Using GIS For Construction Quality Management

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Speaker Background

Danny Kahler, PE

25 Years of Experience in Transportation Design and Construction

Independent Design Quality Assurance for State Highway 130 in Austin TX, a $1.3B Design-Build Tollroad

Risk Engineering Program for the Intercounty Connector in Rockville, MD, a $2.4 B Design-Build Tollroad

Quality Management Program for the KCICON in Kansas City, a $250M Design-Build Signature Bridge

ASQ Chair for Development of a Body of Knowledge in Design Quality Management

ASCE Construction Quality Management and Inspection Committee

TRB Emerging Technology for Design and Construction Committee

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Session Goals

- Understand the general ***characteristics*** of the information associated with construction quality
- Understand the ***differences*** between mapping coordinate systems and engineering coordinate systems
- Understand how the ***fundamentals*** of GIS can help contractors and engineers improve the management of construction quality

Let's Clarify Definitions

Traditional Quality Definitions

Quality Assurance (QA). All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.

Quality Control (QC). All contractor/vendor operational techniques and activities that are performed or conducted to fulfill the contract requirements.

Improved Quality Definitions

Prevention

Process controls to ensure that work is done correctly the first time

Appraisal

Evaluation of processes, or work after it has been produced

Internal Failure

Nonconforming work before it is incorporated into following work

External Failure

Failure of work after it has been incorporated into following work

Types of Construction QA

Inspection

Sampling and Testing

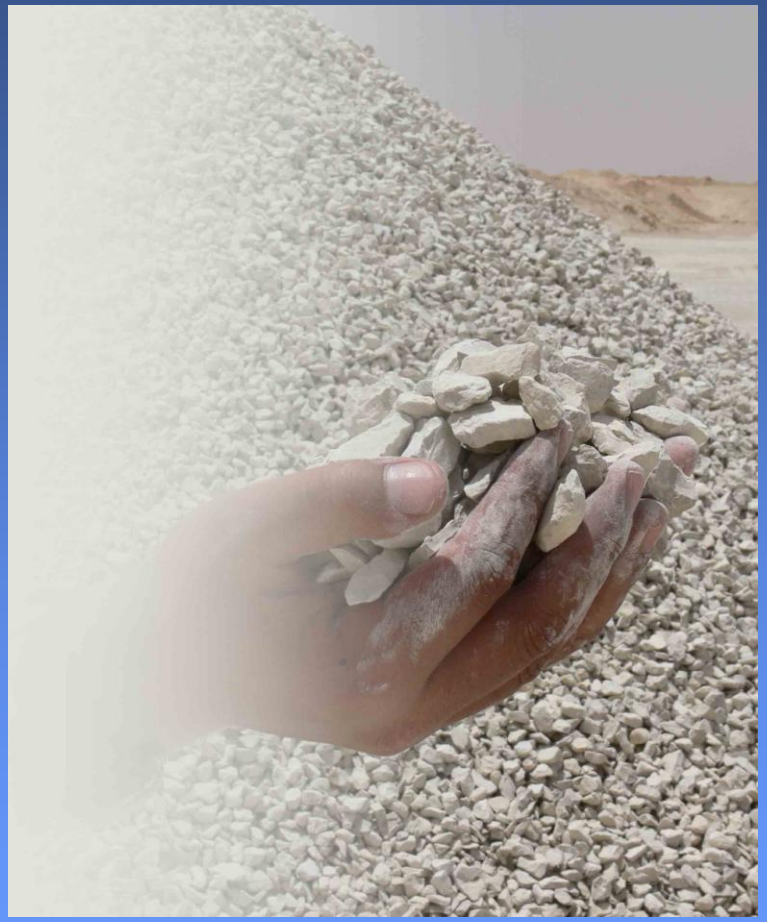
Construction Services

Inspection

Determining if the attributes of ***workmanship*** conforms to the plans and specifications.

Sampling and Testing

Determining if ***materials*** characteristics conform to the specifications.



Construction Services

- ***interpreting*** plans, specifications, inspections, samples, and tests.

