Scheduling & Estimating Integration
— 5D BIM Case Study

CLAYCO
Tomislav Zigo, AIA, CM-BIM, LEED AP+C, Vice President of VDC
Liang Gong, PE, PMP, LEED AP+C, VDC Engineer
About the speaker

Tomislav Zigo
Vice President, VDC
Clayco inc.
St. Louis, Missouri, United States

Over the past two decades Tomislav has been an advocate of digital technology implementation as a researcher, designer and over past six years as a designer - builder. His experience includes work in the vanguard of BIM methodology implementation on large healthcare, institutional and industrial projects; research work in the field of Building Performance Analysis; optimization and use of mobile and immersive technology and mentorship positions in a number of local and national architectural firms during their transition toward BIM adoption. Currently he leads Clayco's VDC department and teaches at Washington University in St. Louis.
About the speaker

Liang works as a VDC Estimator/Engineer at Clayco. Liang works directly with the company’s preconstruction/estimating department and VDC to develop accurate detailed project takeoffs and utilizes various programs to assist with other aspects of our business as needed including project management, BIM development and coordination, 3 dimensional detail production and coordination with development of 3D models. Liang reviews and verifies accuracy and completeness of all project documents received and also analyzes and reviews bids, constructability review, and value engineering analysis for all projects received. Liang got his Master of Engineering Management degree from Duke University and Bachelor in Civil Engineering degree from Tianjin University, China.
Contents

• Clayco and its current estimating platforms
• Logistics Tracking: Equipment Sets working with Dynamo
• VICO 5D demo for a healthcare project: Top down method
• VICO 5D demo for a residential project: Bottom up method
• Design versions comparison modes
• One click takeoffs for a structural model
• From Rhino to VICO
• Customized reporting template
• Estimating Platform Integration
Clayco

- Headquartered in Chicago
- Founded in 1984 as a Design-Build Contractor
- Revenue of over $1.5B for 2016, $1.8B in 2017
- ENR top 400 Contractors 2017 Rating #22
- Approximately 1800 employees
- National Diversification of Project Types
- Over 70 LEED Accredited Professionals / 45 LEED Certified Projects
Clayco - Structure
Clayco Approach

- Determine clear objectives
- Recognize main participants
  - Architects / Engineers
  - Pre-Con
  - VDC
- Adopt standards (Uniformat, OmniClass, LOD requirements)
- Identify collaboration nodes (Clayco entities)
- Have the sense of urgency
- Establish transparency
- Sharing results / work product
Feedback Loop

- Design team is working with building assemblies
- Associating family / type with the corresponding assembly code
- Maintaining consistency from project to project.
- Determining which Revit property needs to form the unique identifier
- Develop estimate centric design template
- Accompanied with the content plan development
- Heavy reliance on worksets and filters
Building Trust

• Architect and Engineers can build great models!
• Estimating is an art – form
• Every project is different
• Our templates are not IP (share)
• Trust but verify – twice at least
• Communicate
• Abandon “gotcha” approach
• Be transparent
• No software is perfect
Herding Cats

https://www.youtube.com/watch?v=hx1jdgTs03U "Best Cat Commercials EDS Cat Herders" from YouTube
Laws
Rules
Systems
Automation
Logics
Algorithms


https://priestlandscomputing.com/algorithms-2/
To *think* as a **VDC engineer**
Integrate Logistics_Equipment Sets: Asset management
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Question 1: How to search Rooms in Revit?

Question 2: How to stand in center of a room when using “Show in Model”? (Out of a surprise)
Integrate Logistics_Equipment Sets: Rooms into 5D Process

**Question 1: How to integrate Barcodes into Revit?**
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Question 1: How to integrate Barcodes into Revit?

No Barcode information
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Read from Revit and write to Excel – To grasp all the room information
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Read from Revit and write to Excel – To grasp all the room information
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Read from Excel and write to Revit – Write Barcodes back to Revit
Integrate Logistics_Equipment Sets: Rooms into 5D Process

Barcode Added
Question 2: How to stand in center of a room when using “Show in Model”?

Where is the room?
The room is hidden by a wall or floor.
Room name, room number and barcode are transferred to the associated 3D tag and then to 360 Field by expanding scripts.
Have a deeper look at the logics behind
**Integrate Logistics_Equipment Sets: Rooms into 5D Process**

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Question 2: How to stand in center of a room when using “Show in Model”?
Question 2: How to stand in center of a room when using “Show in Model”?

