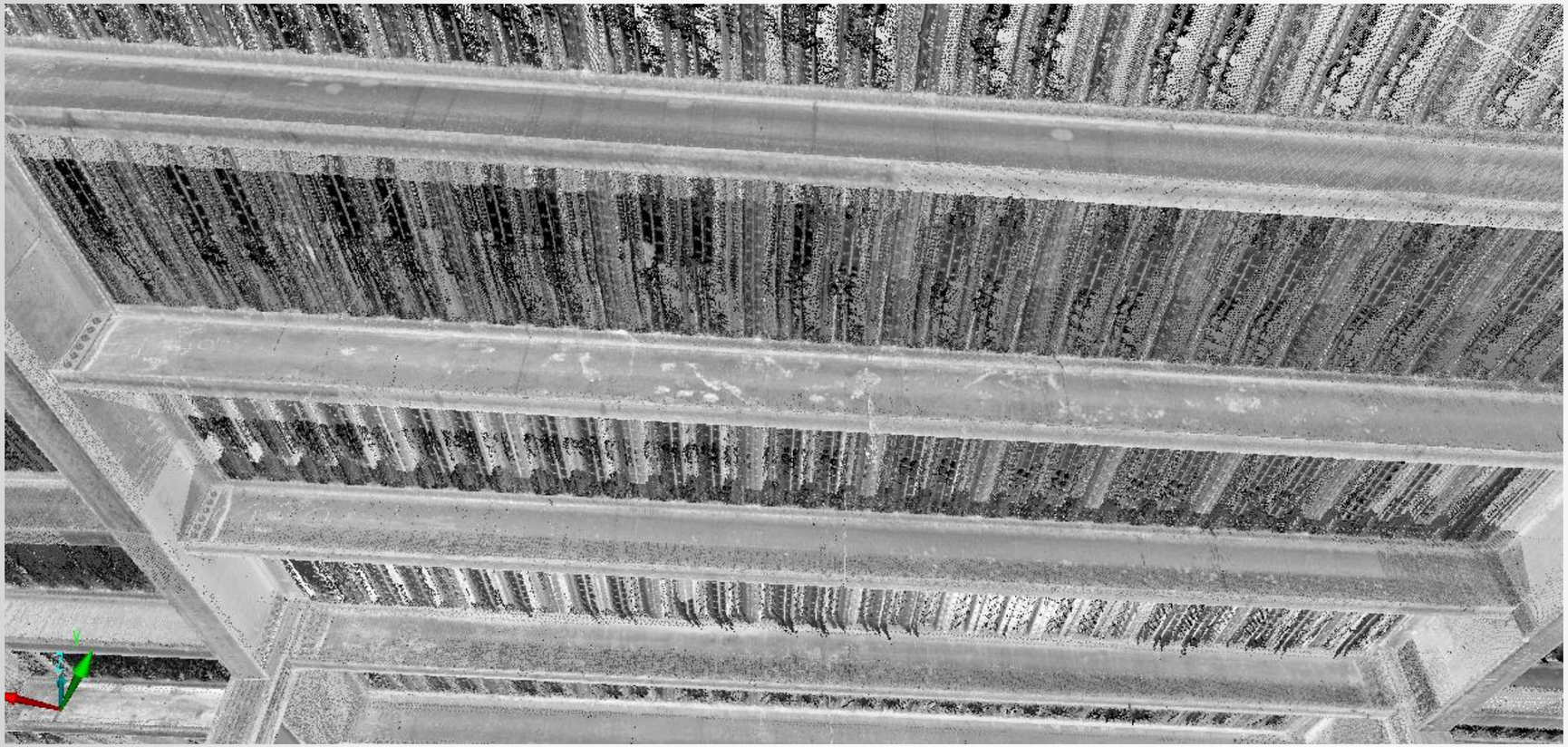
- Only for certain deliverables
- May be creating more liability
- Need to ensure scans are leveled



Benefits:

- Same cost and schedule benefits (if done right)
- Less field time

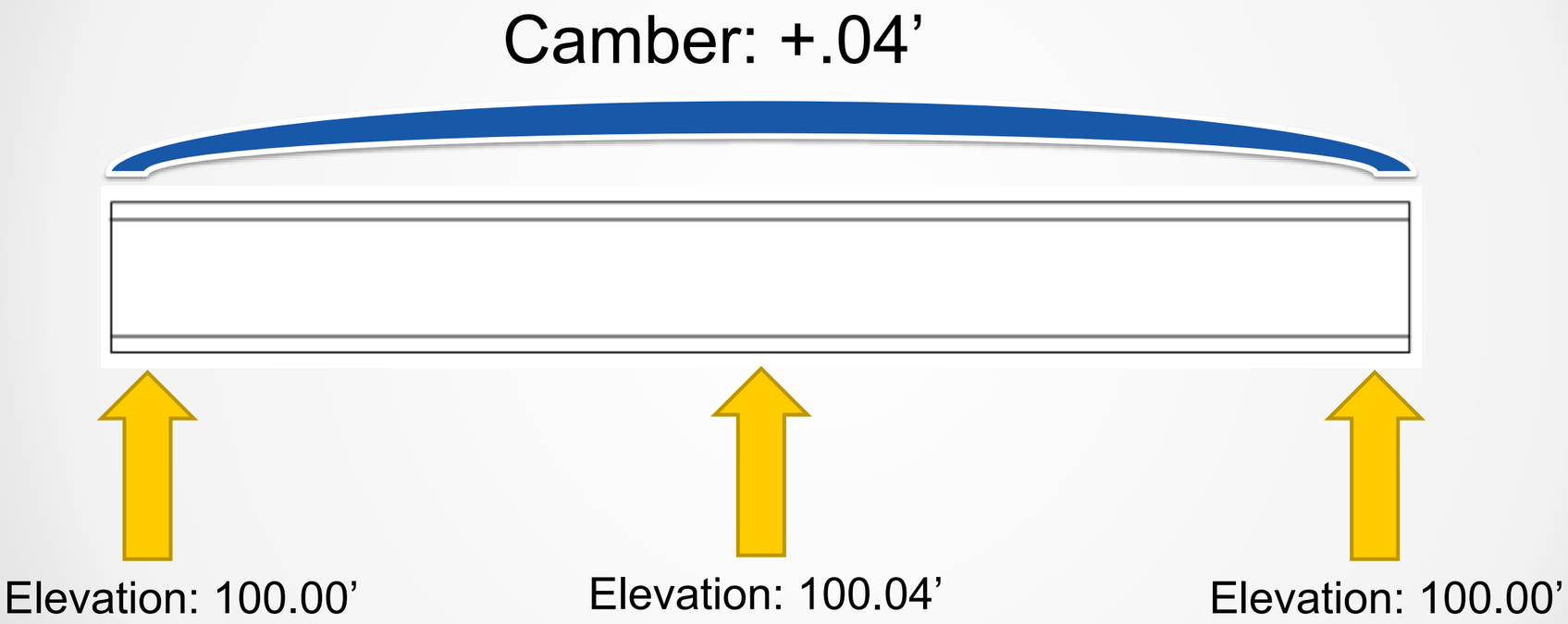
Structural Steel Deliverables



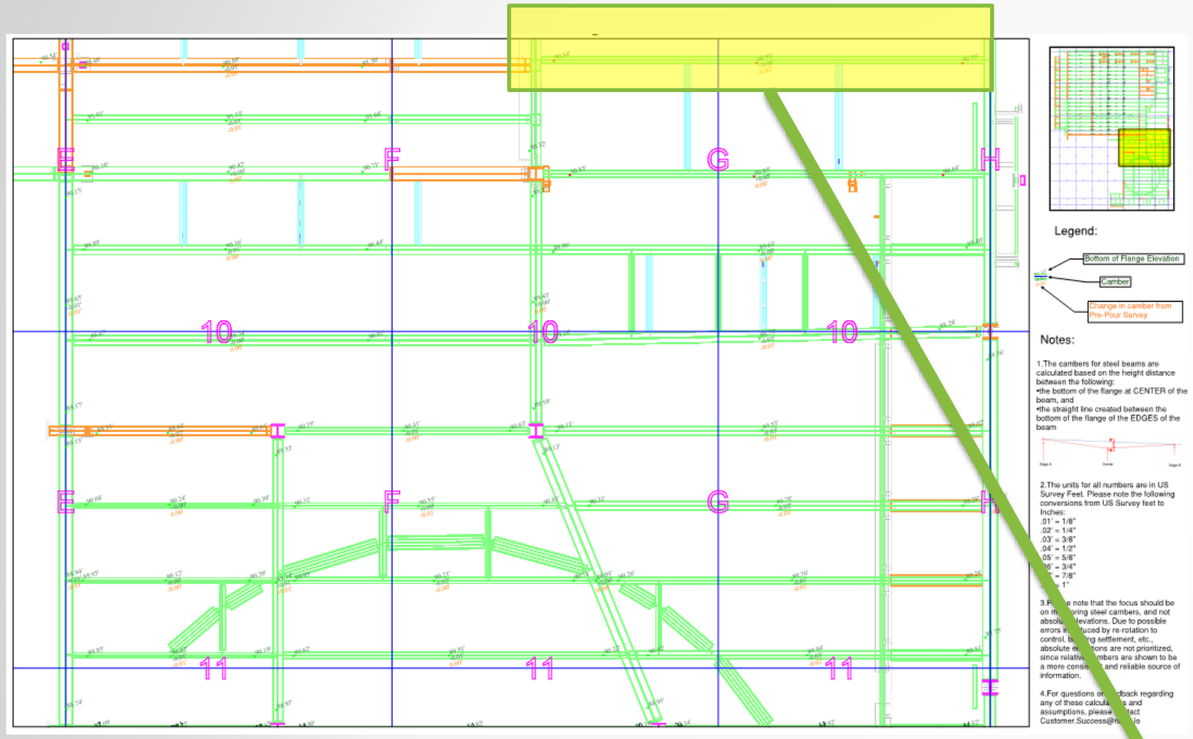
Steel and
Fabrication and
Erection Tolerances

Installation Cambers

Structural Steel Camber Analysis



Structural Steel Monitoring





- Pre: Verify Design Camber to <u>installation</u> of steel is correct
- Post: Ensure <u>performance</u> of steel is correct

Steel Monitoring – Design vs. Field Camber

Value

New Stanford Hospital Project

Palo Alto, CA

Level 3 Overhead Steel:

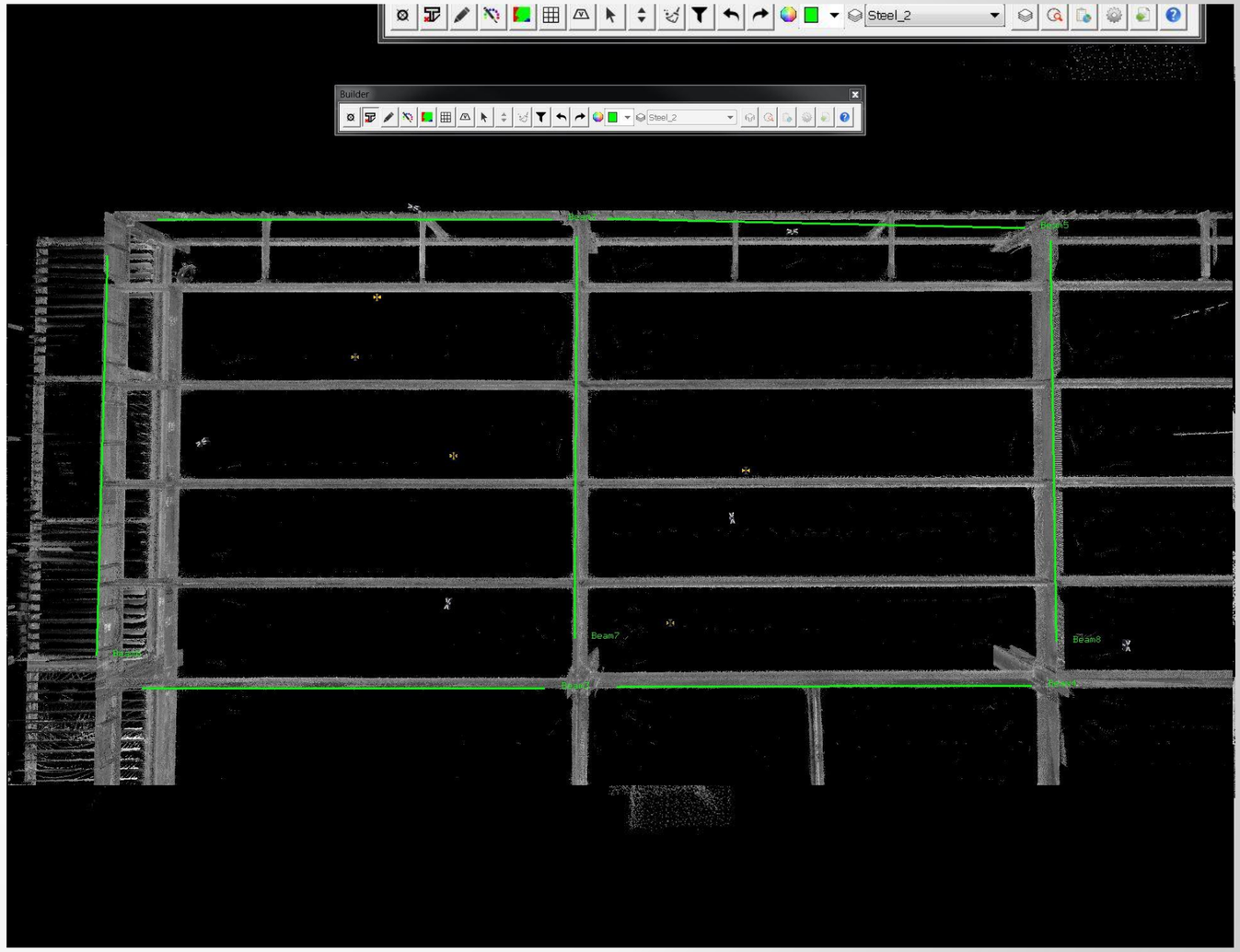
- 67,280 sq ft Concrete 4,368 LF Steel
- Distance from finish floor to steel = 30’