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What Does The Contractor Do?

- Contractors are ***responsible*** for their own process control (Prevention)
- Contractors should ***perform*** their own internal quality assurance (Appraisal) to make sure that their work meets plans and specifications
- Contractor quality data is ***not legal*** for acceptance unless it has been statistically validated by similar verification done under the direct supervision of a licensed professional engineer

What Does The Engineer Do?

- Engineers professionally ***assure*** whether or not the work is in general conformance with the plans and specifications.
- Inspectors and technicians may ***perform*** this work under the direct supervision of an engineer
- Evaluation, acceptance, rejection of the work is ***regulated*** as part of the practice of engineering

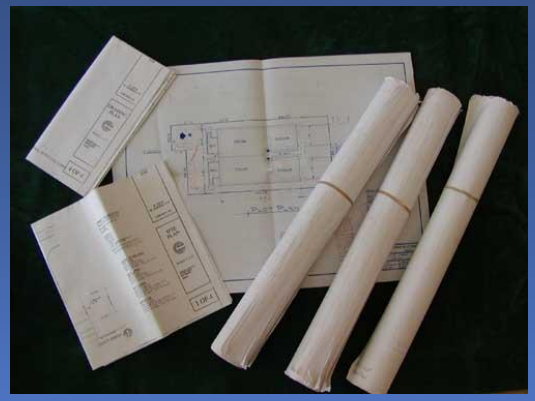
Regulation of Construction QA

Manitoba Engineering and Geoscientific Professions Act

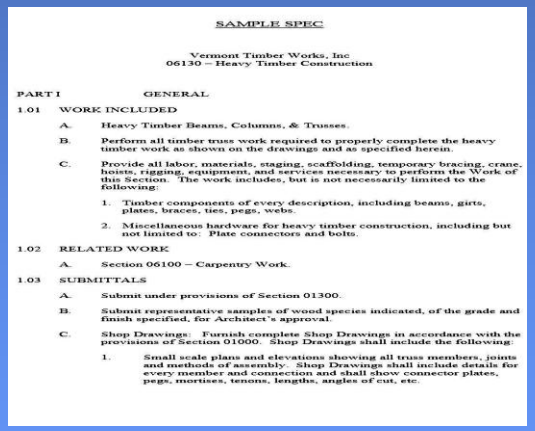
"practice of professional engineering" means any act of planning, designing, composing, measuring, evaluating, ***inspecting, advising, reporting, directing or supervising***, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public interest or the environment.

Quality Assurance Information

- Conformance to ***Plans***
  - Horizontal Location
    - Elevation
      - Dimensions
        - Slopes
          - Size



- Conformance to ***Specifications***
  - Compressive and Tensile Strength
    - Durability and Toughness
      - Color and Texture
        - Tolerances
          - Other measurable physical properties



SAMPLE SPEC

Vermont Timber Works, Inc
06130 – Heavy Timber Construction

PART I GENERAL

1.01 WORK INCLUDED

A. Heavy Timber Beams, Columns, & Trusses.

B. Perform all timber truss work required to properly complete the heavy timber work as shown on the drawings and as specified herein.

C. Provide all labor, materials, staging, scaffolding, temporary bracing, crane, hoists, rigging, equipment, and services necessary to perform the Work of this Section. The work includes, but is not necessarily limited to the following:

1. Timber components of every description, including beams, girts, plates, braces, ties, pegs, webs.

2. Miscellaneous hardware for heavy timber construction, including but not limited to: Plate connectors and bolts.

1.02 RELATED WORK

A. Section 06100 – Carpentry Work.

1.03 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Submit representative samples of wood species indicated, of the grade and finish specified, for Architect's approval.

C. Shop Drawings: Furnish complete Shop Drawings in accordance with the provisions of Section 01000. Shop Drawings shall include the following:

1. Small scale plans and elevations showing all truss members, joints and methods of assembly. Shop Drawings shall include details for every member and connection and shall show connector plates, pegs, mortises, tenons, lengths, angles of cut, etc.

What's In Common?