Before

After
Integrate Logistics_Equipment Sets: Rooms into 5D Process
Integrate Logistics_Equipment Sets: Rooms into 5D Process
Integrate Logistics_Equipment Sets: Rooms into 5D Process
Integrate Logistics_Equipment Sets: Rooms into 5D Process
Current Platforms

- AUTODESK – TRIMBLE
- AUTODESK – BECK
- ORACLE – P6

- Same modeling practice
- Similar take – off logic
- Different levels of integration
- Very capable – different process logic
- Different learning curve
- Race to full cloud integration…
Why SqFt is Different?
From Revit to Naviswork

The curtain wall instances are hosts to other instances where their geometries have been usurped. Because there is no geometry, the curtain walls will not exist in the NWC.
Add all curtain panels together

19.83 + 21.66 \times 11 + 21.67 \times 2 + 23.22 + 22.56 + 23.63 = 370.84 < 413.33
From Naviswork to DEstimator

The curtain wall are not even shown under Walls.
VICO added all curtain walls together under one TOI
5D Top-down

- Model Register
- LBS: Location Based
- Takeoff Manager
- Cost Planner
- Task Manager
- 4D Task Group
- VSP: VICO Schedule Planner

5D Bottom-up

- Model Register
- LBS: Location Based
- Takeoff Manager
- Cost Planner
- Task Manager
- 4D Task Group
- VSP: VICO Schedule Planner

Merging Point
Cook County and the Cook County Health and Hospital Systems have hired Clayco, Inc., as the developer and design/builder to program, design and construct the new nine (9) story, 282,000 square foot Central Campus Health Center ("Center").

The new Center will be constructed with a structural steel braced frame erected upon a belled caisson foundation. It will feature stand-alone MEP systems with air cooled rooftop units and hot water VAV reheat. The exterior will be enclosed by a combination of curtain wall and unitized GFRC panels.

The project is targeting LEED Silver Certification. It has an approximate budget of $108.5 million and a 3rd quarter of 2018 completion date.
5D Top-down: Explore 5D

See attached video
Make sure no floating objects are presented in view.

Check Visibility Overrides in Revit.

Only visible objects will be exported into VICO.

Shortcut: VV
5D Top-down: Revit Export

VICO Add-in is located at Revit – Add-ins – External Tools – Publish to VICO office

Export to the estimator’s computer name.

Set up new project CCHHS in VICO. CCHHS will be listed on the projects in the Publish Data window.

Make sure Assembly codes and Family and Type are checked. The structure of VICO is based on Uniformat Elemental Classification. Attached please find the Uniformat file.

Make sure these are checked.
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5D Top-down: Project Settings

Customized combined window views

Project basic information
5D Top-down: Model Register

Revit exported model (Shell, interior, MEP, etc.) will be listed here. Select the model for takeoff and right click to activate. Only selected model will be shown in the 3D View.

Suggested customized combined window views:
Model Register_3D, LBS Manager_3D, Takeoff Manager_3D View_Cost Planner, Takeoff Manager_3D View_Takeoff Pad, Task Manager_Cost Planner, 4D Task Group_Task Manager.
The divided zones in this module will facilitate categorizing the following takeoffs and scheduling based on locations.

**Filtering**: filter the types to be shown exclusively in 3D view. Properties: click on object to see its quantities information.

Right click on each level: 1) Define level Z value from 3D model 2) Manually assign 3D elements.
5D Top-down: LBS (Location Based Schedule Manager)_3D View Horizontally

The divided zones in this module will facilitate categorizing the following takeoffs and scheduling based on locations.

Right click on each level to access Floor Plan View. In Floor Plan View, Polylines can be drawn to divide zones based on project’s needs.
5D Top-down: Takeoff Manager_3D View_Cost Planner

TOIs (Takeoff Items) are organized by **assembly codes** and **family and types**. That is why these two parameters must be exported from Revit.

Quantity parameters are calculated under TOI. Data are divided by zones defined in previous LBS Manager. Click on Net Reference Surface Area, the corresponding area will be highlighted in pink in the 3D View.
TOIs types include Beam Rectangular, Column Rectangular, Curtain Wall, Curtain Wall Frame, Curtain Wall Panel, Door, Equipment, Light Fixture, Object, Pipe Fitting, Railing, Roof, Slab, Stair, Wall and Window.

