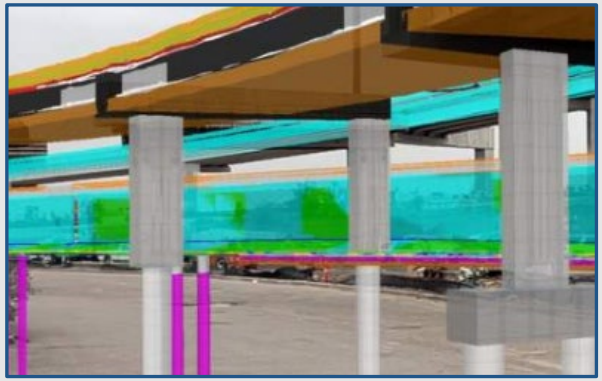


3D Technology Solutions in Construction

Verification of Retaining Wall System

TEAM Conference
Branson, MO
March 14, 2024

Gregory Cleveland, PE, CCM
SAM

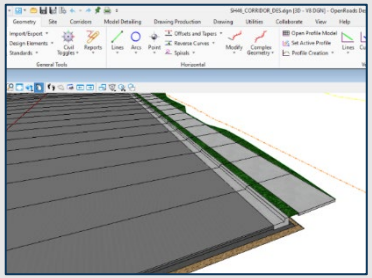
Table of contents

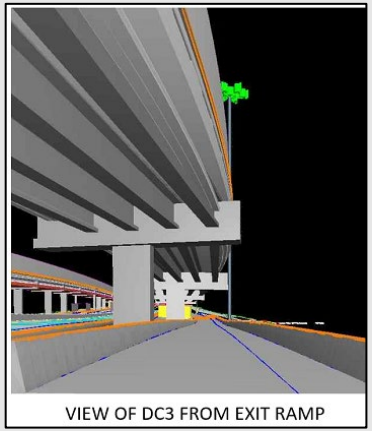
What is 3D Technology Solutions for Construction?

- In general, 3D technology enhances a traditional 2D view or model to provide a more realistic view
- 3D software and 3D scanning are helping to improve safety, productivity and quality during construction phase operations
- Key Benefits of 3D Construction:
  - Conceptually view project features in the field
  - Compare as-built versus as-designed
  - Make insightful decisions timely
  - Improve construction quality

Establishing TxDOT Pilot Projects

- TxDOT is embracing Digital Delivery
  - 3D plans using Bentley's OpenRoads Designer
  - Machine models for construction
- Created 3D Construction Inspection Pilot Projects
- Goals:
  - Evaluate readily available 3D technology
  - Compare as-built versus as-designed
  - Evaluate precision and accuracy
  - Assess ease of use

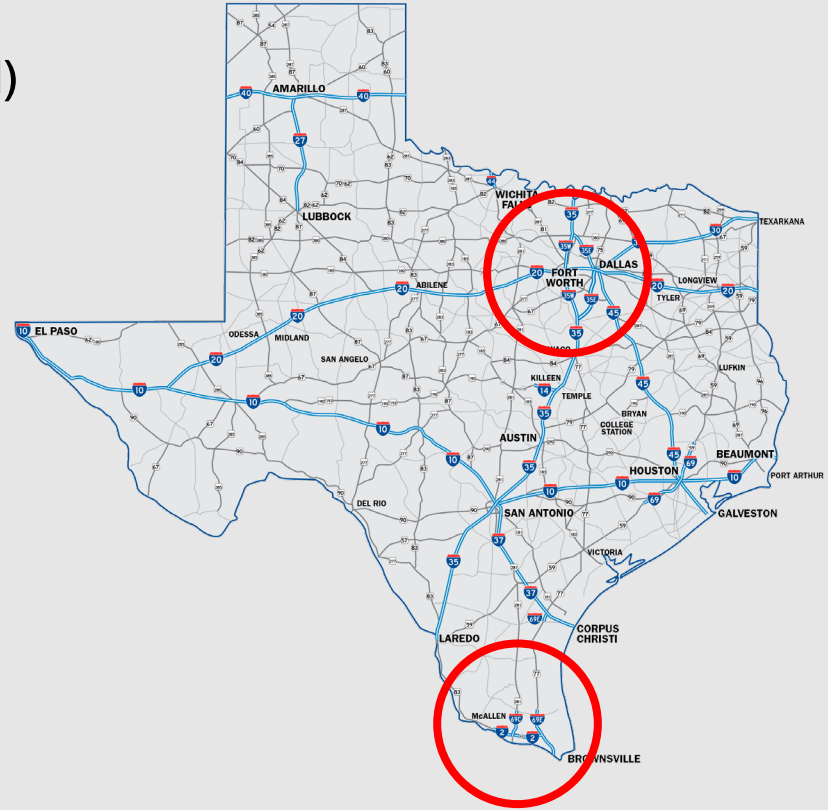




VIEW OF DC3 FROM EXIT RAMP

Establishing TxDOT Pilot Projects

- I-2/I-69C Design-Build Interchange ($303M)
  - TxDOT Pharr District
  - 4 DC's and associated roadways
  - Pilot: May 2023
- Southeast Connector Design-Build ($1.6B)
  - TxDOT Fort Worth District
  - Widening of I-20, I-820, US 287
  - Pilot: August 2023



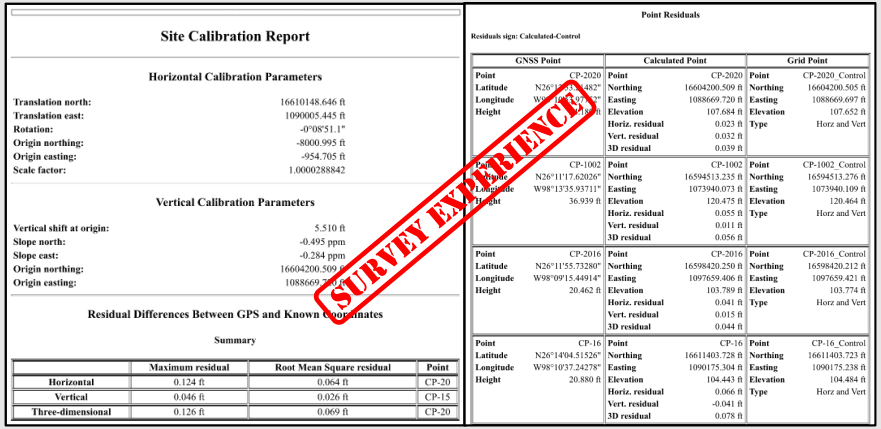
Technical Working Group and 3D Technology Evaluated

