Thanks to Paul for intro. I am Kurt Sommer.
I am here to briefly review our rationale and to report on the status of the QC/QA/IC pilot project on US31/US35 at Kokomo.

**Session:** 74  
**Session Title:** QC/QA Earthwork and Intelligent Compaction

**Date:** March 6, 2013  
**Time Period:** 1:00-1:50 p.m.
Contract Pilot Project

- US 31/US 35 at Kokomo
  - IR-30111 in Greenfield District
    - James Colonis, AE
    - Elsadig Ibrahim, PE
  - Primco - Prime Contractor
  - Fox Contractors-Earthwork Subcontractor
  - Sitech Indiana-GPS and IC Tech Support

US 31/US 35 at Kokomo
IR-30111 in Greenfield District
James Colonis, AE
Elsadig Ibrahim, PE
Samantha DeSollar, Assistant PE
Deion, INDOT HT
HNTB- Additional Jobsite Inspection for INDOT
Nayyar Siddiki-INDOT Geotechnical Engineering
Primco - Prime Contractor
Fox Contractors-Earthwork Subcontractor
Sitech Indiana-GPS and IC Tech Support
North Connection of Kokomo Bypass

- New connection with US 35
- New connection with existing US 31 at North
Typical Section

Common Excavation: 278,000 Yd$^3$
Borrow: 695,000 Yd$^3$
Four Steps To High Performance Earthwork

1. Test Methods
2. Equipment
3. QC/QA Process
4. Acceptance Of Soil Compaction
Test Methods

- Dynamic Cone Penetrometer (DCP)
  - ITM 509

Dynamic Cone Penetrometer (DCP)
ASTM D 6951 (ITM 509)
Moisture Tests

- ITM 506
  - Drying By Microwave
Four Steps To High Performance Earthwork

1. Test Methods
2. Equipment
3. QC/QA Process
4. Acceptance Of Soil Compaction
Soils IC System

Display
Radio
GPS Receiver
Controllers
Accelerometer
Slope Sensor

Courtesy of Caterpillar
US 31/US 35 at Kokomo

Intelligent Compaction Roller
Intelligent Compaction Roller With GPS
Real Time Feedback For Compactor Operator
Location
Passes Completed
Stiffness Of Soil
IC Equipment and GPS

- Fox Made Sincere Commitment
- 4 Cat CS-56 Smooth Drum Vibratory IC Rollers
- High Accuracy GPS Base Stations
  - Setup By Sitech, Indiana
IC Equipment and GPS

Rollers Setup With 3D Terrain Model For Contract

Same As All Earthwork Equipment On Contract

Local Coordinates Used

Not Compatible With FHWA IC Software

Sitech Converted Data To Make Compatible

DELETED:

Local Coordinates Used

Not Compatible With FHWA IC Software

Sitech Converted Data To Make Compatible

GPS Error Exceeded 1.6” Tolerance

FHWA Has Since Increased Tolerance To 6” In Guide Specification
IC Equipment and GPS

**Roller IC Data Uploaded Wirelessly Every 5 Minutes**

- Sitech/Trimble Cloud Server
- Trimble Connected Community On Internet
- Processed Data Available As Excel Zip Files

**Roller Printout Used To Document IC Activity On Job**

Imperfect, But Fully Effective

Output Listed 5 Deficient Areas $>100$ Ft$^2$
IC Equipment and GPS

Roller Set To Collect Data
Roller Set To Collect Data

Forward Mode Only
Vibratory Mode Only

Operators Target 2 Mph
IC Equipment and GPS-Lessons Learned

- FHWA Relaxed GPS Tolerances Slightly
- Job Should Be Designed On UTM Coordinates, Not Local (Arbitrary) Coordinates
- Cloud Uploading Is Ideal
- Printouts Allowed Decisions And Acceptance In Field As Planned
- No External Data Analysis Needed
Four Steps To High Performance Earthwork

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4 Steps To High Performance Earthwork
1. Test Methods
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QC/QA Process

Most Components Of Road Building Are Manufactured Within A QC/QA Process:

- Equipment
- Aggregate
- Liquid Asphalt
- Hot Mix Asphalt
- Cement
- Concrete Pavement

- Steel
- Steel Beams
- Reinforcing Steel
- Epoxy Coatings
- Precast Concrete Beams

Equipment
Aggregate
Liquid Asphalt
Hot Mix Asphalt
Cement
Concrete Pavement

Steel
Steel Beams
Reinforcing Steel
Epoxy Coatings
Precast Concrete Beams
QC/QA Process

QC/QA Earthwork Construction

QC/QA Earthwork Construction
QC Plan
Sampling And Testing
   Moisture
      1/1400 Yd³
   Strength (DCP)
      1/1400 Yd³
   Optimum Moisture Content
IC Roller Data
   On-Board Printer Output
   Electronic Data
QC Testing