Painting Mode allows to allocate (add and deduct) the Takeoff Quantities to different Takeoff Items. New TOI can be created by right click in the Takeoff Manager.
5D Top-down: Takeoff Manager_3D_Takeoff Pad

Takeoff Pad is a breakdown of TOI in Takeoff Manager.

Take the HM door TOI as an example, the total Width and Height in Takeoff Pad equals to the Width and Height in Takeoff Manager.
5D Top-down: Creating Takeoff Report

Please see the attached customized Clayco quantity takeoff report template. Besides the TOQ in Takeoff Manager, customized TOQ can be created in Expression Editor.
### 5D Top-down: Creating Takeoff Report

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<td>C1010.10.60.D-C1010.10.60_D4</td>
<td>SQ FT</td>
<td>6,555.29</td>
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<tr>
<td>154</td>
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<td>C1010.10.B3-Basic Wall: C1010.10.B3_B3</td>
<td>FT-IN</td>
<td>1,289.47</td>
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<tr>
<td>155</td>
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<td>C1010.10.B6-Basic Wall: C1010.10.B6</td>
<td>SQ FT</td>
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<td>156</td>
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<td>C1010.10.50.F-C1010.10.50.F_F4</td>
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<td>C1010.10.50.A2-C1010.10.A2_A2</td>
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<td></td>
<td>C1010.10.50.A2-Basic Wall: Exterior Column</td>
<td>Column Wrap</td>
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<td></td>
<td>C1010.10.50.A1-Exterior Knee Wall</td>
<td>FURRING STUD</td>
<td>SQ FT</td>
<td>1,909.69</td>
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<tr>
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<td></td>
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<td></td>
<td>C1010.10.A3-Basic Wall: Column Cover Walls</td>
<td>FURRING STUD</td>
<td>SQ FT</td>
<td>258.69</td>
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<tr>
<td>161</td>
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<td>C1010.10.J8</td>
<td>CMU</td>
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<td>C1010.10.J8-C1010.10.J8_J8</td>
<td>CMU_J8</td>
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<td></td>
<td>C1030</td>
<td>INTERIOR DOORS</td>
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<td>164</td>
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<td></td>
<td>C1030.10</td>
<td>INTERIOR SWING DOORS</td>
<td>EA</td>
<td>3.00</td>
</tr>
<tr>
<td>165</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C1030.10-C1030.10_F01_44x84_HM_HM</td>
<td>SWING DOOR_44x84_HM_HM</td>
<td>EA</td>
<td>3.00</td>
</tr>
<tr>
<td>166</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C1030.10-C1030.10_F01_36x84_HM_HM</td>
<td>SWING DOOR_36x84_HM_HM</td>
<td>EA</td>
<td>6.00</td>
</tr>
<tr>
<td>167</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C1030.10-C1030.10_F02_36x84_HM_HM</td>
<td>SWING DOOR_36x84_HM_HM</td>
<td>EA</td>
<td>34.00</td>
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<td></td>
<td></td>
<td>C1030.10-C1030.10_F01_36x84_HM_WD</td>
<td>SWING DOOR_36x84_HM_WD</td>
<td>EA</td>
<td>12.00</td>
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<td>169</td>
<td></td>
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<td></td>
<td>C1020210-4 Panel</td>
<td>REVOLVER</td>
<td>EA</td>
<td>1.00</td>
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<tr>
<td>170</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>C1030.10-C1030.10.F02_44x102_HM_HM</td>
<td>SWING DOOR_44x102_HM_HM</td>
<td>EA</td>
<td>1.00</td>
</tr>
</tbody>
</table>
The estimates structure in Cost Planner is organized by **Assembly codes** in Uniformat Elemental Classification. Attached please find the Uniformat file.

Map TOIs from Takeoff Manager to Cost Planner by dragging the TOQ and dropping to the Source Qty. The mapping routine will be shown in the formulas under Source Qty.
5D Top-down: Task Manager_Cost Planner

Task Manager provides the interface for defining Tasks and for mapping cost assemblies and components (labor, material, and equipment) to these Tasks using drag-and-drop.

Tasks can be added by 1) a single task by subcontractor Or 2) self-performing labor work and material supplied.

Task Drivers are defined by adding hours/unit (consumption rate) or units/hour to cost component.
5D Top-down: 4D Task Group_Task Manager

4D Task Group allows to create a movie for different task groups. Map the tasks from Task Manager to 4D Task Group by dragging and dropping under each subcontracting category. Pick the colors to represent each of the major task categories for that Sub.