- Technical Working Group (TWG) Established
  - Weekly meetings at first; moving to bi-weekly
  - Coordination/communication between TxDOT Districts and Divisions (ALD/CST), DB Contractor, Surveyors, and Vendors
  - Preconstruction, Construction, Post-Construction phases
- Trimble SiteVision → Visualization tool using mixed reality and ORD plans
- Pix4D with viDOC → Photogrammetry & LiDAR based technology
- Bentley Synchro → Inspection forms tied to element and P6 schedule

Trimble SiteVision (Preliminary Findings)

- Preconstruction Phase Tasks
  - Equipment delivery/setup/training takes time to learn
  - ORD file transfer to Trimble Connect requires ORD experience
  - Equipment site calibration
    - Compared project survey control well within 0.1 foot
    - Be aware of obstructions
    - Survey experience required

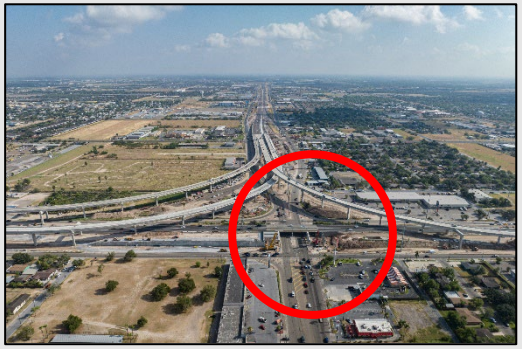
Trimble SiteVision User Guide

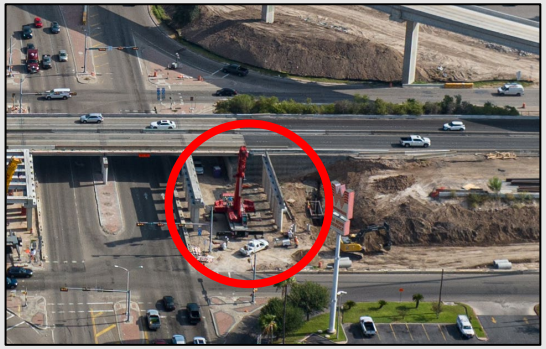


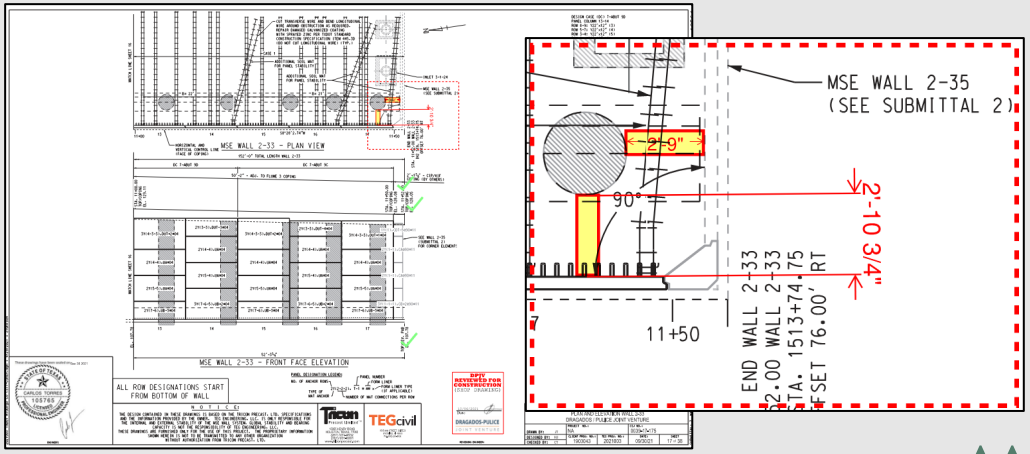
Site Calibrations with SAM and DB Contractor Surveyors

Trimble SiteVision (Preliminary Findings)

- Preconstruction Phase Tasks
  - Retaining Wall 2-33 & 2-35
  - Review bridge plans and retaining wall shop drawings
  - Measurements to the back of proposed retaining wall panels from the drilled shaft extensions