Total Station & Philly Rod Method

- 8 Mobilizations for 64 Manhours
- 3 Points on each main beam member

3D Laser Scanning

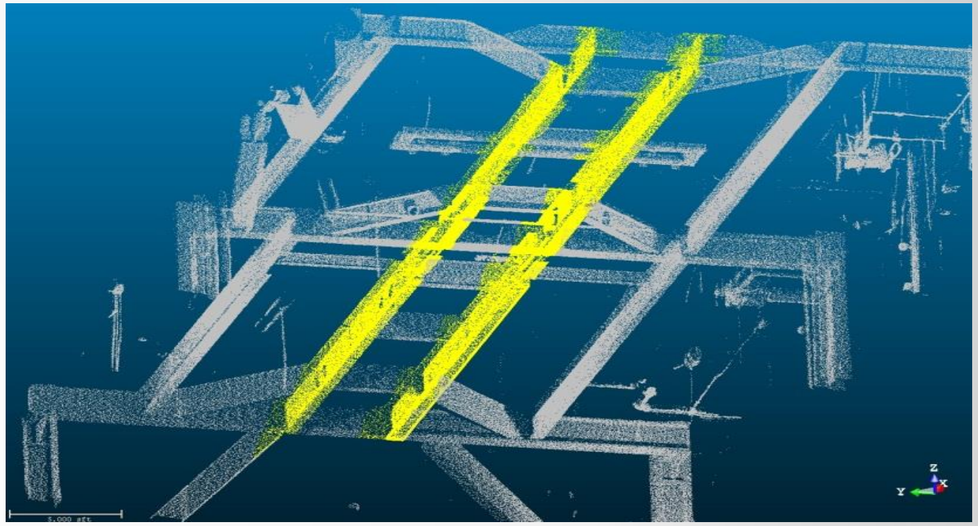
- 155 Scans for 13 Man Hours
- Captured 100% of existing structure (main beams, jr. beams, interstitial steel, Level 3 concrete floor data)
- Provided Point cloud for Beam Penetration Verification
- Allowed for Instant RFI Dimensioning Clarification

