(CEC-90153) Minnesota DOT Deploy GCS900, Business Center – HCE and VisionLink with the DOTs GEOPAK software to automatically monitor large scale excavation in Carver County

James Schneider
Advanced Materials and Technology
Project Details (CSAH 61/101 Reconstruction)

• Flood Mitigation Project
  • Repeat Flooding last 20-years
  • Minimal number of River Crossings

• Project Description
  • Bridge
    • Floodplain north of Minnesota River Channel
    • 4-Lane
    • 4,225-ft long
    • 41 total spans
  • 2 Roundabouts
  • Bike Lane
Project Details (Cont.)

- Muck Excavation
  - 20 to 35 feet
  - 350,000 cy of muck
  - 510,000 cy excavation
- Water Table
  - 5 ft below surface
- Automated Machine Guidance – Excavation
  - Added through Special Provisions
Soil Borings
Special Provision Highlights
Automated Machine Guidance - Excavation
The Contractor will use an Automated Machine Guidance (AMG) System for collection and recording of GNSS coordinates for creation of a 3D model reflecting the muck excavation bottom.
Equipment Requirements

Instrumented with the following:

• Ability to connect to:
  • RTK-GPS
    • Local, ground-based base station, and/or
    • MnDOT MnCORS-VRS Network
  • Total Station
• Onboard Documentation System
Equipment Requirements – Data Transfer

• Modem, or Wi-Fi for transferring data to cloud storage and mapping.
Equipment Requirements: Submersible Enclosures

• Submersible enclosures for sensors may be needed.

• The Department anticipates that there will be locations with standing water.
• Provide user ID / passwords to Department

• Duration of Access
  • Prior to start of excavation efforts requiring AMG-Excavation until
  • 90 days after final acceptance per MnDOT 1516.2
Cloud Computing and Mapping

• Mesh Size after Post Processing
  • \( \leq 24 \text{ in} (600 \text{ mm}) \) in X, Y, Z direction

• Filter Abilities
  • Current, Lowest, Highest Elevations (filter and map)
  • Time/Date
  • Location/Project Extents

• Import and Export Surface (3D) Models in *.TTM/LandXML format

• Import corridor (background) designs
  • Including station-based alignment data
Automated Machine Guidance Data

- Coordinates
  - XYZ Accuracy ≤ 0.2 ft (5 cm)
  - County Coordinates
    - NAD83 (adjustment as specified by Department)
    - NAVD88 Vertical Datum
  - Indicate cutting edge of the excavation equipment

- Data Collection Interval
  - Continuous
Calibration of GNSS Accuracy

- ≥10 locations, at least 2 ft (600 mm) apart
  - Different boom stick and buck orientations

- Mark location next to bucket

- Collect and compare GNSS coordinates
  - AMG system vs. Independent Device (Rover)
  - ΔX, ΔY, & ΔZ ≤ 0.33 ft (100 mm)
System Failure

• System Failure
  • Excavation equipment becomes inoperable and/or
  • AMG system does not collect and/or store data per requirements of contract

• Contact the Department
  • Start/End of System Failure

• Grace Period
  • Resolved by beginning of next day of excavation req. AMG-Excavation

• Conventional Survey Methods
  • Supervision of Licensed Land Surveyor or
  • Plan approved by Dept.
Automatic Mapping Control
(Mapping / Recording)

• Use the AMG-Excavation system (GCS900 Grade Control System) at all muck excavation locations.

• Department GNSS Checks
  • GNSS checks at discretion of the Department.
    • $\Delta X$, $\Delta Y$, & $\Delta Z \leq 0.33$ ft (100 mm)
Material Visual Verification

Layer 1 – Silty Clay, with Sand, Slightly Organic, Grey, Fine Alluvium

Layer 2 – Clayed Sand, Some Gravel, Grey, Coarse Alluvium

Layer 3 – Clayed Sand, Lots of Gravel, Mottled, Light Brown, Coarse Alluvium
Trimble GCS900 for Excavators

Figure Courtesy of Trimble
Caterpillar 374D Fitted With Dual GNSS Receivers
CB460 – In-Cab Display and Graphics