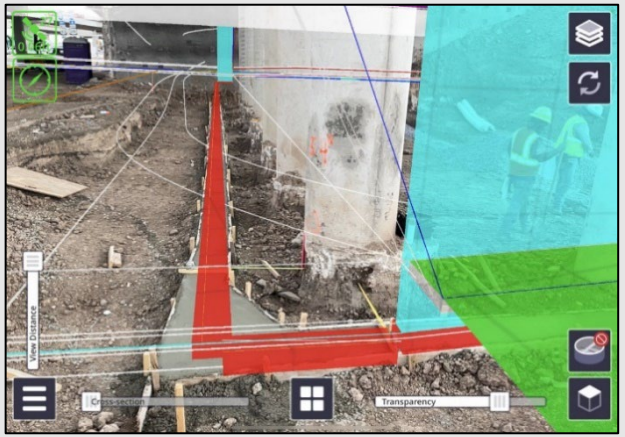






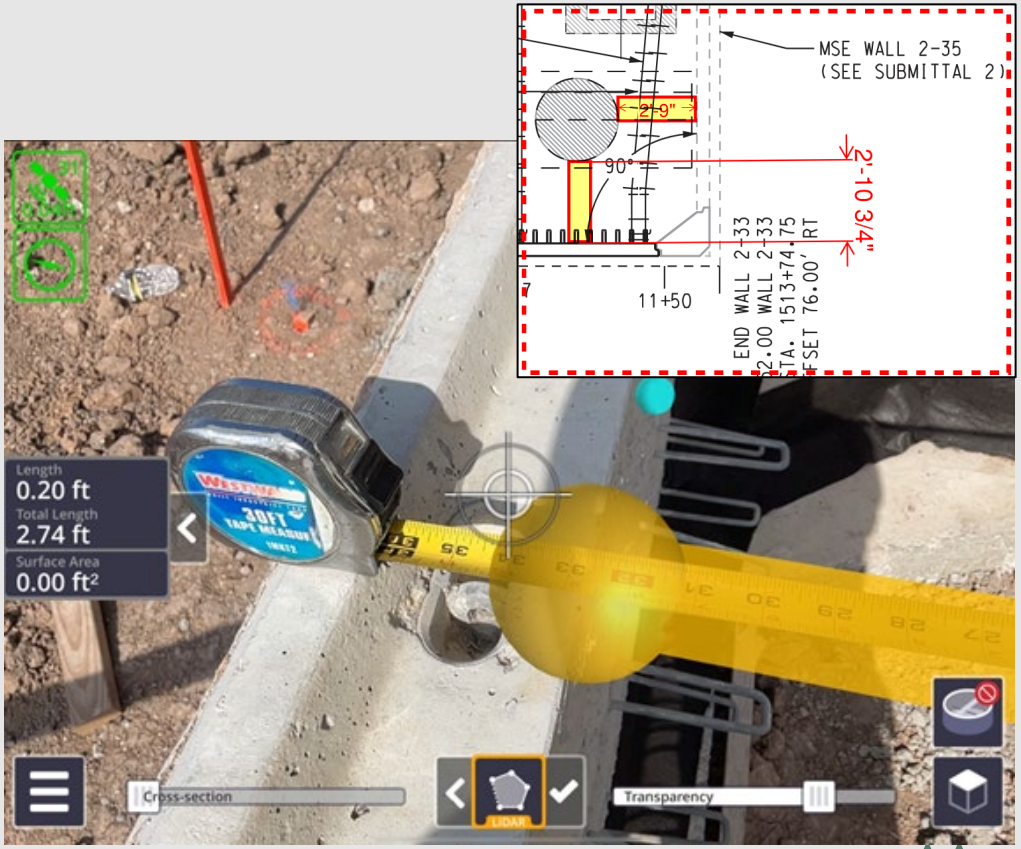
Trimble SiteVision (Preliminary Findings)

- Construction Phase Tasks
  - <u>Verify leveling pad layout</u>
  - Measuring tape was used to verify Trimble measurements
  - Pulled tape from the edge of the drilled shaft to the proposed back of panel
  - Trimble depicts leveling pad is at the right location



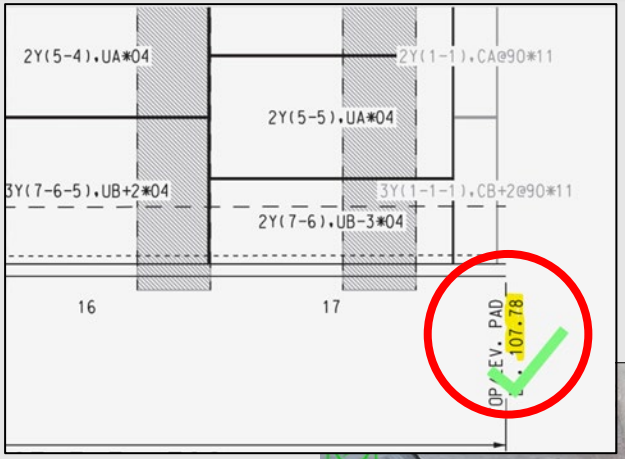
Trimble SiteVision (Preliminary Findings)

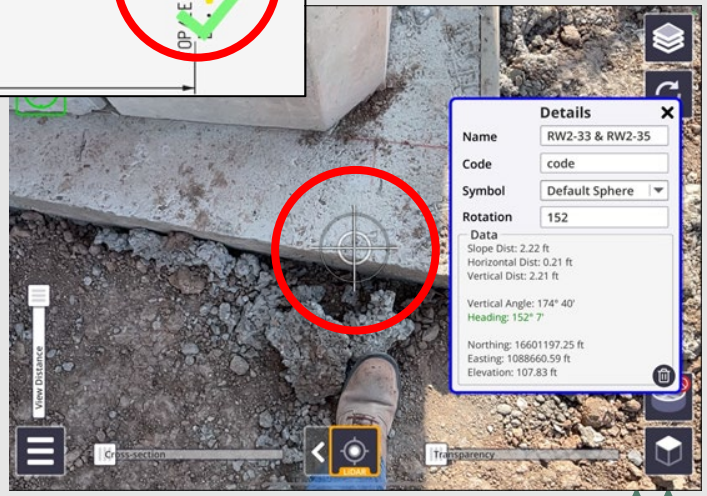
- Construction Phase Tasks
  - <u>Verify placement of panel</u>
  - Plan dimension is 2.75’ (2’-9”)
  - Trimble measurement is 2.74’
  - The placement of the panel is acceptable



Trimble SiteVision (Preliminary Findings)

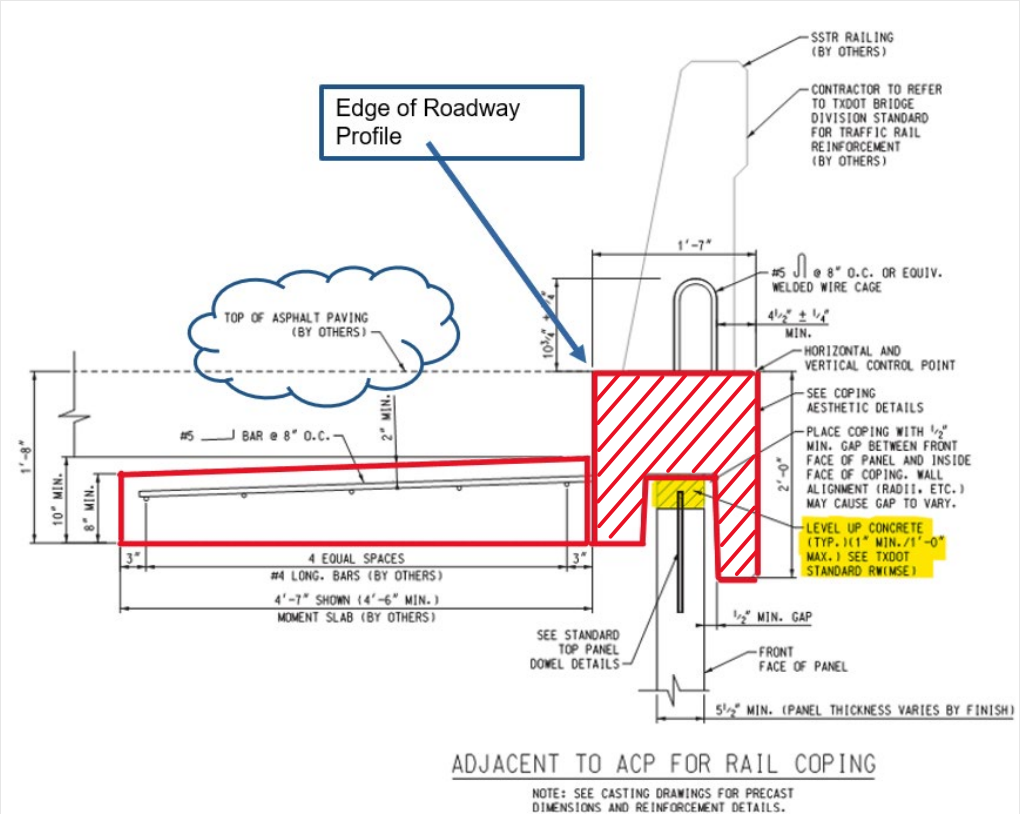
- Construction Phase Tasks
  - <u>Verify elevation of leveling pad</u>
  - Plans elevation = 107.78’
  - Trimble elevation = 107.83’
  - Leveling pad is 0.05’ above plan elevation
  - Elevation of leveling pad is considered acceptable