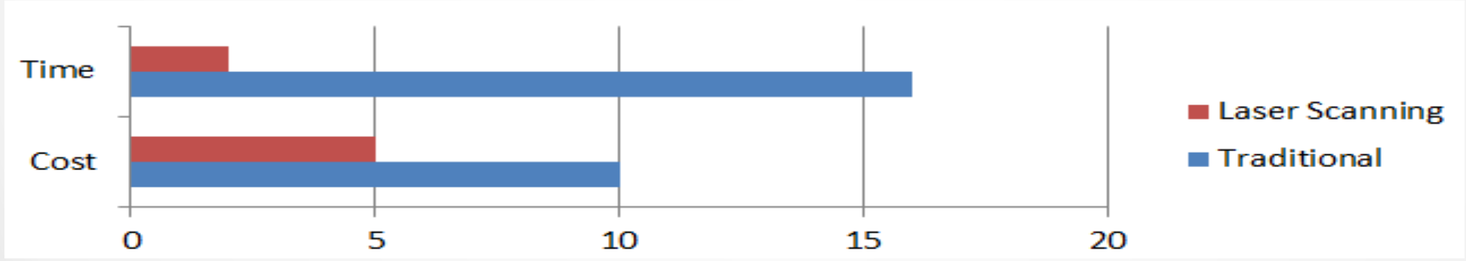


Intra-operative MRI system – Kaiser Oakland Medical Center



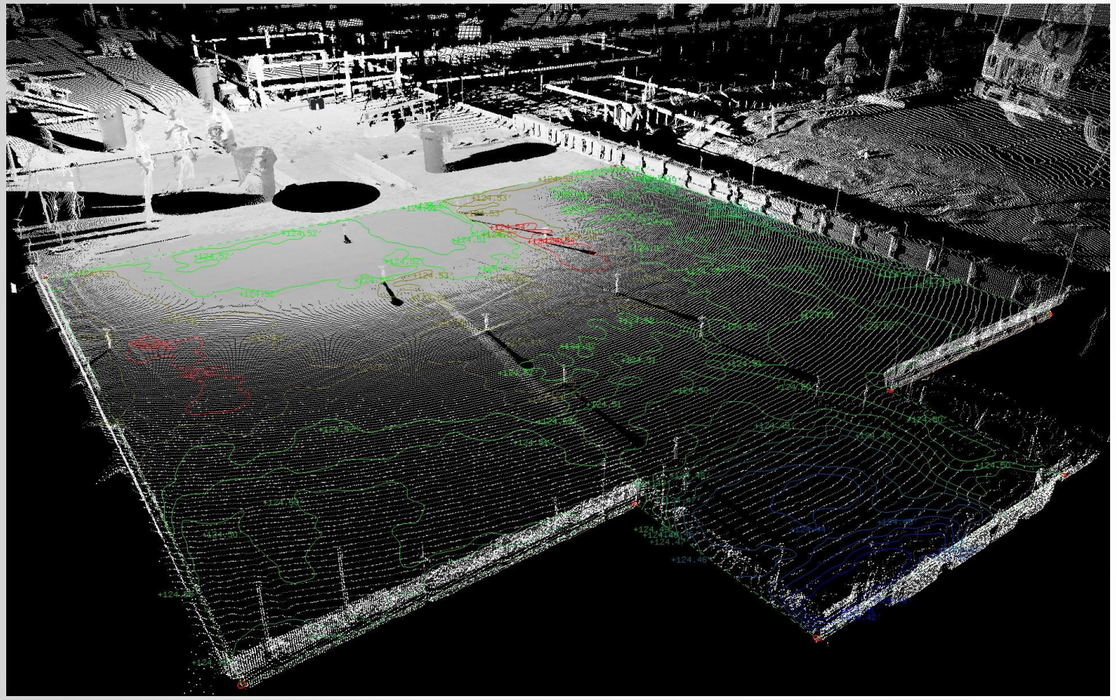


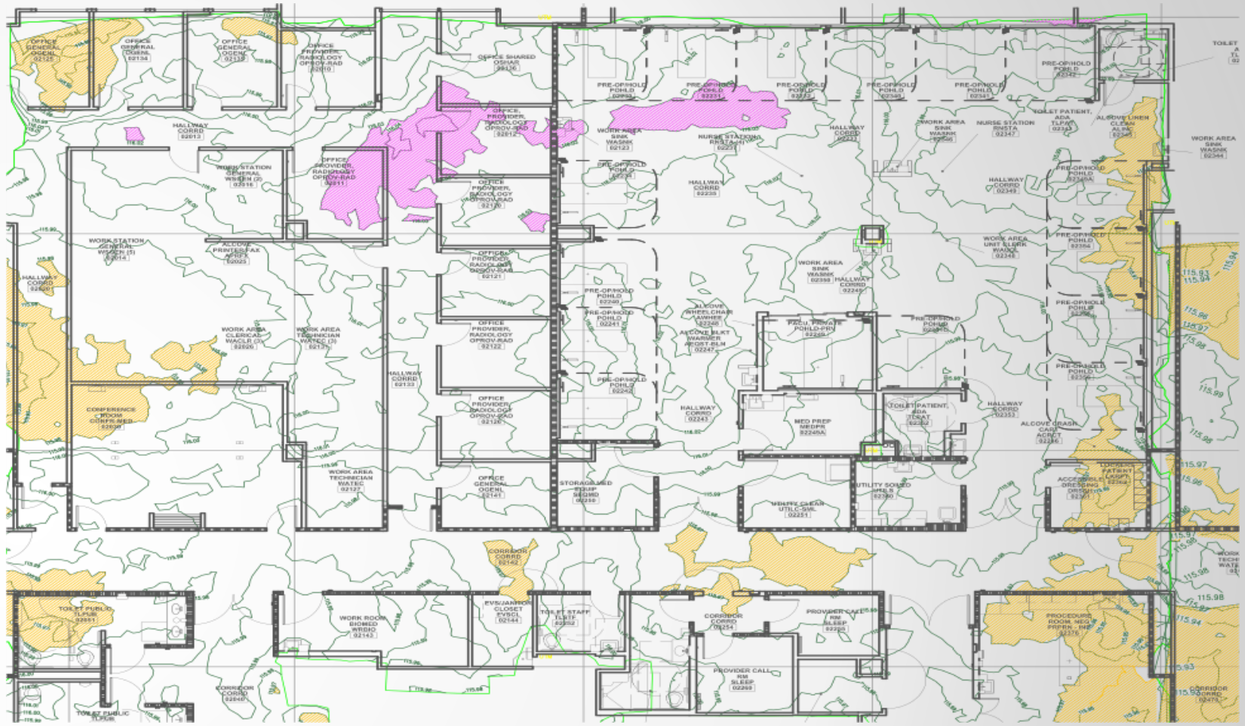




"IMRIS...alignment is within a millimeter of optimum. This is the best steel installation IMRIS has seen in the last five years of worldwide equipment placements." Jim Kautz, Sr. Project Manager, Kaiser Permanente National Facilities Services

Concrete Flatness – What is it?





American Concrete Institute®

+3/8 inch

-3/8 inch



Flooring Material:
$1-$2/square foot



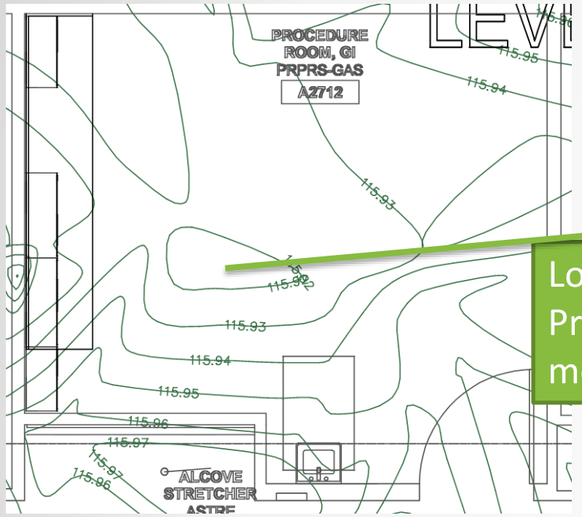


Concrete Grinding:
$4-$5/square foot

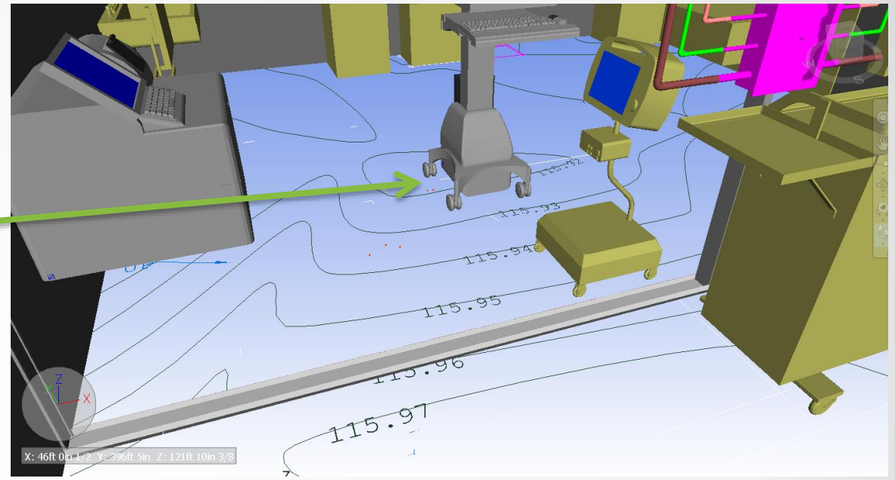


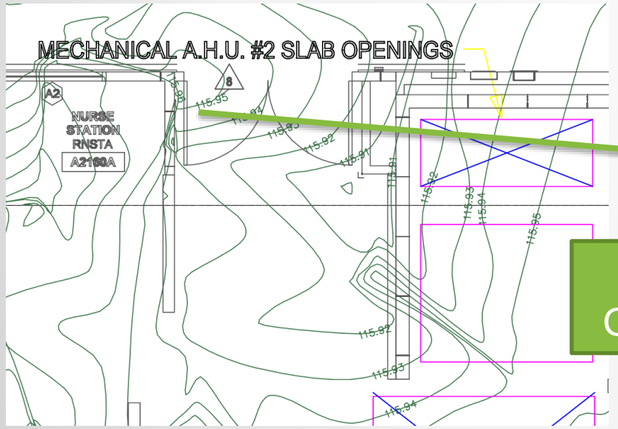
- Door Undercuts
- Deck to Deck Heights
- Prefabricated Walls with MEP

