JEC Conference
Composites as a Worthy Alternative to Traditional Materials in the Construction Industry

Paris, March 16, 2017

The future of building: The growing use of composites in construction and architecture
A study commissioned by the JEC Group

Presenter: Andrew Mafeld
Managing Director
Connectra Global KB, Sweden
www.connectra.biz
Introduction to Connectra: Consulting in business development of materials

<table>
<thead>
<tr>
<th>Assignments Completed</th>
<th>Over 140 client-tailored assignments since 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clients served in</td>
<td>W.Europe, E.Europe, N.America and Asia</td>
</tr>
<tr>
<td>Materials covered include</td>
<td>Composites, Thermoplastics, Thermosets, Reinforcement Fibres, Fabrics, Non-Wovens, Insulation Materials, Glass, Metals, Wood, Foams and Specialties</td>
</tr>
<tr>
<td>End use markets covered</td>
<td>Aerospace, Automotive, Truck, Renewable Energy, Construction, Marine, Industrial Equipment, Pipes, Recreation &amp; Other</td>
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</tbody>
</table>
### Introduction to Connectra:
Consulting in business development of materials

| Type of project tailored to clients’ needs: | • **Market studies** (global, regional, national, regional or by industry sector)  
• Facilitation of Business Development Strategies  
• **Business Plan** synthesis  
• **Commercial Due Diligence** for acquisitions  
• Technology auditing / cost modelling / Competitive Assessment  
• Expertise sharing / Training / Company Meeting facilitation |

*The future of building: The growing use of composites in construction and architecture  
**JEC World, Paris, March 16, 2017***
The future of building: the growing use of composites
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Topics covered

- Introduction
- Composites in Architectural Projects
- Composites Systems for whole or partial, new build or refurbishment
- Composite Elements for new build or refurbishment
- Composites for reinforcement and repair
- Conclusions
The future of building: the growing use of composites

Introduction – topics covered

- The Purpose, Scope and Targeted Audience
- The Definition and Scope of Composites in the Construction of Buildings
- Three major segments – categories of building
- Grouping the many composite applications in the construction of buildings
- Many good reasons for using composites in the construction of buildings
The Purpose, Scope and Targeted Audience

▪ The Purpose of the project
  – Spreading knowledge about composites in the construction of buildings
  – Growing the use of composites in the construction of buildings

▪ The scope of the project
  – The Geographic Scope - Global
  – The Time Scope – Existing, Cutting edge and Futuristic applications

▪ Targeted Audience
  – Participants in the Building Industry Supply Chain
  – No prior knowledge of composites assumed
  – Examples documented enough to be of interest to existing players
Grouping the many composite applications in the construction of buildings

- Few limits of human ingenuity and creativity
- 68 examples have been chosen to illustrate the multitude of applications
- Four distinct sub-segments naturally appeared

<table>
<thead>
<tr>
<th>Composite Application sub-segment</th>
<th>Number of examples</th>
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<tbody>
<tr>
<td>Architectural projects</td>
<td>20</td>
</tr>
<tr>
<td>Systems and Sub-Systems in Composites for New Building and Refurbishment</td>
<td>24</td>
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<tr>
<td>Composite Elements for New Build or Refurbishment</td>
<td>13</td>
</tr>
<tr>
<td>Composite Systems for Reinforcement and/or Repair of Buildings</td>
<td>11</td>
</tr>
<tr>
<td>Total number of examples</td>
<td>68</td>
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</table>
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Key perspectives on composites in architectural projects

- Usually high profile projects
- Largest segment is public buildings, often linked to design competitions
- Many façade projects but also roofs, domes and pavilions
- The two most common reasons for the use of composites:
  - Freedom of design/form/aesthetics
    - often coupled to and enabled by
  - Light weight compared to traditional materials
- Other reasons for use cited:
  - Corrosion resistance
  - Low maintenance
  - Translucency
  - Advantages of off-site manufacture
  - Ability to pass the necessary fire tests
Many leading architects now use composites