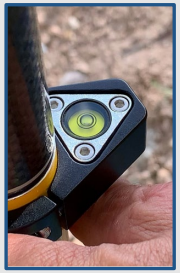


Trimble SiteVision (Preliminary Findings)

- Construction Phase Tasks
  - <u>Review Edge of Roadway Profile</u>
  - Prior to paving operations
  - GNSS measurements performed
  - Interface between coping and hot-mix pavement
  - Comparison made to elevations from as-designed cross-sections



Trimble SiteVision (Preliminary Findings)



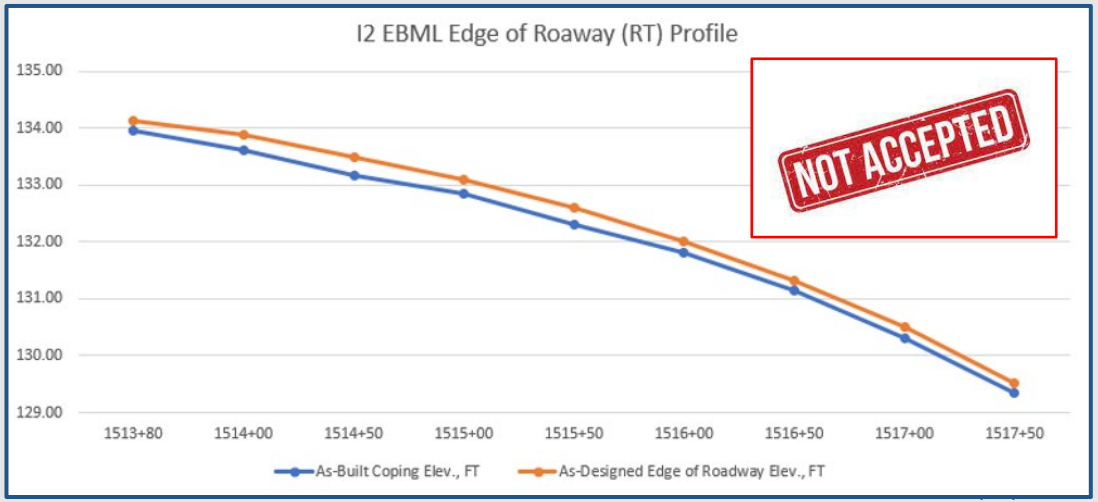
Benchmark # 2
Actual Elevation = 110.01’
GNSS Elevation = 110.00’

Benchmark # 3
Actual Elevation = 108.61’
GNSS Elevation = 108.62’

Trimble SiteVision (Preliminary Findings)

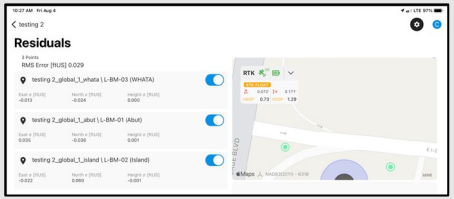
- Construction Phase Tasks
  - <u>Edge of Roadway Profile Review</u>
  - Actual profile is 0.23’ or 2.76” lower than as-designed
  - Critical Hold Point Inspections
    - Elevation of leveling pad
    - Tolerances between panels
    - Coping level up concrete

Station	As-Built Coping Elev., FT	As-Designed Edge of Roadway Elev., FT	As-Built to As-Designed Delta, FT
1513+80	133.96	134.14	-0.18
1514+00	133.62	133.89	-0.27
1514+50	133.17	133.49	-0.32
1515+00	132.85	133.10	-0.25
1515+50	132.31	132.6	-0.29
1516+00	131.81	132.01	-0.20
1516+50	131.14	131.32	-0.18
1517+00	130.32	130.50	-0.18
1517+50	129.34	129.53	-0.19
		Average --->	-0.23



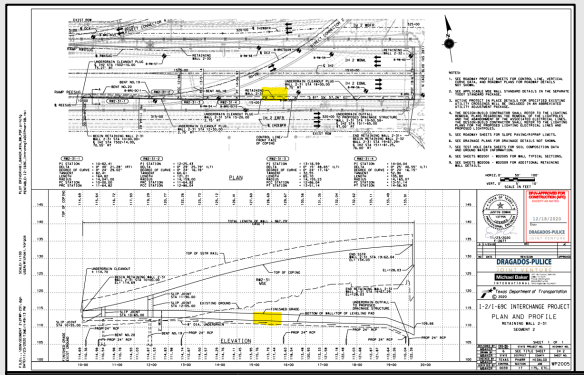
Pix4D (Preliminary Findings)

