Eliminating Construction Waste
As a Pathway to Project Success

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About the speaker

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About the speaker

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Senior Business Consultant at Autodesk.
15 years experience as a building design structural engineer and general contracting project manager, working primarily on integrated project delivery healthcare and residential projects.
About the speaker

John Wiegand

Principal Business Consultant at Autodesk.
John has worked in and on the business of construction for 34 years, and has been a strong Lean advocate. He has spent the last 6 years at Autodesk supporting customer outcomes in the AEC space.
Sustainability & Lean for Construction
The Autodesk vision is to help people imagine, design, and make a better world
MATERIALS
- emissions & waste
- materials/resources productivity

ENERGY
- emissions
- energy & carbon productivity
3,600
MORE BUILDINGS PER DAY
~50% GLOBAL EXTRACTION
>30% IS WASTED
CARBON WASTE
EC3: Embodied Carbon in Construction Calculator
C&D waste generation estimates for the 10 most common building/project types in Alameda County

<table>
<thead>
<tr>
<th>BUILDING TYPE</th>
<th>PROJECT TYPE</th>
<th>MEDIAN LB/SQ FT</th>
<th>LOW END² LB/SQ FT</th>
<th>HIGH END³ LB/SQ FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>Demolition/Deconstruction</td>
<td>10.0</td>
<td>1.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>New Construction</td>
<td>14.8</td>
<td>2.6</td>
<td>59.3</td>
</tr>
<tr>
<td>Commercial</td>
<td>Remodel</td>
<td>6.9</td>
<td>1.9</td>
<td>20.1</td>
</tr>
<tr>
<td>Commercial</td>
<td>Repair/Reconstruction</td>
<td>10.0</td>
<td>1.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>Tenant Improvement</td>
<td>3.8</td>
<td>1.2</td>
<td>11.6</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>New Construction</td>
<td>6.0</td>
<td>3.5</td>
<td>10.8</td>
</tr>
<tr>
<td>Office</td>
<td>Tenant Improvement</td>
<td>2.3</td>
<td>1.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Residential</td>
<td>New Construction</td>
<td>7.3</td>
<td>3.9</td>
<td>14.6</td>
</tr>
<tr>
<td>Residential</td>
<td>Remodel</td>
<td>24.6</td>
<td>9.0</td>
<td>67.4</td>
</tr>
<tr>
<td>Retail</td>
<td>Tenant Improvement</td>
<td>6.4</td>
<td>1.7</td>
<td>17.6</td>
</tr>
</tbody>
</table>
Definitions used in materials selection:

"Unprocessed wood is based on the Timber Trade Federation's definition, i.e. comprises softwood and hardwood timber;"

"Processed wood is based on the Timber Trade Federation's definition, i.e. comprises wood based panel products in which wood is pre-dominant in the form of strips, veneers, chips, strands or fibres, and includes plywood, chipboard, cement-bonded particleboard (CBPB), oriented strand board (OSB) and medium density fibreboard (MDF);"

"Soft flooring includes natural carpet, vinyl flooring and linoleum etc; and"

"Structural waterproofing includes damp proof course (DPC) membrane and roofing materials, including mastic asphalt, polymers and bitumen."
### Table 2: Wastage Rate Data for Materials at Baseline and Good Practice