Value - Downstream Effects on Concrete

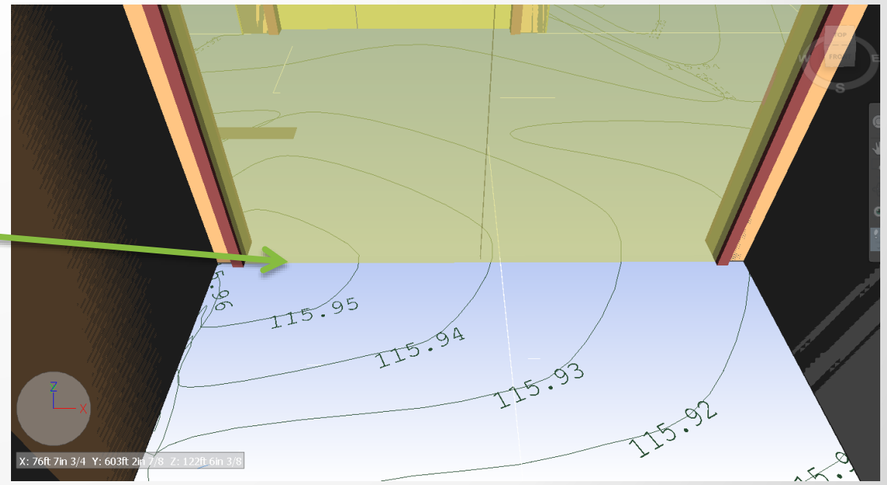


Low spots detected in Procedure Room, might affect mobile computer station





Pre-emptive Quality Control - Door-Swings



Where has McCarthy scanned Concrete?



Kaiser Oakland
13 levels - 980,000 sqft



Kaiser South Bay
4 floors, 320,000 sqft



Stanford Adult Hospital
8 levels - 824,000 sqft



UCSF Parnassus



UC Berkeley Lower Sproul



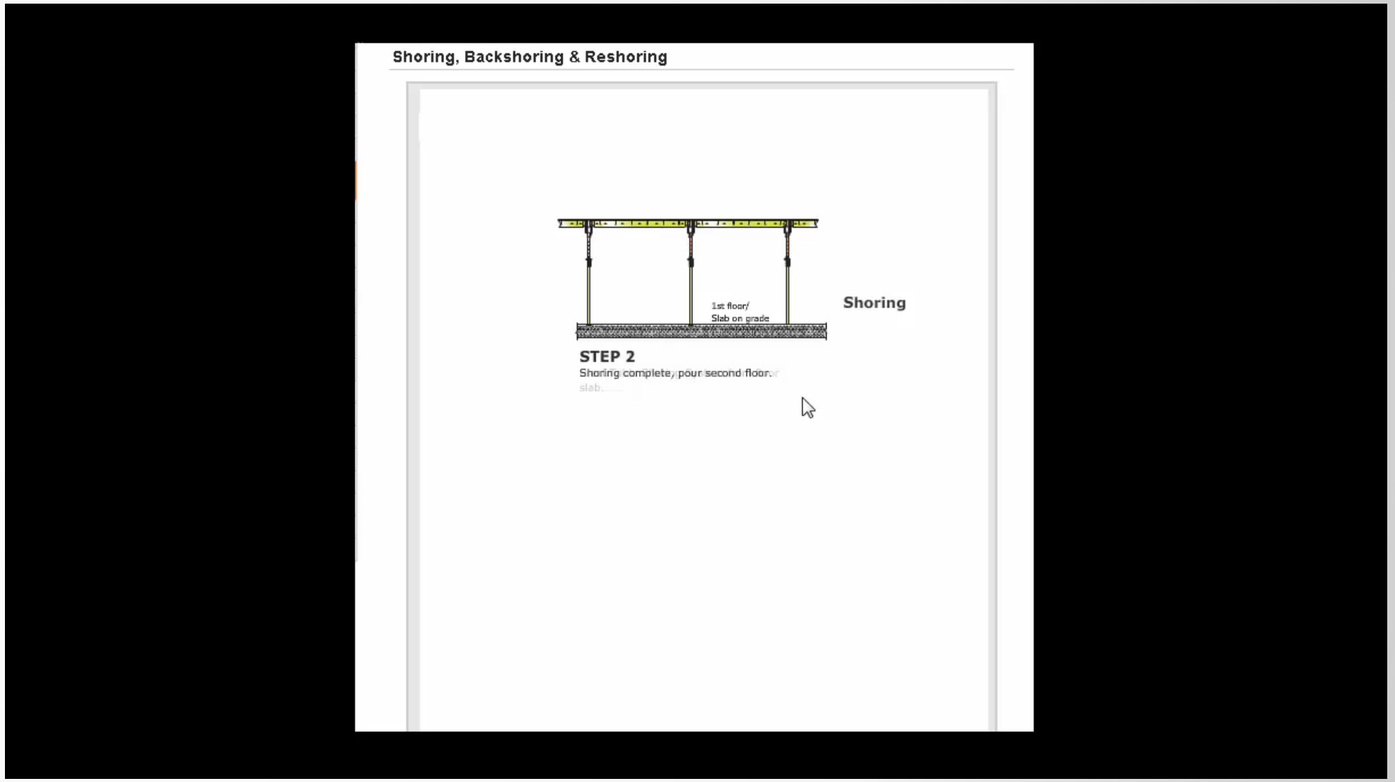
SF Bay Area Housing Authority

Many more to come…

Concrete Monitoring – Shoring/Reshoring Cantilever

What is it?

Cantilevered decking is reinforced with shoring, propping up the cantilevered end based on design deflection. The shoring transfers the loading down to the next level, hindering any downward displacement of the cantilevered section. Once the concrete is poured and reaches design strength, shoring is removed, allowing for downward displacement of cantilevered end. Following design parameters, if the initial upward deflection caused from propping up the deck equals that of design deflection from anticipated loading, the concrete floor will “settle” flush.



Concrete Monitoring – Shoring/Reshoring Cantilever

Case Study

New Stanford Hospital Project

Palo Alto, CA

Cantilevered Towers

- Level 4 Cantilevered at exterior 30’ bay
- Exterior bays were shored prior to concrete deck pours
- Once all pours were complete & concrete design strength reached for Levels 4, 5, 6, 7, and Roof, shoring was removed
- Initial Steel fabrication allotted for concrete floors to be curled 2” above design finished floor elevation from supported bays getting higher to cantilevered ends