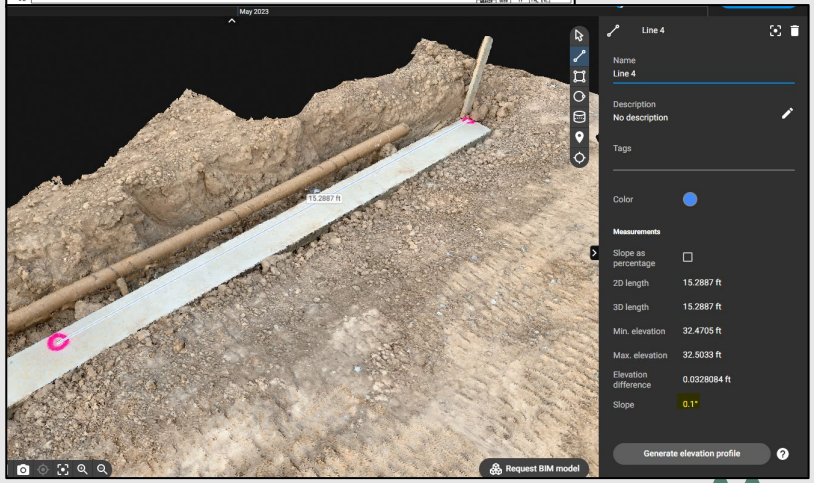
- Preconstruction Phase Tasks
  - Equipment used viDoc RTK Rover, iPad Pro and the Pix4D application
  - Obtained localization file from DB Contractor and scanned benchmarks to verify calibration of equipment
  - Calibration was an issue and worked with Vendor to resolve
  - Scans of retaining wall features to verify prior to panel placements



Pix4D (Preliminary Findings)

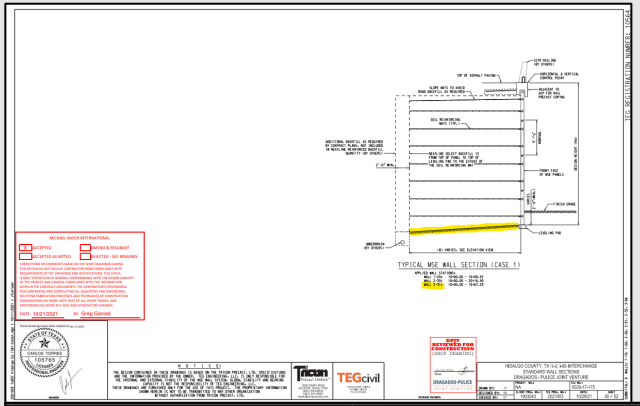
- Construction Phase Tasks
  - <u>Verify levelness of leveling pad</u>
  - Spec: no more than 1” plastic shim height is used
  - Scan performed and measured
    - Slope = 0.2%
    - Elevation difference = 0.39” < 1”
  - Leveling pad is considered level





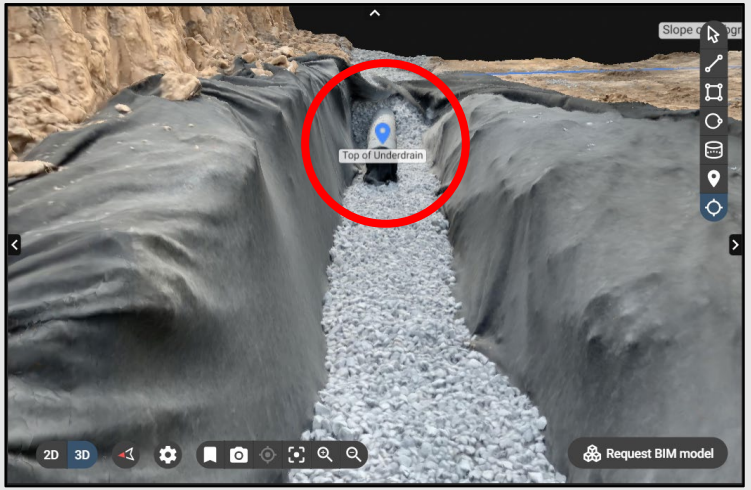
Pix4D (Preliminary Findings)

- Construction Phase Tasks
  - <u>Verify slope direction of subgrade</u>
  - Line was drawn between top of leveling pad toward the underdrain area
  - Elevation difference = 0.57’
  - Subgrade is sloping correctly



Pix4D (Preliminary Findings)

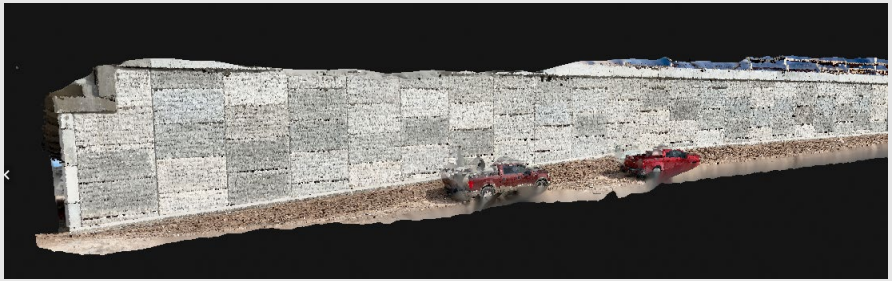
- Construction Phase Tasks
  - <u>Verify underdrain is lower than subgrade</u>
  - Measured using point feature with elevation difference = 1.24’ lower