<table>
<thead>
<tr>
<th>Material</th>
<th>Baseline</th>
<th>Data Sources &amp; Assumptions</th>
<th>Good</th>
<th>Data Sources &amp; Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bricks and Blocks</td>
<td>20%</td>
<td>Workshop consensus that up to 16% wastage occurs on delivery to site and 5% on site. Validated by BRE and NW Trials.</td>
<td>10% (Bricks)</td>
<td>5% if on-site wastage only and confirmed by project data for blockwork from Bovis Lend Lease and NW Trials. Also validated by BRE. Bricks considered more fragile than blocks so higher rate of 10% applied, although Waste Aware Construction suggests that 7.5% is appropriate for bricks. The source of Waste Aware Construction data is not fully verified so bricks remain at 10%.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5% (Blocks)</td>
<td></td>
</tr>
<tr>
<td>Aggregates</td>
<td>10%</td>
<td>BRE range is 10-15% depending on material and Waste Aware Construction suggests 10% for general inert. Carillion suggests 7.5%.</td>
<td>5%</td>
<td>Based on aggregates used in sub-structure and materials being readily available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surfacing Materials(^a)</td>
<td>5%</td>
<td>Confirmed by Carillion.</td>
<td>2.5%</td>
<td>Confirmed by Carillion.</td>
</tr>
<tr>
<td>Tiles and Ceramics</td>
<td>8%</td>
<td>Based on top end of BRE and NW Trial range of 5-8%.</td>
<td>5%</td>
<td>Based on previous WRAP research and confirmed by NW Trial and Carillion but higher than Waste Aware Construction Data at 3%.</td>
</tr>
<tr>
<td>Concrete Pre-Cast (Large Pre-Cast Elements)</td>
<td>1%</td>
<td>Larger structural pre-cast concrete elements such as beams and frames generate little waste, confirmed with Bison and Mitchellson Construction.</td>
<td>0%</td>
<td>Larger structural pre-cast concrete elements such as beams and frames generate little waste, confirmed with Bison Concrete Products and Mitchellson Construction.</td>
</tr>
<tr>
<td>Concrete In-Situ</td>
<td>5%</td>
<td>4% from Aberystwyth research findings, 5% by Carillion and 5-6% reported by WRAP as general consensus across industry for range of in-situ concrete products. Top end of NW Trial Range of 2.5 to 5%.</td>
<td>2.5%</td>
<td>1.8% from Aberystwyth research findings and BRE estimate of 3.3%. Carillion confirmed 2.5% and Bovis Lend Lease project data 4%. Bottom end of NW Trial Range of 2.5 to 5%.</td>
</tr>
<tr>
<td>Screed</td>
<td>5%</td>
<td>Can be considered similar to in-situ concrete (Arup structural specialists).</td>
<td>2.5%</td>
<td>Can be considered similar to in-situ concrete (Arup structural specialists).</td>
</tr>
<tr>
<td>Gravel</td>
<td>10%</td>
<td>Assumed to be same as aggregates. Confirmed by Carillion and validated by BRE.</td>
<td>5.5%</td>
<td>Previous WRAP research – based on drainage stone.</td>
</tr>
<tr>
<td>Sand</td>
<td>12.5%</td>
<td>Confirmed by Carillion and assumed to be higher than for aggregates due to wide availability of material.</td>
<td>5.5%</td>
<td>Based on aggregates used in sub-structure and materials being readily available.</td>
</tr>
<tr>
<td>Stone</td>
<td>10%</td>
<td>Based on top end of typical range of 5-10% for paving stones and kerbs. Depends on type and size of stone.</td>
<td>5%</td>
<td>Based on low end of typical range of 5-10% for paving stone and kerbs. Depends on type and size of stone. Building stone around 5% (WRAP and BRE). Best practice considered 3%.</td>
</tr>
<tr>
<td>Other Inert(^b)</td>
<td>10%</td>
<td>Based on aggregates. Assumed to be lost through</td>
<td>5%</td>
<td>Based on aggregates. Assumed to be lost through movement on</td>
</tr>
</tbody>
</table>

\(^a\) Includes Asphalt, Bitumen and Macadam

\(^b\) Other non-hazardous inert wastes such as soils and excavation wastes
Construction and demolition waste management

Materials and Resources

Possible 2 Points

**Intent**

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.
Option 1. Diversion (1–2 points)

Path 1. Divert 50% and Three Material Streams (1 point)

Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams.

OR

Path 2. Divert 75% and Four Material Streams (2 points)

Divert at least 75% of the total construction and demolition material; diverted materials must include at least four material streams.

OR

Option 2. Reduction of Total Waste Material (2 points)

Do not generate more than 2.5 pounds of construction waste per square foot (12.2 kilograms of waste per square meter) of the building's floor area.
Lean for Construction
Handling Lean Construction from Beginning to End with Autodesk
Experience With Lean Practices - US

- At least two thirds of contractors have at least some experience with all of the Lean practices included in the study.
- Contractors have the highest level of experience with weekly work planning and PPC, and the lowest level of experience with pull planning.
Anticipated Engagement With Lean Practices in Next Two Years in US

- Over two thirds of contractors with experience in these practices expect to increase their engagement with weekly work planning and PPC, and early stakeholder Involvement.
- 60% of contractors with experience in pull planning expect to increase their engagement with it.
- No contractors with experience in weekly work planning or pull planning expect to decrease their engagement, and only 1% of those with early stakeholder involvement do.

![Percentage of Those With Experience With Each Method in US (n=112, 96, 113)](chart)

- **Weekly Work Planning and PPC**: 20% increase significantly, 47% increase slightly, 32% remain about the same, 2% decrease, 5% not sure.
- **Pull Planning**: 17% increase significantly, 43% increase slightly, 36% remain about the same, 3% decrease, 2% not sure.
- **Early Stakeholder Involvement**: 22% increase significantly, 43% increase slightly, 32% remain about the same, 2% decrease, 3% not sure.
### Willingness to Invest in BIM-Based Technology Solutions That Would Improve Lean Practices

- US contractors are most interested in investing in technologies to improve pull planning, although the willingness to invest in technologies is high for all the lean practices.
- While the number of US respondents at a medium or higher level of experience cautions against breaking down the analysis, there is directional evidence suggesting that large contractors are the most willing to make these investments, especially for weekly work planning and PPC, and early stakeholder involvement.