Concrete Monitoring – Shoring/Reshoring Cantilever

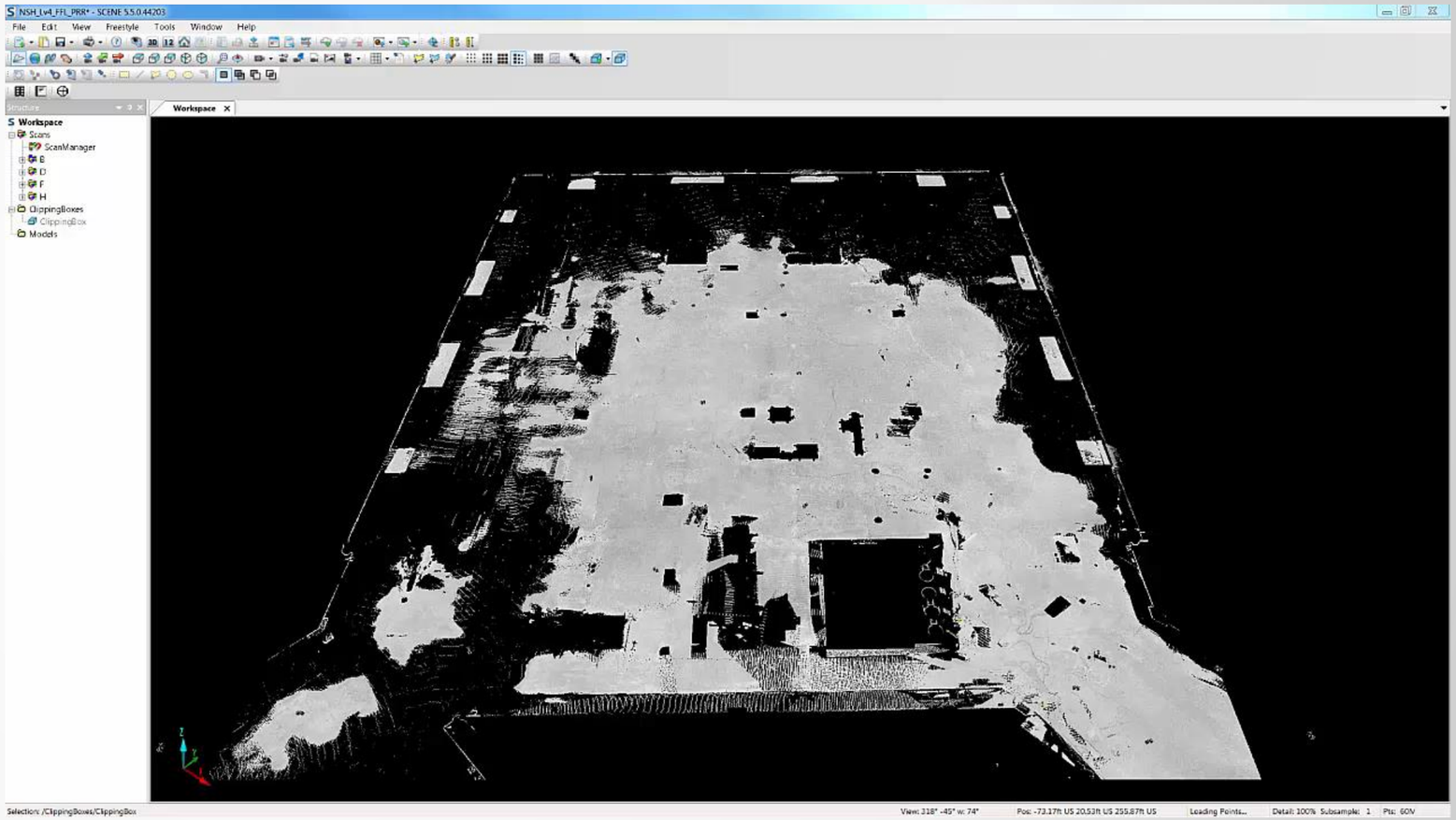
Case Study

New Stanford Hospital Project

Palo Alto, CA

Cantilevered Towers

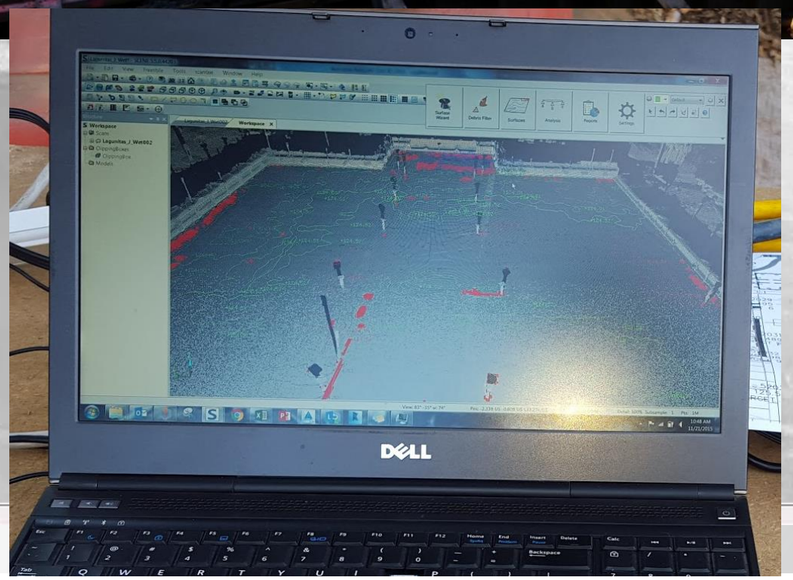
- Scanned for FF prior to shoring removal
- Check for rise in elevation between interior supported bays and exterior cantilevered sections
- Scanning for FF after shoring removal scheduled once total loading is applied
- Design theory stated once all loading complete and shoring removed, exterior Level 4 beams would deflect so the edge of concrete deck was at design finish floor elevation
- There is a large required deflection, we want to monitor to ensure deflection occurs according to plan



