Improving Construction Efficiency with Digital Fabrication. An Environmental Insight

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36% of global energy use and 39% of energy-related carbon dioxide (CO2) emissions

Over the next 40 years, the world is expected to build 230 billion square metres in new construction – adding the equivalent of Paris to the planet every single week.

In France
79% of housing available in 2030 exist since 2006, 50% of whose will have been built before the first RT

Sustainable design & construction technics

In 2014 in France, the construction sector generated 227.5 million tonnes of waste, 80% of which is inert.

In 2017, 55% of the world’s population residing in urban areas by 2050, 68%.

Source: Global Status Report 2017

Source: World Urbanization Prospects: The 2018 Revision

Source: Global Status Report 2017

Source: Optimisation mécanique et énergétique d’enveloppes en matériaux composites pour les bâtiments, Natalia Kotechkova-Weiler, 2013

Source: enquête « Déchets et déblais produits par l’activité de construction en 2014 », SOeS

Over the next 40 years, the world is expected to build 230 billion square metres in new construction – adding the equivalent of Paris to the planet every single week.
230 billion sqm of new construction in next 40 years
Source: Global Status Report 2017

#1 Consumer of global raw materials
Source: World Economic Forum and BCG
Global labor-productivity growth trends

Based on a sample of 41 countries that generate 96% of global GDP.

Source: OECD; WIOD; GGCD-10, World Bank; BEA; BLS; national statistical agencies of Turkey, Malaysia, and Singapore; Rosstat; McKinsey Global Institute analysis
Timber High-Rise Challenge

The world tallest timber tower
© Michael Green Architecture
Conceptual Fabrication Strategy: 1. Inflated pneumatic membrane
2. Robotically reinforce membrane with carbon fiber from inside
3. Stable composite shell
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2014-2015
Landesgartenschau Exhibition Hall: Top view, section and volume (left)
Robotic Fabrication of panels (right)

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BUGA WOOD PAVILION 2019
© ICD/ITKE/IlGS University of Stuttgart

Space Truss Masonry Walls With Robotic Mortar Extrusion
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#1 Academic Work on Environmental Evaluation of the Practice

cf. I. Agustí-Juan et G. Habert, «Environmental design guidelines for digital fabrication»
From PQ Mesh to Reciprocal Frame

Marionette Technic for panel's planarity

Assembly

R. Mesnil, T. Gobin, et O. Baverel, « Form Finding and Design of a Timber Shell-Nexorade Hybrid » Advances in Architectural Geometry, Gothenburg, Sweden, 2018

C. Douthe et al., « Design and construction of a shell-nexorade hybrid timber structure » IASS Annual Symposium 2018

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« Form Finding and Design of a Timber Shell-Nexorade Hybrid » Advances in Architectural Geometry, Gothenburg, Sweden, 2018
Life Cycle Assessment method _ ISO 14040 / 14044
EcoInvent 3.2 Cut-Off _ EN 15804
OpenLCA SoftWare
ReCiPe MidPoint (H) _ ILCD Handbook

Sensitivity Analysis on Robotic’s Outlay

<table>
<thead>
<tr>
<th></th>
<th>1st Scenario</th>
<th>2nd Scenario</th>
<th>3rd Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotic Cell</td>
<td>37.62 H</td>
<td>1 Week / 5 day / 120 H</td>
<td>2 Months / 1440 H</td>
</tr>
<tr>
<td>CNC Cell</td>
<td>1 H</td>
<td>1 Week / 5 day / 120 H</td>
<td>2 Week / 576 H</td>
</tr>
</tbody>
</table>

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1st Scenario > 37.62 h = 0.04%
2nd Scenario > 120 h = 0,1%
3rd Scenario > 1440 h = 1.4%
Outlook & Further Investigations

- Precision of Energy Consumption of the Robotic Cell
- Sensitivity Study on the Length of Fabrication Series
- Comparison with Conventionally Fabricated Constructive System

Thank you for your attention