- QC Techs Worked With Fox
- Performed One Point Proctor Of Borrow/Common To Get Target Optimum Moisture Content
- Performed Microwave Moisture From Borrow/Common To Determine Need For Drying Or Wetting
- Microwave Speeds Testing Process
- Performed DCP On Compacted Lifts To Determine Suitability For Additional Lifts
QC Testing
- Communicated With INDOT QA
- When Ready For QA Testing
- Used GPS Rover
  - To Determine Boundary And Area Of The IC Mapping Area.
- Oversaw Mapping With IC Roller
- Identified Large Deficiencies
  - INDOT Made Extra Effort To Catalog Small Deficiencies Since In IC Research Mode
US 31/US 35 at Kokomo

- QC Testing - Lessons Learned:
  - Certified Tech Exam Was Issue
  - Relationships Between QC And Earthwork Sub
  - Forms And Recordkeeping Lacking
  - Education Of QC Techs Needed

QC Testing - Lessons Learned:
- Certified Tech Exam Was Issue
- Relationships Between QC And Earthwork Sub
- Communication Needed Development
- Forms And Recordkeeping Lacking
  - Future Will Require A “Diary” And Daily Record Submittals
- Education Of QC Techs Needed
  - Techs Needed Pushed To Maximize Tests Performed
  - Techs Needed To Understand Importance Of Their Role

INFORMATION from deleted slides:
- Prime Hired A Sub To Perform QC Testing
  - Now Fox Using Own Employee
- Fox Submitted QC Plan
  - Revisions Needed, But Reasonable Initial Submittal
  - Techs Needed To Take The Soils Certified Tech Exam
  - Slow Process
  - Allowed A PE Employee To Perform Duties Of QC Manager In Interim

QC Testing
- QC Sub Worked For Prime
  - Earthwork Sub Worked For Prime
  - Unique Relationship
  - Adjustments And Communication Required
  - INDOT Preached Significantly To QC Sub To Get Them To Understand Role

QC Forms And Records
- INDOT Shared Forms, But Not Really Suited For QC
Four Steps To High Performance Earthwork

1. Test Methods
2. Equipment
3. QC/QA Process
4. Acceptance Of Soil Compaction
   - Test Sections
   - Compaction Acceptance By DCP
   - Compaction Acceptance With IC Construction
   - Deficient Areas

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4 Steps To High Performance Earthwork
  1. Test Methods
  2. Equipment
  3. QC/QA Process
  4. Acceptance Of Soil Compaction
US 31/US 35 at Kokomo

- Acceptance Of Soil Compaction
  - Test Sections
    - 100 Ft Long And 20 Ft Wide
    - Compact To Meet DCP Target For Given Soil
    - Map With IC Roller
      - Establish Target IC-MV
        - IC-MV=Intelligent Compaction Measurement Value
        - CMV=Compaction Measurement Value (Cat.)
Acceptance Of Soil Compaction

Test Sections

- Moisture
  - Two Locations
  - -3 % And +2 % Optimum For Silt-Clay Materials
  - -6 % Optimum For Granular Materials

- Strength
  - DCP At 4 Locations
  - Confirm That Lab DCP Target Achieved
Test Sections for IC Mapping

Test Sections Required By Specification

Size Clearly Defined, But Little Else

Specification Didn’t Explain Or Define Correlation Between IC-MV And DCP

20x100’ Test Section

Too Small, Unless Part Of Larger Production.

Target IC-MV Established Initially

Adjustments Were Made Later
Test Sections for IC Mapping

- Jobsite PE And Assistant PE Remained Alert And Flexible
  - Experimented And Learned From CMV Output And Soil Response
  - “Something Clicked” After Six Weeks
  - Drafted Test Section Document Based On Field Activities
US 31/US 35 at Kokomo

Test Sections for IC Mapping

Test Section On Any Mapped Area

- Refined And Successfully Implemented August To November
- Calibrate CMV To Size Of Deficiencies For Any Mapped Area
- The Correct Target IC-MV Is The Value That Allows The Roller To Identify All Deficiencies (As Verified By DCP), Sized Properly, With No False Deficiencies And No False Passing Areas

Test Sections for IC Mapping

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Test Sections for IC Mapping

Test Section On Any Mapped Area

Target CMV=6.

Roller at Edge of Deficient Area Before Verification of Limits with DCP
Test Sections for IC Mapping

Check Limits of Deficient Area With DCP
Test Sections for IC Mapping

Determine Exact Limits of Pass / Fail With DCP
Test Sections for IC Mapping

Adjust Target CMV In Roller To Adjust “Red” Area

“Red” Boundary Set To Match DCP Pass / Fail Limits
Test Sections for IC Mapping

- Drive Roller To Pass / Fail Boundary To Confirm
- Target CMV = 4
- Use This Target To Evaluate Mapped Area For 70% Compliance
Test Sections for IC Mapping-Lessons Learned