Define colors to present different tasks in the following 4D schedule simulation.
5D Top-down: Schedule Planner

Views to define task sequence:
- Network View
- Flowline View
- Gantt View
- Resource View
100 Kingshighway will be a 36-story, luxury apartment tower overlooking Forest Park.

Once complete, tower will be tallest residential building in the city of St. Louis. Along with the building’s size, another striking feature will be the project’s incredible modernist exterior, designed by Studio Gang. The large expanses of glass facade are intended to give the building’s residents a range of natural lighting and sweeping views of the park and city. Clayco’s subsidiary, Ventana was selected to design, manufacture, and install the exterior window systems.

The base of the tower will be a mix of retail space, apartment amenity space, and parking. The parking garage will have a 185-vehicle capacity. Concrete Strategies is providing the reinforced concrete structure. The tower itself will contain 316 apartment units. The project broke ground in the Spring of 2018.
5D Bottom-up: Workflow Explore 5D

See attached video
5D Bottom-up: LBS Slicing Floors
5D Bottom-up: Takeoffs and Costs
5D Bottom-up: Export P6 Schedule into XML File

Schedule was originally built up by scheduler in P6
5D Bottom-up: Import XML into VSP and Map it to the existing project

- Imported original XML schedule
- VICO project DPP schedule
5D Bottom-up: Costs and Tasks

Synchronize VSP Schedule with VICO Office

Merging Point: Task Manager

Map cost assemblies and components (labor, material, and equipment) to Tasks using drag-and-drop.
5D Bottom-up: Control Mode vs Planning Mode (Actual vs Scheduled vs Forecast)

Input actual start and finish date of a task:
Level 7 to Level 15 curtainwall installation has been finished
5D Bottom-up: Control Mode vs Planning Mode (Actual vs Scheduled vs Forecast)
5D Bottom-up: Control Mode vs Planning Mode (Actual vs Target vs Forecast)

**Target**: enables the planned schedule which we are targeting

**Actual**: a reflection of the current plan including all detailed tasks

**Forecast**: takes all actualized data to generate a comparative model
5D Bottom-up: Expense and Income

- Define payments to subcontractors under Expense Events.
- Define income from owner under Income Events.
- Provides a basis for accurately forecasting and controlling the net cash for a project.
- Provides a firm link to completion of locations progressively through a project.
5D Bottom-up: Cash Flow _ Target
5D Bottom-up: Cash Flow _ Target vs Current

Curtainwall installation is delayed
• Resource Histogram allows using historical actualized data to trend resource quantities, resource hours, quantities and cost in the future.

• Resource Histogram allows us to determine the potential risks of resource or quantity over or underage
5D Bottom-up: Resource Histogram

Number of hours needed by week

Curve line: Accumulative number of hours

Total number of hours
5D Bottom-up: Risks

Risks

1. Starting Risk
2. Duration Risk
3. Resource Beginning Risk
4. Resource Come Back Delay
5. Production Factor Risk

Risk management includes planning continuous work, using buffers and being proactive to prevent delays
Risk Simulation is used to validate the reliability of a schedule and to optimize the schedule to find the optimal trade offs between cost and time under conditions of uncertainty.

- Monte Carlo Risk Simulation is a tool to model and identify problem in the schedule.
- Results can be used to alert the GC to make proactive decisions.
- Monte Carlo Risk Simulation provides a probability calculation to access each of the 5 risk categories.
Monte Carlo Risk Simulation: How to assign risk levels (variabilities) to tasks (variables)

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Start of Schedule Task</th>
<th>Schedule Task Duration (%)</th>
<th>Beginning Risk</th>
<th>Correlation Delay</th>
<th>Production factor</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>TASK 1</td>
<td>0/0/0</td>
<td>0/0/100/100/100</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
<tr>
<td>DRILLED HRS &amp; RETENTION</td>
<td>Low/High</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Foundation</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
<tr>
<td>CAPS/GBS/WALLS</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
<tr>
<td>FLOOR CONSTRUCTION</td>
<td>High/Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
<tr>
<td>LEVEL 2</td>
<td>High/Intermediate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
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<tr>
<td>LEVEL 3</td>
<td>High/Intermediate</td>
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<td>Low</td>
<td>Low</td>
<td>0/0/0</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

*Note: The table shows a risk simulation for various tasks with different risk levels and dependencies.*
5D Bottom-up: Risk Simulation

Define Iterations

30%
Install curtainwall

Percentage of risk that location can occur
5D Bottom-up: Risk Simulation_Temporal Distribution

Verticals: Probability of completion at a specific day
Curve: Probability of completion before a specific day (accumulatively)

Conclusion: Very Risky. Need to introduce buffer to optimize schedule
5D Bottom-up: Risks

**Actions:**

- We use the probability values to assess the schedules areas of most risks
- By using this data we can determine how we can use our optimization tools
- We can add buffer, change resource amounts, make tasks ASAP, combine tasks and split tasks
Questions

Why do we plan logistics?
When to deliver materials?
How many deliveries are required?
Time and resources needed for receiving and hauling?
What is the lead time before production can start?