- Everything has a ***GROUND LOCATION***.
- This makes project quality assurance ***different*** than manufacturing quality assurance.
- ***GROUND LOCATION*** can bring together what might normally seem to be disconnected quality assurance data.

Methods of Project Location

- Linear Projects
  - Station and Offset: ***Curvilinear*** alignments which are tied to XY coordinates. Complex projects may have dozens of separate alignments
- Area Projects
  - Local XY: ***Cartesian*** (rectangular) systems based on a local starting point.

GIS Project Location

- XY, or Northing and Easting
- Z, or Elevation
- Correct projection file
- Need to have correct units
  - US Survey Foot vs. International Foot?

Mapping vs. Engineering

Mapping is usually tied to *earth location*. May have large scale distortions. Lat-Long and UTM most common.

Engineering is just enough coordinate system to get the project ***built***. Some dimensions are relative to other elements. Absolute coordinates are often derived from State Plane Coordinates.

Advantage of GIS

Can bring multiple coordinate systems into one view.

Some quality data could be collected on paper using recreational GPS units.

Can overlay project onto the “gold mine” of publicly available GIS data.

Various Engineering Coordinates

State Plane at grid (Oklahoma DOT)

State Plane with county scale factor (Texas DOT)

State Plane with project scale factor (Missouri DOT)

State Plane with scale factor and truncated (Utah DOT)

Local XY based on iron pins (Many municipalities)

Nearest tree or fence post (Many utilities)

GIS Information Framework

Points - Used to represent data that only exists in one place. Easiest to export to offline database or spreadsheet software

Lines – Used to represent linear data such as streams, roads, trails

Areas – Used to represent area data such as drainage basins, field, political boundaries

Quality Assurance Data

- Inspections
  - Point: foundations, poles, connections, check dams, headwalls
  - Line: pipe, curb & gutter, guardrail, striping, conduits, concrete barrier, silt fence
  - Area: earthwork, subgrade, base, pavement, bridge deck, surface treatment, vegetation

Quality Assurance Data

- Samples and Tests
  - Point: Density, Gradation,
  - Lines: Lots (averaged samples or tests)
  - Area: Lots (averaged samples or tests)
  - Volume: Based on linear or area

Quality Assurance Data

- Quantities
  - Point: Inlets, Poles, Manholes
  - Line: Curb, Pipe, Guardrail, Pipe, Conduit
  - Area: Subgrade, Paving, Bridge Deck
  - Volume: Based on linear and area

Other Data

Pay Items – quantities tied to unit cost used to pay a contractor on ***design-bid-build***

Cost-Loaded Schedule Activities – used to pay a contractor on ***design-build***

Work Breakdown Structure – used to ***organize*** the work

Materials Codes – used to ***classify*** materials

Resources – manpower and equipment ***mobilized*** to the project

Recommended Accuracies

Layout: 0.01 foot (+/- 0.10 foot construction tolerances).