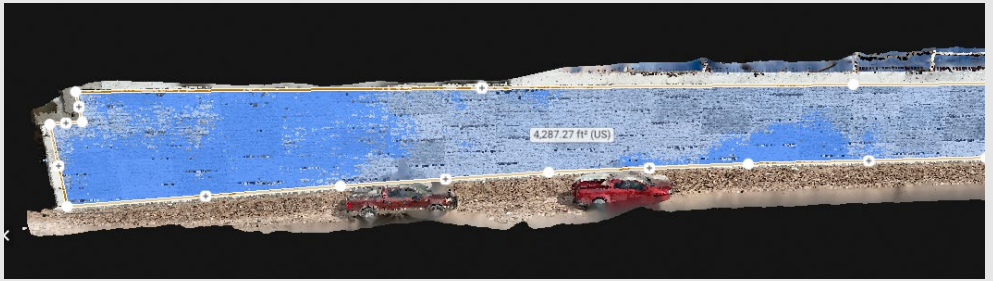


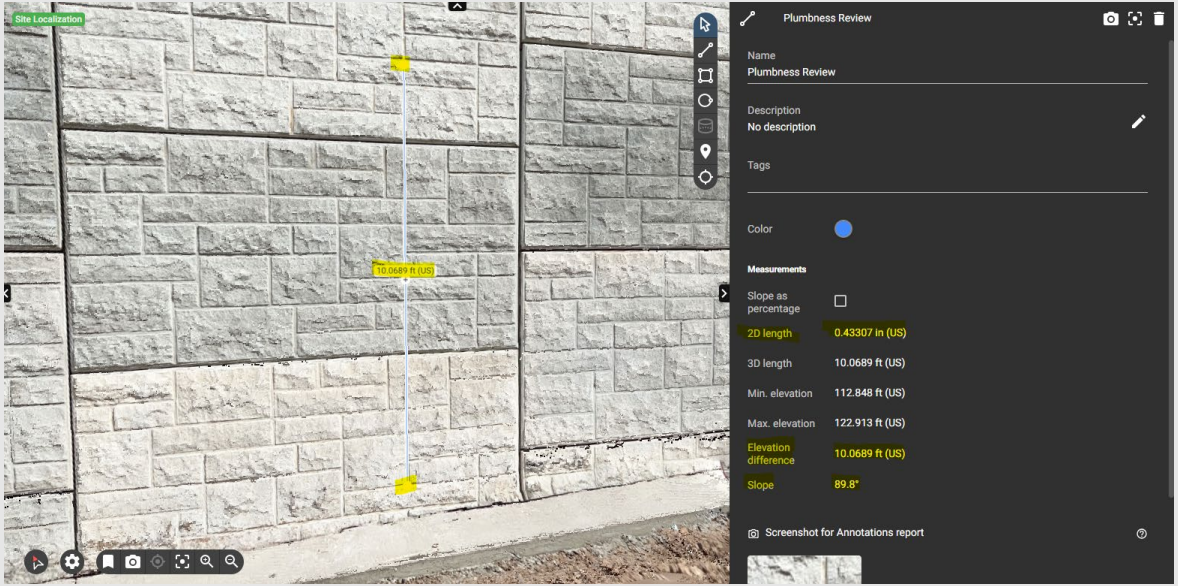
- Pix4D also takes hundreds of geotagged photos while scanning

Pix4D (Preliminary Findings)

Pix4D (Preliminary Findings)

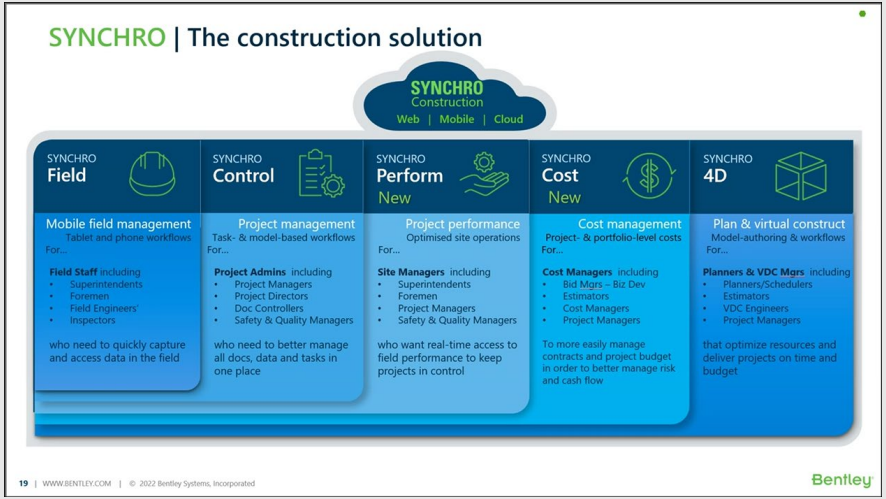






Bentley Synchro (Efforts to date)

- Bentley Suite of software include many packages
- To support 3D Construction Inspection, the pilot project focused on two key aspects
  - Form Building Technology
  - Dashboard Functionality
- Proof of concept
  - Develop Construction Inspection forms
  - Use Dashboards to present key project metrics