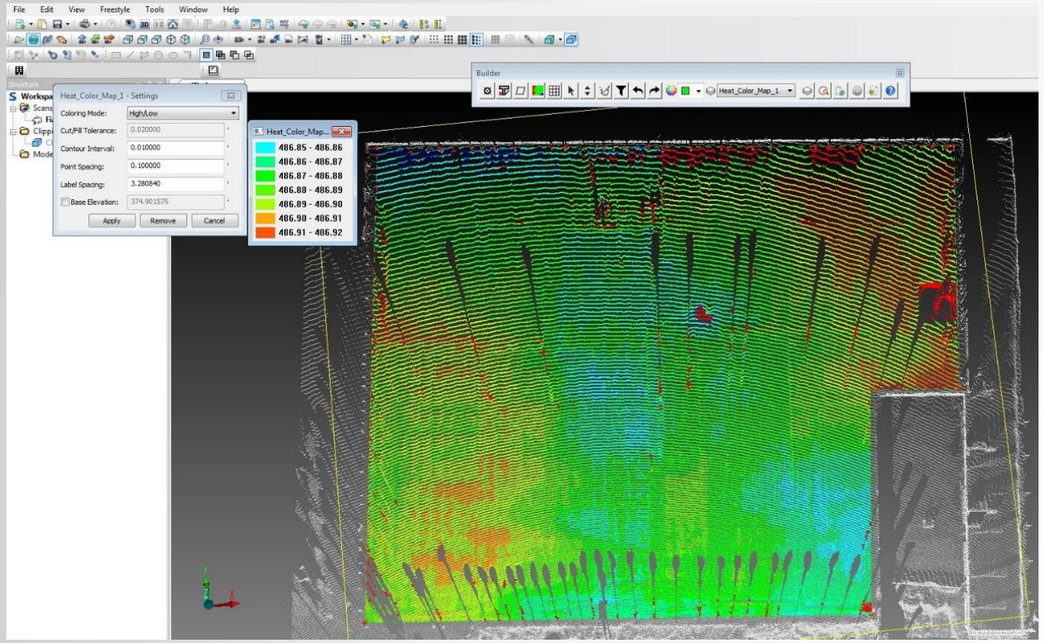
Wet Concrete

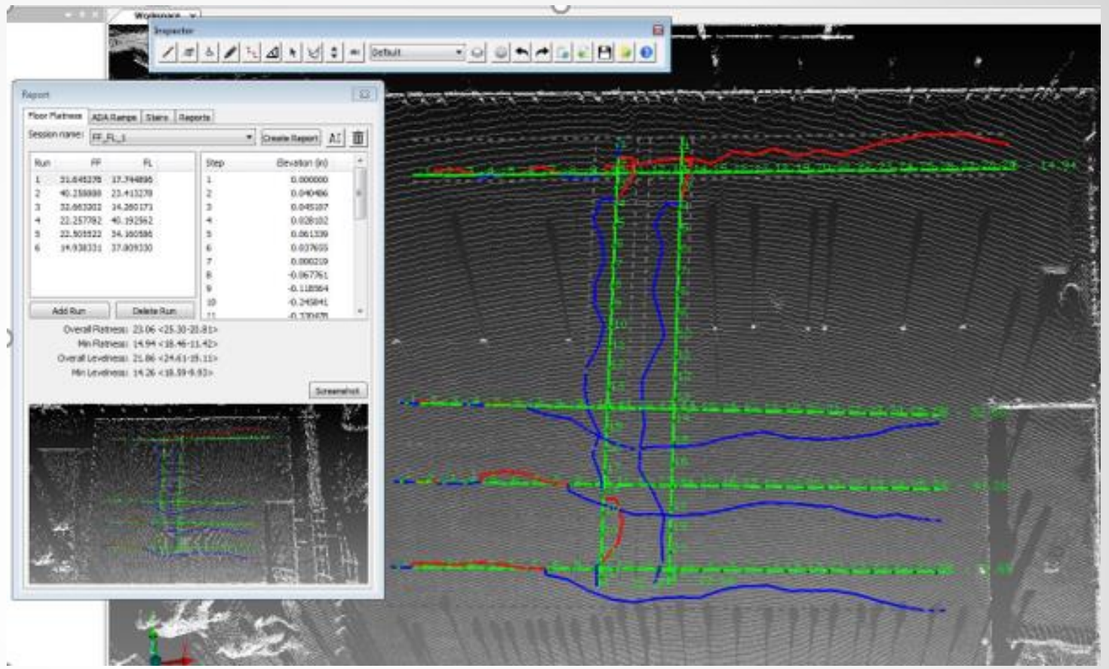
- One Scan Workflow
- No Registration
- Feedback to concrete crew
- Positive Correlation between fixing and next day condition
- <7 minute from scan to deliverable





Building Code Compliance





Down/Out Measurements

American Concrete Institute®

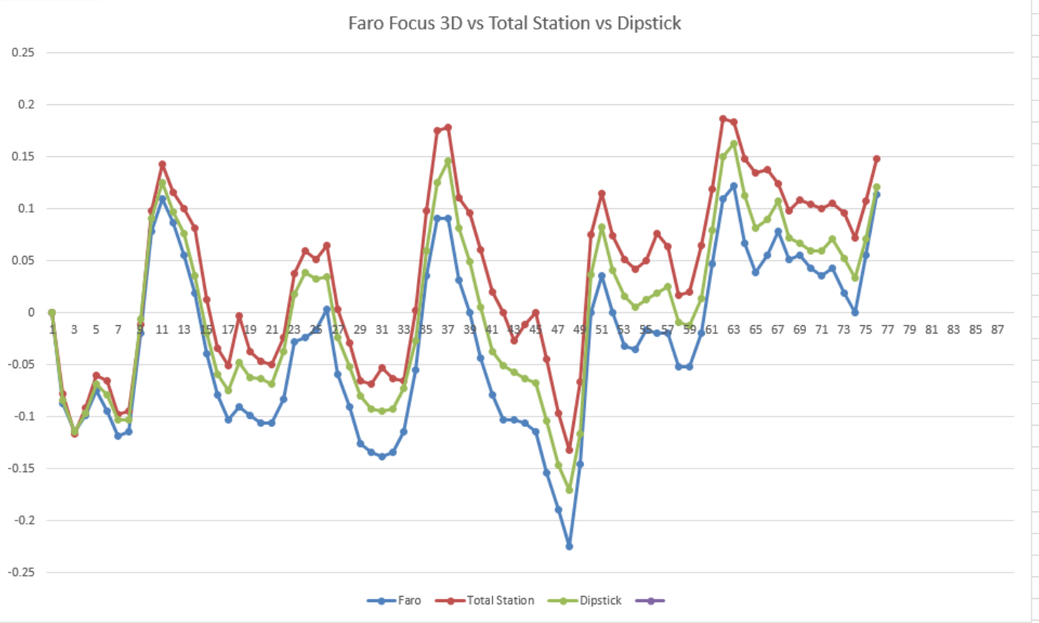
Achieve better FF/FL Results the next day = Passed Inspections

- FF20
- FF50
- FF 90

ASTM INTERNATIONAL

ASTM 1155 Floor Flatness

Well known laser screeding company ran FARO next to a Dipstick® floor profiler and a total station

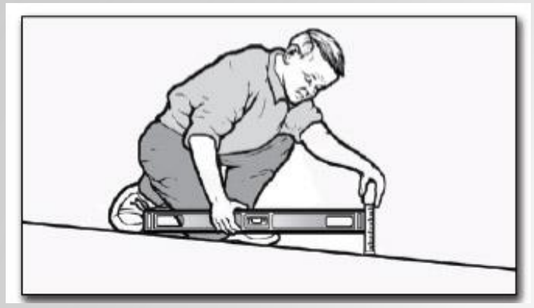


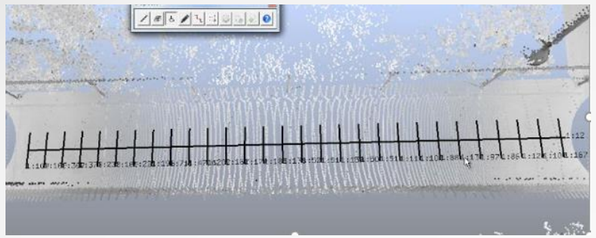
	Faro	Total Station	Dipstick
FF Values	36.02	35.99	36.37
Faro vs Dipstick Difference	1%		

