CASE STUDY

Model for the Automatic Costing of Earthworks (MACE)

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CLIENT: N/A (Research and Development)

SCOPE:

Model for the Automatic Costing of Earthworks

12d DIMENSIONS:

- Research

Project Summary

The Model for the Automatic Costing of Earthworks (MACE) prototype provides an automatic costing of earthworks (moving material from cut to fill areas) for road and rail infrastructure projects using minimal inputs.

Background

Currently, earthworks estimates take a long time to calculate and, as such, estimators often use approximate methods for the haul distances and time required for the movement of material. This method may lead to inaccurate cost estimates. MACE provides a detailed cost estimate based on the optimal movements from cut to fill, the actual haul roads that can be created over the surrounding terrain, and the velocity and acceleration that haul vehicles can achieve over these haul roads. The time required to move cut to fill is then calculated and a total dollar and carbon cost for the earthworks is determined. This is performed in a matter of minutes, and a final dollar and carbon cost is calculated. The MACE program, coupled with an automatic infrastructure cost estimation program (such as the Roadworks Estimator), will allow cost engineers to quickly and accurately prepare Concept, Strategic and Detailed earthworks cost estimates for road and rail in a fraction of the time of current estimating methods in an attempt to proceed with a design that minimises the total project cost.

For more information

To find out more about how you can create better designs faster with the 12d Model solution for civil engineering design, visit www.12d.com.

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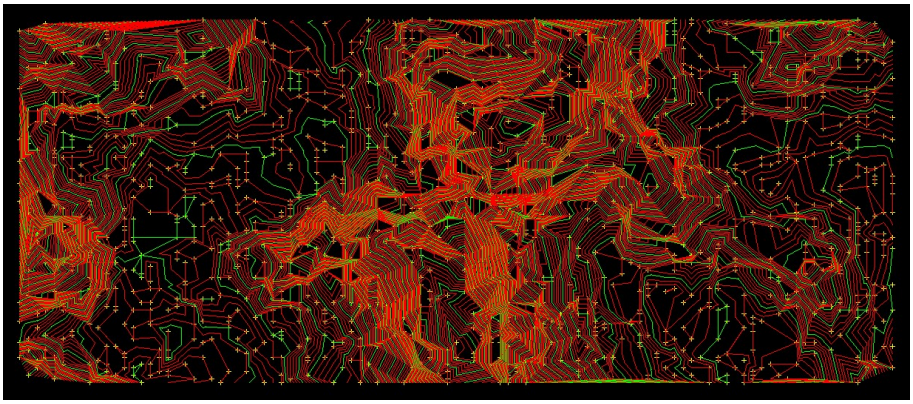

Triangulation of the survey points by 12d to create a Digital Terrain Model (DTM)

The Challenge

Accurate cost estimates for earthworks on road/rail projects are currently difficult to produce. They require manual calculation of cut/fill volumes from road alignment drawings, manual assessment of where material needs to move to/from, and estimation of how material will be hauled. Currently, estimating systems do not automatically calculate the specifics of the haul road or the time it will take to move a vehicle along this path based on the attributes of the haul vehicle.

These shortcomings result in a time-consuming process to produce cost estimates for earthworks. MACE addresses this by quickly determining the cut/fill volumes and locations (using Excel macros) and the required haul road profiles (using 12d macros), and by simulating vehicles travelling along the haul road based on the unloaded/loaded acceleration and deceleration of the vehicle (using Excel macros from the 12d output). A comprehensive cost and carbon cost of the entire project's earthworks is analysed in minutes.

The Solution

Calculating the cost to move earthworks material in the MACE prototype - steps:

- Create a digital terrain model (DTM) within 12d Model of the road/rail site by downloading the terrain survey points (from Google Earth) and triangulating these points in 12d to create a TIN.
- Input the centreline of the road rail project onto the DTM and add batters to the road centreline to connect the road deck with the surrounding terrain. 12d then produces a cross section and the volume of cut/fill at each point along the road chainage.
- An Excel macro calculates the most efficient locations to movement of material from cuts to fills.
- Haul vehicles, however, are restricted in the slope that they can travel down/up as well as the degree of turns they can achieve. The shortest possible path between the required cut/fill areas over existing terrain, that fulfilled the slope and turn radius conditions, was determined by a macro in 12d. This was an iterative path-finding algorithm that started at the "cut" site, and attempted to move in 10 metre intervals, towards the "fill" destination (while satisfying gradient and turning radius conditions). If it reached a point where it was "stuck", with no viable point points, it would move back one step and try a different route. The final set of "haul paths" could then be determined.
- A text file output of the required haul roads are then produced by the macro (see Appendix 8). This "haul profile" document contains a precise breakdown of the co-ordinates (x,y,z), grade, distance and direction of each haul road.
- This file is then imported into an Excel macro which determines how long a haul vehicle will take to travel along each haul road. It does this by:
  - Selecting the appropriate haul vehicle (dozer, scraper or dump truck)
  - Using detailed manufacturer specifications for the haul vehicle, the Excel macro simulates the vehicle moving along the haul road. The macro takes into account the possible acceleration of the vehicle in each of its gears up/down the haul road, slowing down for corners (using the manufacturer's retarder specifications), and of course this speed and acceleration profile is different for the loaded and unloaded haul trips.
  - From this simulation, the time required to travel along the haul road fully loaded and return unloaded is calculated. The macro also determines the diesel fuel consumption of the haul vehicle and the carbon dioxide emitted.
- Once the haul time for each of the required movements from cut to fill areas on the road/rail has been determined, the final dollar and carbon cost for the earthworks of this project are determined.

Result

The cost estimate for earthworks is currently done manually and takes a long time to calculate. The MACE program automates this process and produces a fully costed solution, including choice of haul vehicle and the most efficient movement of material from cut to fill locations, in a matter of minutes. The estimate can then be finessed to account for local peculiarities of the site if needed.

12d Model is instrumental to the MACE program. It is required to create a Digital Terrain Model of the site, to establish the road alignment and required batters, to calculate the volume of material that must be moved from cut to fill areas. Then the 12d path-finding algorithm macro determines the "haul roads" from cut to fill over the existing terrain.

12d® Model

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