- 3D Excavator Lightbar
- Guidance View Area
- Optional Text Area
- Mapping/Recording Icon
- Guidance Settings
- Status Bar
- Cellular Signal Strength
### GNSS Checks

<table>
<thead>
<tr>
<th>Northing (FT)</th>
<th>Easting (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>162817.10</td>
<td>558248.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elevation (FT)</th>
<th>Design Elev. (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>729.55</td>
<td>705.00</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Bucket Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.8</td>
</tr>
</tbody>
</table>
Data Flow

Cloud Storage: Trimble Connected Community

Cloud Computing / Mapping: Trimble Vision Link Legacy

Trimble Business Center - HCE

Filter by Lowest Elevation
General Filter Settings for Surface File Export

- Elevation Type: Lowest

- Project extents dates for the limits of each excavation area
  - 1st Day of Excavation for given area to Current Date
  - Ensure lowest elevation is captured and exported for volume calculations.
Excavation Details
GNSS Checks
Holes in Bucket
Video: Rolling Surcharge using Dozer
Mixing of Materials
High Water Table
Bottom of Muck Surface
Beginning Stages – Muck not Removed
Improved Excavation Process
Video: Bottom of Muck Surface in Trimble Business Center
Trimble Business Center Earthwork Volume Report
## Trimble Business Center Earthwork Volume Report

### Project File Data
- **Name:**
- **Size:**
- **Modified:** 8/30/2013 1:10:56 PM (UTC-6)
- **Time zone:** Mountain Standard Time
- **Reference number:**
- **Description:**
- **Comments 1:**
- **Comments 2:**
- **Comments 3:**

### Coordinate System
- **Name:**
- **Datum:**
- **Zone:**
- **Grid:**
- **Vertical datum:**
- **Default:** WGS 1984

### Earthwork Volume Report

**Unclassified surface compared to Unclassified surface**

<table>
<thead>
<tr>
<th>Surfaces</th>
<th>Classification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT_DN12_101363</td>
<td>Unclassified</td>
<td></td>
</tr>
<tr>
<td>final tin</td>
<td>Unclassified</td>
<td></td>
</tr>
</tbody>
</table>

### Bank Volumes Based on Surface Geometry Alone

<table>
<thead>
<tr>
<th>Material</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut material</td>
<td>404,422.3 yd³</td>
</tr>
<tr>
<td>Fill material</td>
<td>7,850.8 yd³</td>
</tr>
<tr>
<td>Excess</td>
<td>396,571.5 yd³</td>
</tr>
</tbody>
</table>

Note: ‘Cut Material’ is defined as material where [final tin] is lower than [BIT_DN12_101363]. ‘Fill Material’ is defined as the volume of material where [final tin] is higher than [BIT_DN12_101363].

Note: The above volumes are calculated solely from the geometries of the selected surfaces. No material properties are applied to the above numbers.
Volume Report QUANTITY IS THE ‘TOTAL CUT’ ONLY (NOT THE BALANCE)

<table>
<thead>
<tr>
<th><strong>Total Cut</strong></th>
<th>404422.281 Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Fill</strong></td>
<td>7850.841 Cubic Yards</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td>90342.934 Sq Yards</td>
</tr>
<tr>
<td><strong>Balance</strong></td>
<td>396571.440 Cubic Yards</td>
</tr>
</tbody>
</table>
Lessons Learned

• Running Total

• Excavate to a Design

• Turn Software off when not in use to eliminate unwanted data and keep the surface model clean
Benefits of AMG – Excavation Method

- Increased Safety.
- No need to DTM excavated surface
- Visual representation of excavation
- Ability to obtain an excavated bottom surface in areas difficult to survey (under water)
- Surface created for accurate volume calculations
- No need to establish boundary for excavation
- Real-time tracking by all personnel
- Ability to obtain a more dense and accurate DTM vs. conventional survey methods
- Time and resource savings
Cons of AMG-Excavation Method

- Need an experienced operator to dig to a design verses ‘digging a hole’
- Initial cost and calibration
- Data service required to obtain real-time results
- Backup method needed when system is down.
Questions?