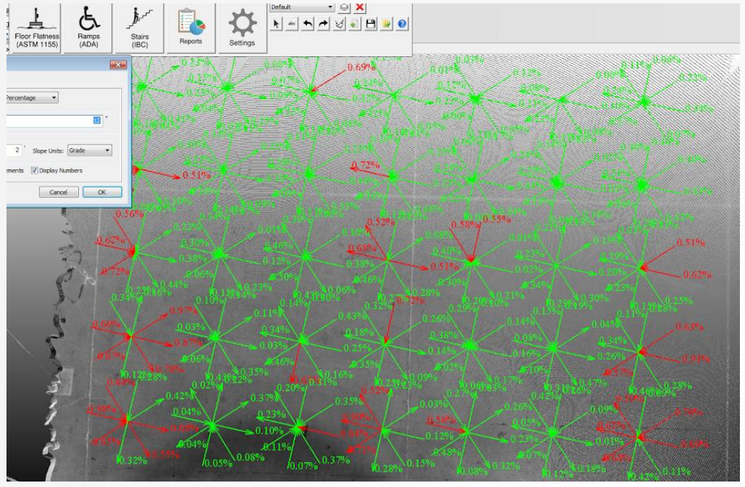
F – number comparison

- FARO F_F =36.02
- Total Station F_F = 35.99
- Dipstick ® F_F = 36.37

- Result: 1% difference between FARO and floor profiler
- ***Now official ASTM 1155 (2014)***
- Compare to $2000-$3000 per mobilization to conduct FF/FL Test by 3rd party inspection company



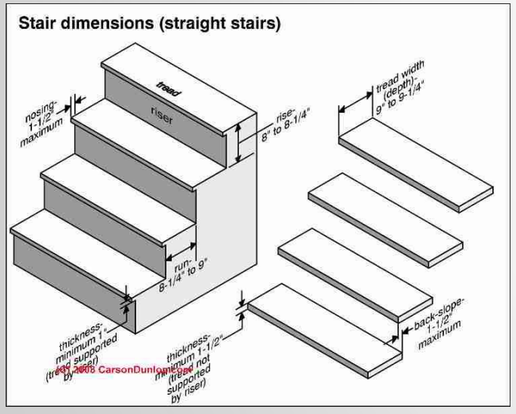


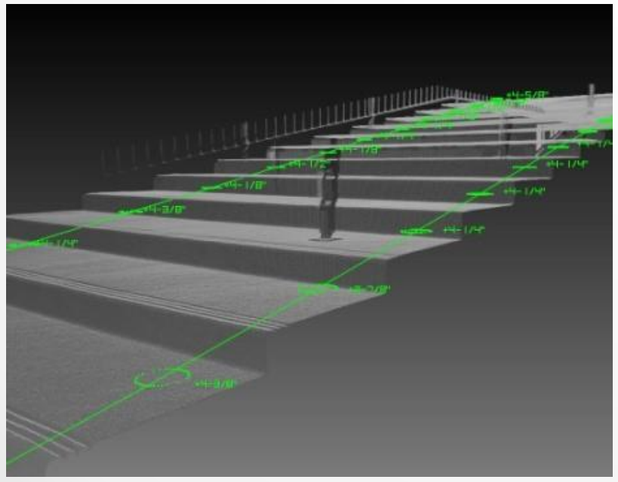


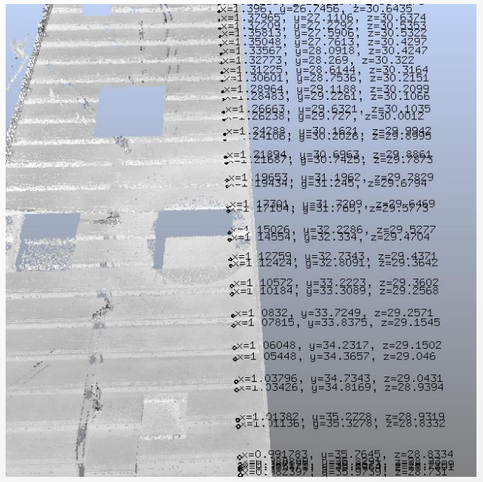


Why?

- Pass Inspection
- Prevent Litigation

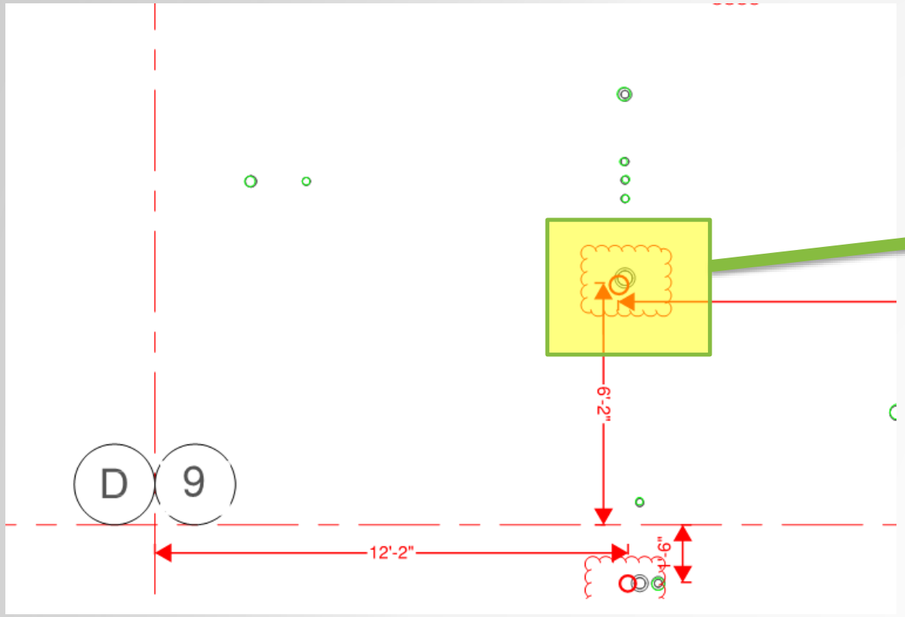








UC Berkeley Lower Sproul
Fire-Marshall Initiated Stair Survey





Case Study:
Kaiser Oakland Medical Center

- Hundreds of penetration/Floor
- Additional drilling required for major penetration offsets ($900-$2300 per mistake)
- Cost + Schedule Impact

Cost Analysis – Scan vs no scan
$900-$2300 per mistake (overall + downstream effects)
$2000-$3000 per entire floor of scanning
10 mistakes prevented = ~5x-10x ROI

How you can contribute – New Standard Creation



“Level of Accuracy”



E06 Committee

ReCap

- Current State of the Industry
- Why Scan during Construction?
- Best Practice Workflows
- Benefits
- Code Compliance
- How you can contribute

Questions?



Joshua Engelbrecht

VDC Engineer

Jengelbrecht@McCarthy.com



Philip Lorenzo

Product Manager

Philip@Rithm.io

Booth: 1131