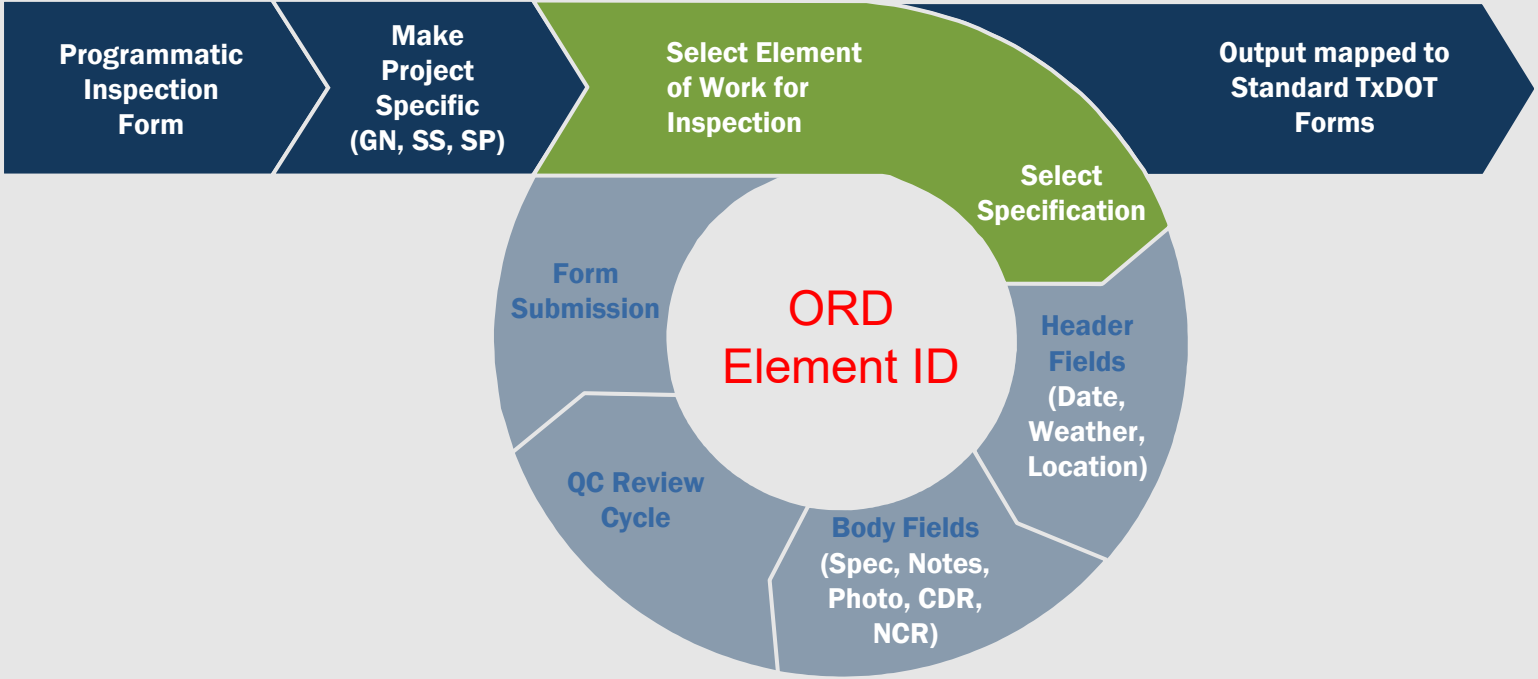


Bentley Synchro (Efforts to date)

- Construction Inspection Forms
  - **Core features:** date, location, weather, schedule, element of work, specification requirements, observations, photos
  - **Enhancements:** conforming/non-conforming work, P6 schedule, % complete, safety, environmental, record keeping, tied to other work (e.g., testing)

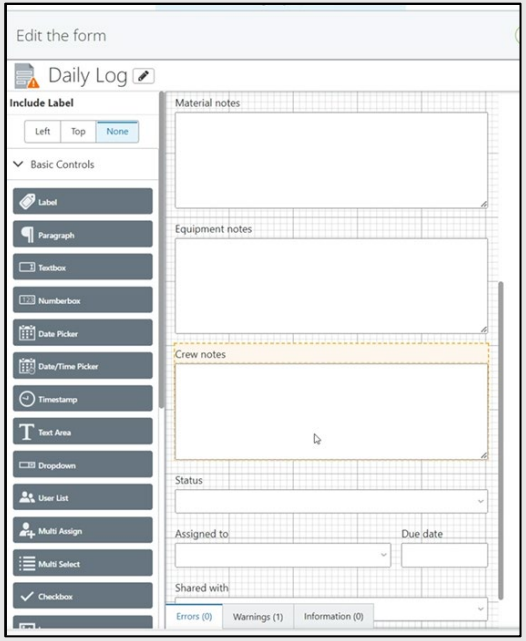
Item Series	Item	Item Description	Section	Reference	Requirement
400	416	DRILLED SHAFT FOUNDATIONS	Materials	Safety	Has proper protection been placed around drilling site?
400	416	DRILLED SHAFT FOUNDATIONS	Materials	416.2	Concrete mixture design is approved for installation
400	416	DRILLED SHAFT FOUNDATIONS	Materials	416.2	Approved water-reducing admixture is used when using casing that will be
400	416	DRILLED SHAFT FOUNDATIONS	Materials	416.2	Does mineal drilling slurry meet Table 3 requirements?
400	416	DRILLED SHAFT FOUNDATIONS	Materials	416.2	Slurry testing performed, if applicable
400	416	DRILLED SHAFT FOUNDATIONS	Materials	Record Keeping	Tag for the reinforcing steel
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	General Notes	Casing is required for 18" Drilled Shafts
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Drilled Shaft Installation Plan Submittal and Review are completed
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Drilled Shaft location tolerances:
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Vertical plumbness is 1in. per 10ft. of depth
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Center of shaft located under column is within 1in. of horizontal plan posit
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Center of shaft located inder footing is within 3in. of horizontal plan positi
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Has embankment at bridge ends been installed prior to installing drilled sh
400	416	DRILLED SHAFT FOUNDATIONS	CONSTRUCTION	416.3	Do drilled shafts passing through the structural volume of retaining walls m
400	416	DRILLED SHAFT FOUNDATIONS	DRY DRILLING	416.3.1	Shaft has been excavated through all anticipated materials encountered to
400	416	DRILLED SHAFT FOUNDATIONS	DRY DRILLING	416.3.1	Was satisfactory found material encountered at the plan elevation?
400	416	DRILLED SHAFT FOUNDATIONS	DRY DRILLING	416.3.1	If not, has engineer approved any adjustments made to the bottom of shaf
400	416	DRILLED SHAFT FOUNDATIONS	DRY DRILLING	416.3.1	Has there been any caving condition, ground water seepage, or soil squeez
400	416	DRILLED SHAFT FOUNDATIONS	SLURRY DISPLACEMENT METHOD	Environmental	Are measures in place to contain slurry runoff?
400	416	DRILLED SHAFT FOUNDATIONS	SLURRY DISPLACEMENT METHOD	416.3.4	Was slurry mixed on-site in a reservoir of sufficient capacity, and allowed t
400	416	DRILLED SHAFT FOUNDATIONS	SLURRY DISPLACEMENT METHOD	416.3.4	Was a head of slurry maintained at or near ground level during and after ex

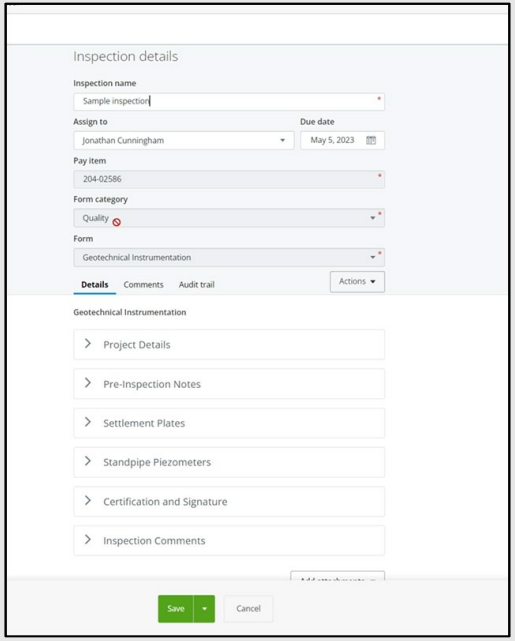
Consistent Inspection Form Creation



Bentley Synchro (Efforts to date)