- Soil Stiffness And Response Is Complex
- Increased Lifts Often Saw Lower Stiffness
- Rain Caused Stiffness Response To Change Overall
- Test Section Can Really Be Any Mapped Area
  - The Target Is Set After Mapping
  - Boundary Of Deficient Area Is Correlated With DCP And IC
- Caterpillar CMV Scale Is Too Low (Value Of 2 To 7 Is Typical)
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Acceptance Of Soil Compaction

Compaction Acceptance By DCP

Moisture
- One Location per day minimum
- -3 And +2 % Optimum For Silt-Clay Materials
- -6 % Optimum For Granular Materials

Strength By DCP
- Each Lift
- 1/1400 Yd³
- DCP Blow Counts > Lab Target Blow Count
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IC Construction
IC Construction Operations Criteria
Construction Area
Mapping Construction Area
Minimum 90% Coverage Required
IC-MV (Stiffness)
Minimum 70% Of Mapped Construction Area
Must Exceed IC-MV Target
Used Roller Printout To Evaluate
IC QC Data Output
- Looked At Data Separately At Later Date
- Not Connected With Daily Jobsite Acceptance Decisions
- Filtered By Time And Location And Roller
IC QC Data Output

Viewed In Veda With Statistical Analysis

- 2D Only
- Difficult To Find A Specific Location Graphically
- “Sublot” Feature Helped Show Trends And Regions Of Varying Stiffness
- Sublots Could Be Used In Future For Uniformity Based Analysis
IC QC Data Output

Let’s Look at Actual Data

FHWA Veda Software
IC QC Data Output

- All Data
  - 282,000 points
  - September 2012
- One Roller, Number 1517
- Maxed Out Veda
- Average CMV = 10
IC QC Data Output

- **Focus on September 24, 2012**
- 33,800 points
- One Roller, Number 1517
- One Mapped Location
- Average CMV = 13.3
- Target = 6
- Target % Achieved = 84%
IC QC Data Output

- Focus on September 24, 2012
- 33,800 points
- Same Mapped Location as Prior Example
- Create Sublots
- Size 50’ x 100’
- Visual and Statistical Uniformity
- Failed to Meet 70%
- 1600’ Location and 1650’ Location
IC QC Data Output-Lessons Learned
- Veda Needs Improved Graphical Interface
- Need Ability To Find Points Graphically
- Need 3D Stacking Of Layers
- DCP Correlation Inconsistent and Not Useful
- Sublots Allowed For Good Uniformity Analysis

INFORMATION from deleted slide

IC QC Data Output
- Point Test (DCP) Data Must Have Full GPS Northing And Easting For Each Test
- Veda Has A Linear Correlation Function Between DCP And IC-MV
  - Results Were Not Useful In Kokomo
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Acceptance Of Soil Compaction

Deficient Areas

- Individual Areas Of Less Than 1500 Ft²
  - Do Not Meet The IC-MV Target
  - No Excessive Pumping Or Rutting
  - Accepted If DCP And Moisture Meet Requirements
IC Deficient Areas

Average Deficient Area <300 Ft$^2$

Specification Allowed Deficient Area Up To 1500 Ft$^2$.

These Were Extremely Rare Overall;

Only 3 Large Deficiencies

3424, 1785, And 1728 Ft$^2$
IC Deficient Areas

All Deficient Areas

- Individual Areas: 326
- Average Area: 260 $\text{ft}^2$
- Total Area: 82,790 $\text{ft}^2$
- Volume: 6132 $\text{yd}^3$ Of 400,000 $\text{yd}^3$
- Volume: 1.5% of Total Earthwork
IC Deficient Areas

37 Deficiencies
Between 500 Ft² And 1500 Ft²
Total: 37
Average Area: 783 Ft²
IC Deficient Areas-Lessons Learned

- Deficiencies Needed To Be Custom Correlated To The IC Roller
  - A Given Mapped Area Correlated Well With IC Roller, After Target Adjusted
  - Meeting IC Specification Of “At Least 70% Of Mapped Area Must Exceed Target IC-MV” Was Readily Achievable
IC Deficient Areas-Lessons Learned

- Consider Smaller Allowable Deficiencies In Future - Especially For Subgrade
  - Consider Reduced IC Mapping Frequency
    - US 31/US 35 Mapped at 2’ Intervals
    - FHWA Proposing 8’, 4’, 2’, 1’ Below Subgrade In Future
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4 Steps To High Performance Earthwork
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Questions?

QC/QA Earthwork Construction

*The Time Is Now!*
Thanks to Lee Gallivan, FHWA and George Chang, Transtec Group, for some technical content and slides.

Also, Elsadig Ibrahim, Samantha DeSollar, Deion, James Colonis, INDOT Greenfield; Ron Walker, Nayyar Siddiki, Office of Materials Management; INDOT Soils Tech Committee; Contractors; Fox-Caleb Fry and Jim Orr; Sitech-Creg Adkins; JTRP Research Team; Tom Duncan, FHWA; and Everybody Else that I forgot to mention.