Survey Grade GPS or Total Station

Quantities: 0.1 foot to Subfoot

Mapping Grade Carrier – Post Processed

Density tests: Subfoot

Mapping Grade Carrier – Post Processed or RT Service

Gradation tests: 1 – 3 Feet

Mapping Grade Code – Real Time SBAS

Concrete tests: 2 – 10 Feet

Mapping Grade Code – Real Time SBAS

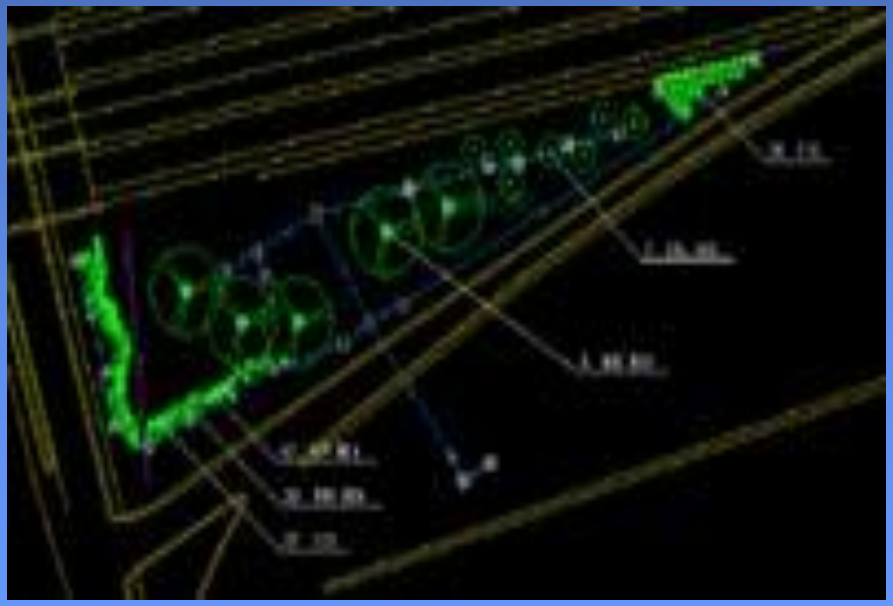
Project Resources and Environmental: 5 – 20 Feet.

Recreational Grade Code – Real Time SBAS

Master Design Files

Master Design Files are 2D CADD files of the raw design in the project coordinate system. Design elements in design files are drawn exact, with no text or dimensioning.

Design elements may be separated by levels or layers, or assigned to categories through an associated database



Design Files as Background

Can be used as a background on data collectors.

Can be organized to only show key design elements.

Gives the construction inspector the same view of the design as the design engineer.

Can be used to verify correct layout using survey-grade positioning technology

Geospatial PDF plans are an emerging technology

GIS for Quality Analysis

Fit

Are the project elements in the correct plan location, within the specification tolerances?

Strength

Do the materials in the project have the required strength? i.e. compressive, tensile, shear, abrasion, durability, etc.?

Appearance

Do the project elements have the required appearance?

GIS Advantages

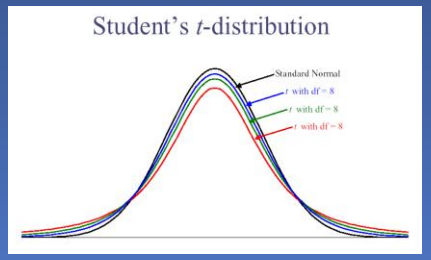
- See all quality:
  - In one view
  - Relative to time
  - Against compliance with plans and specs
  - Categorized by producer
  - Categorized by inspector
  - Categorized by risk

Statistical Validation

Allowed by FHWA under 23 CFR 637

Most engineers are not trained in it

Traditional data is difficult to collect



GIS for both Quality Control and Quality Assurance makes data collection easier.

Expand validation beyond just sampling and testing: Automated Machine Guidance, Smart Compaction, Electronic As-Builts.

Construction Quality Assurance

Traditional Way	*GIS Way*
Text-based	*Graphics-based*
Data in Office	*Data in Field*
Manual Forms	*Handheld Collector*
Separate Measurements	*Integrated Measurements*
Delay	*Immediate*
Custom	*Off the shelf*
One copy	*Infinite copies*

“I Need A Laptop”

For ***years*** inspectors have lobbied for laptops.

Laptops are a ***coveted*** status symbol item

Laptops won’t improve construction quality assurance

QA will ***improve*** when we revolutionize the data collection process.

Inspectors need ***strategically designed*** tools, not status symbols.

Inspectors need reliable ways to collect and find information

Needs from Vendors?

- Software that directly imports master design files
- Software that can easily use alignments
- Software that can use other databases for lookups

Can we lock ESRI, Bentley, Autodesk, Trimble, Topcon, Magellan, and Adobe all in the same room and not let them out until come up with a solution?

Needs from Professionals?

Control the quality of the design model

Clearly define the project coordinate system

Break the addiction to paper

Understand relational data

Train the “paraprofessional” (new ASCE term)

Learn how to analyze data

Standardize the coordinate systems

Thank You For Attending

How To Contact The Speaker:

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