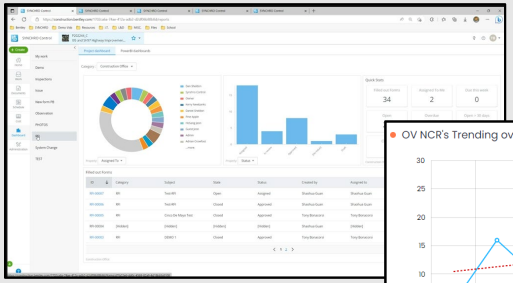
- Construction Inspection Forms
  - Using Synchro Form builder
  - Creating OV and IQF inspection forms for:
    - Item 416, Drilled Shafts
    - Item 423, Retaining Walls
  - Not duplicating efforts with CST
  - Adding form enhancements

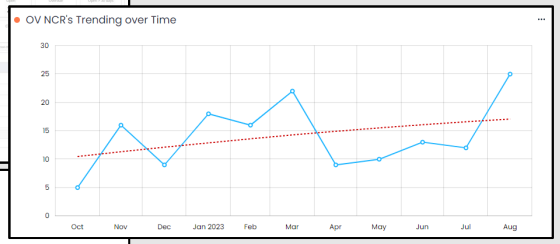


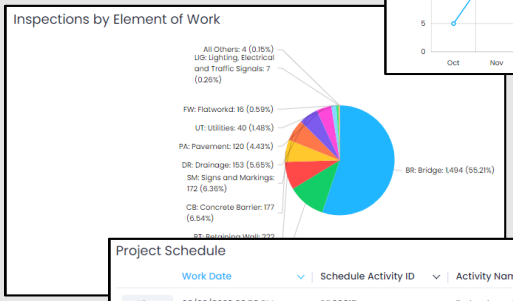


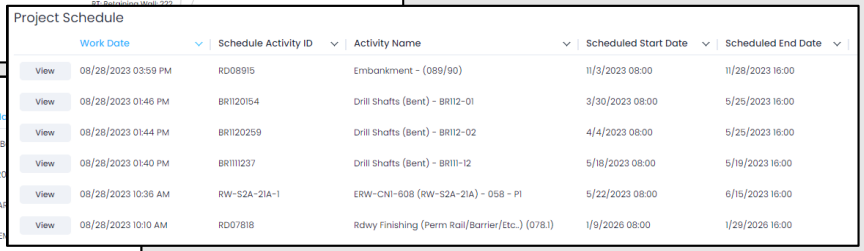
Bentley Synchro (Efforts to date)

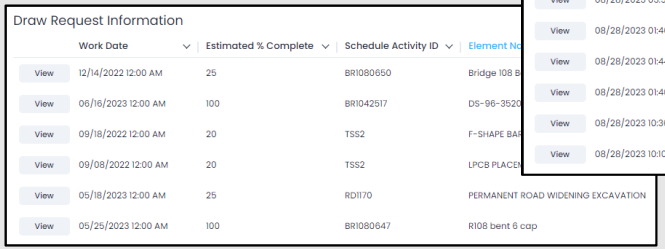
- Synchro Dashboard Development
  - Dashboards created using metadata from inspection forms
  - Examples will include:
    - Approved Inspection Reports
    - NCRs/CDRs trending over time
    - Draw Request by Work and Activity ID





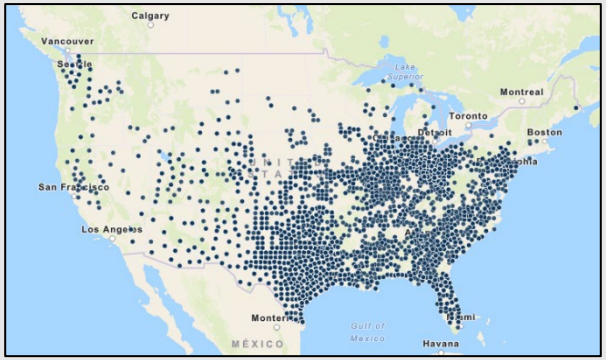


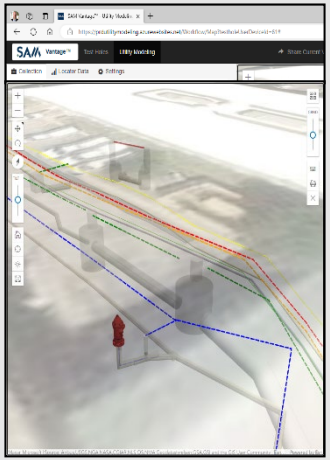


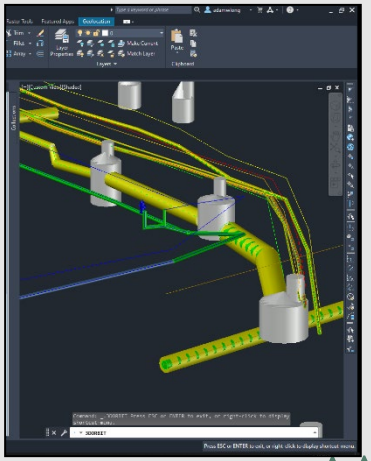


SAM Applied Technology Group

- SAM is the largest combined geospatial solutions and inspection services provider in the nation
- SAM Applied Technologies (AT) Group consists of Software Programmers, Surveyors, & Engineers
- Key Services:
  - Application Design and Implementation
  - Security and GIS Website Deployment Services
  - Mobile Application Development
  - Custom Programming and Workflow Design







Retaining Wall Construction

Retaining Wall Construction

Next Steps

- I-2/I-69C (retaining wall, DC-1, UAS)
- SEC Connector (TWG, columns/drainage, other technology)
- Approval for proof-of-concept forms and dashboard
- Possible long-term activities:
  - Merge LiDAR scans into Bentley ORD to document progress
  - Develop Quick Reference Guides (QRG)
  - District Training Materials
  - Develop testing forms
  - Tie inspection, testing, progress, and payment to Element of Work

Questions & Answers

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Thank you!