<table>
<thead>
<tr>
<th>Lean Practice</th>
<th>Very High</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>None</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly Work Planning and PPC</td>
<td>13%</td>
<td>20%</td>
<td>30%</td>
<td>21%</td>
<td>1%</td>
<td>6%</td>
</tr>
<tr>
<td>Pull Planning</td>
<td>16%</td>
<td>21%</td>
<td>32%</td>
<td>21%</td>
<td>1%</td>
<td>8%</td>
</tr>
<tr>
<td>Early Stakeholder Involvement</td>
<td>12%</td>
<td>21%</td>
<td>30%</td>
<td>36%</td>
<td>1%</td>
<td>5%</td>
</tr>
</tbody>
</table>

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Likelihood of Including Ongoing Training and Education as Part of Technology Investment

- More than half of contractors in the US and UK say that, if they invested in a BIM based technology solution in the next two years, they would be very likely to include ongoing training and education as part of that investment.
- Far fewer in France report high likelihood, but many more are somewhat likely among the French respondents.
Top Benefits Using Technology for Lean Practices

- Reducing rework is the top benefit that technology would bring to early stakeholder involvement and weekly work planning and PPC.
- Streamlining logistics is another top benefit for early stakeholder involvement.
- Reducing conflicts between tasks is the top benefit expected for pull planning.
Top Challenges to Increasing Use of Lean Practices

- Lack of buy in from the trades is the biggest obstacle for weekly work planning and pull planning.
- The biggest obstacle for early stakeholder involvement is lack of owner buy-in.
- Since obstacles were asked of only those with medium or greater experience, the total numbers are too low for analysis by firm type, size or BIM involvement.
Lean for Construction with Design/Engineering
Lean for Construction with Design/Engineering

Construction Flow vs. Design Flow
Lean for Construction with Design/Engineering

Design Flow

Partners → Input → Information → Process → Curate → Output → Information → Partners
Lean for Construction with Design/Engineering

Negotiating Process Outcome
Lean for Construction with Design/Engineering

Consistent Reliability

Technology
- Push the Envelope

Process
- Leading vs Lagging Indicators

People
- Align Expectations

Conditions of Satisfaction
Design to Preconstruction (Pre-Win Pursuit Analysis)
Maximize Prefabrication in Model Conditioning

Design Development

Model Conditioning

Production Planning

AUTODESK® BIM 360® DOCS

AUTODESK® BIM 360 DESIGN

assemble

DOCUMENT MANAGEMENT MODULE

PROJECT MANAGEMENT MODULE
Lean for Construction with General Contractors
### Four Tasks Every Team Must Do

#### Impact of Fragmentation

<table>
<thead>
<tr>
<th>LEAD</th>
<th>COORDINATE</th>
<th>DECIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• fragmented</td>
<td>• siloed</td>
<td>• late</td>
</tr>
<tr>
<td></td>
<td>• late</td>
<td>• not sticky</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• long latency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REWORK</th>
<th>WORK</th>
</tr>
</thead>
</table>
You Are Entering a Lean Project

**THINK** Differently
- Can you see it done differently
- Are you pursuing **PERFECTION** the first time
- Don’t compromise your rules and principles

**REALIZE** “no problem” is a problem

**LOOK** at the errors in the **PROCESS** not the **PEOPLE**

**BE** transparent in **EVERYTHING**

**IDENTIFY** the forms of **WASTE** whenever you see them

**WORK** to better the whole, not the individual

**EVERYONE** is empowered to make it better
- Do you have the **TOOLS, TIME, and RESOURCES** you need
- You can declare “C’MON MAN!”

**PLAN** the work, work the **PLAN**
- Plan, do, check, act

**SHOW** things **VISUALLY** so that everyone knows where we are

**TRUST** your other partners
- Are you in the “circle of trust”

**RESPECT** others time and effort as you do your own
- Invite challenges without being defensive

**DECLARE** broken processes, promises and plans
- A PROMISE is an element of **TRUST**

**MEASURE** to see how we are doing
- Publish our performance for **ACCOUNTABILITY**

**RECOGNIZE** your mistakes, but be ready to **CORRECT** the process
A Lean Framework
for Integrating Project Delivery

Measurable Value
- High Performing Building

Production Management
- Integrated Systems

Collaboration Co-location
- Process Integration
- Integrated Organization

Visualization Simulation
- Integrated Information

Agreement / Framework
Integrating Process Knowledge
to Design a High Performing Building
Managing with Metrics to Improve Integrated Team Performance

1. Bricks and Mortar: Projected Estimate progress toward Budget
2. Cluster Breakdown
3. Integrated Process Starts
4. Submittals
5. RFIs
6. Project PFC, UCSF Medical Center at Mission Bay

- Reduced conduit, wiring and circuits by 3,000 linear feet, saving $500,000
- Reduced ductwork by 100,000 pounds and piping by 7,000 linear feet, saving $2M

- 610 Total PMIs
Fireside Chat