What are procurement tasks?

A procurement task is composed of the organization of materials or subcontractor work packages that are able to be ordered from a supplier. The following must be finished before a task can commence:

- Design
- Planning accurate task schedule
- Document and Call for tender
- Bid evaluation
- Contract
- Deliver order
- Pull the procurement tasks to scheduled activities
- Calculate durations for Just In Time Delivery
• Procurement milestones are used to identify time considerations to begin a task
• VSP pulls milestones to the commencement of the task
4D & 5D integration

- Location Based **Schedule Manager** facilitates categorizing takeoffs, estimates and scheduling based on 3D locations.
- **Cost Planner** sets up estimates with formulas under Source Qty by mapping TOIs from Takeoff Manager.
- **Task Manager** lays out tasks by mapping cost assemblies and components (labor, material, and equipment) from Cost Planner.
- **Task Groups** allows to create 4D animations by mapping the tasks from Task Manager.
- **Schedule Planner** defines task sequence with Network View, Flowline View and Gantt View.
Comparing Alternatives (Highlight Mode)

Structures_Design Versions Comparison
Comparing Alternatives (Highlight Mode)

Architectures_Design Versions Comparison
Comparing Alternatives (Highlight Mode_2D)

Create batch report in few seconds
Comparing Alternatives (Sliding Mode)

Architectures_Design Versions Comparison

Structures_Design Versions Comparison
Fast Takeoffs_Podium Structural Model

<table>
<thead>
<tr>
<th>Takeoff Objects</th>
<th>Quantities</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>Beams_New Construction</td>
<td>2,881</td>
<td>ton</td>
</tr>
<tr>
<td>Columns_New Construction</td>
<td>304</td>
<td>ton</td>
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<tr>
<td>Slabs_New Construction</td>
<td>226,072</td>
<td>sqft</td>
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</table>

**Willis Tower 5.3.2017**

**BEAM RECTANGULAR**

<table>
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<tr>
<th>Length</th>
<th>Weight</th>
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<tbody>
<tr>
<td>214'13/16&quot;</td>
<td>27.34 Tons</td>
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</tbody>
</table>

**BEAM_T1:tapered:Plate; 17" x 4.5' - 4' x 4.5" SOLID BAR TAPERED**

<table>
<thead>
<tr>
<th>Length</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>215'9/16&quot;</td>
<td>20.31 Tons</td>
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</tbody>
</table>

**BEAM_T1:tapered:Plate; 30" x 4.5' - 8' x 4.5" SOLID BAR TAPERED**

<table>
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<th>Length</th>
<th>Weight</th>
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<tr>
<td>417'-6&quot;</td>
<td>90.42 Tons</td>
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**BEAM_T1:Plate Girder; 8G**

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<tbody>
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<td>49'</td>
<td>5.1 Tons</td>
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**BEAM_T1:Plate Girder; PG 1**

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<tbody>
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<td>105'</td>
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**BEAM_T1:Plate Girder; PG 2**

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<th>Weight</th>
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<tbody>
<tr>
<td>66'-4&quot;</td>
<td>8.09 Tons</td>
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</tbody>
</table>
Rhino Model imported to VICO
Total curtainwall area on tower is 121,805 sqft.

Use formula to define quantities as desired.
Reporting

• Construction grade quantities
  o Steel
  o Concrete
  o Partitions
  o Finishes

• Comparison report
  o Unified models database
  o Quantity reporting
  o Associated cost reporting
  o Visual verification

• Quantity push to estimating platform
Customizing Report Items
Scheduling & Estimating Platform Integration

• Ability to create Master assemblies
• No more corrupted Excel Formulas
• Estimates according to industry standards
  o Masterformat 95, 2004
  o Uniformat 2010
• Historical Cost modeling
• Support for the unlimited WBS and Locations
• P6 development
Q & A
Thank You!