<table>
<thead>
<tr>
<th>Architect Firms cited in the book</th>
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<tbody>
<tr>
<td>ARM Architecture, Melbourne, Australia</td>
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<tr>
<td>Benthem Crouwel Architekten (BCA), San Jose, California, USA</td>
</tr>
<tr>
<td>BIG - bjarke ingels group, Copenhagen, Denmark</td>
</tr>
<tr>
<td>Cheshire Architects, Auckland, New Zealand.</td>
</tr>
<tr>
<td>Dar Al-Handasah, HQ in Beirut, Lebanon</td>
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<tr>
<td>Erick van Egeraat Associated Architects, Rotterdam, The Netherlands</td>
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<tr>
<td>Foster &amp; Partners, HQ London, UK</td>
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<tr>
<td>Gensler, San Francisco, CA, USA</td>
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<tr>
<td>Kengo Kuma, Japan</td>
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<tr>
<td>Kraaijvanger Urbis, Rotterdam, Netherlands</td>
</tr>
<tr>
<td>Mecanoo, HQ Delft, Netherlands</td>
</tr>
<tr>
<td>Omar Kbiri (original idea) working together with unnamed architects</td>
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</tbody>
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<tr>
<th>Architect Firms cited in the book</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Team: Institute for Computational Design - Prof. Achim Menges and Institute of Building Structures and Structural Design - Prof. Jan Knippers, Stuttgart University, Germany</td>
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<tr>
<td>R Studio Arquitectura, Valencia, Spain</td>
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<tr>
<td>Safdie Architects - Moshe Safdie, Singapore/Toronto</td>
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<td>Sandover Pinder of Perth, Australia</td>
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<td>Skidmore, Owings, and Merrill, Chicago, USA</td>
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<tr>
<td>Snøhetta, HQ Oslo, Norway</td>
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<tr>
<td>Spanish architect Vicente Peidró, Spain</td>
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<tr>
<td>Walt Disney Imagineering, Glendale, CA, USA</td>
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<tr>
<td>WATG-Urban-Architecture-studio, Chattanooga, TN, USA</td>
</tr>
<tr>
<td>Wilmotte &amp; Associates, Paris, France</td>
</tr>
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<td>Zaha Hadid Architects, London, UK</td>
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</table>
San Francisco Museum of Modern Art – 2016
Architects: Snøhetta, Oslo, Norway
Moulders: Kreysler & Associates, CA, USA
The Glass Lantern, Apple Zorlu, Istanbul, Turkey
Architects : Foster and Partners
Materials : Carbon Fibre/Epoxy Panels
Producer : PCT, Dubai
Some key observations on the architectural projects

▪ In all cases off-site pre-fabrication was a major advantage for multiple reasons including quality and efficiency
▪ The combination of light weight and on-site multi-panel assembly makes transportation around the world possible
▪ A number of specialised moulders with a full service beyond just moulding has arisen
▪ Installation expertise is also important
▪ Light weight of the composite elements means less requirement on the foundations of the building and any façade support structure
▪ 2016 saw the unveiling of many such projects with composites
▪ Composites are penetrating building codes and passing fire tests that broaden their application possibilities
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Key perspectives on composite systems for either the whole or part of a building

Whole buildings

- Over the years, there have been a wide range of buildings, that have been developed using composites
- Mainly residential but some commercial and public (e.g. schools)
- The range includes:
  - Complete buildings e.g. houses, schools, constructed from kits, often using pultruded parts
  - Complete houses assembled from prefabricated modules
  - Complete GRP houses moulded off site and transported
  - 3D-printed buildings using cement based composites
- Uses include permanent residence, temporary residence, offices, schools, & other permanent & temporary structures
Luxury Portable Buildings
Producer: Inpod, Mumbai, India
Material: GRP
Concept 3D Printed Freeform House
Architects: WATG Urban Architecture, Chicago
Manufacturer: Branch Technology (printing to start in 2017)
House to be located in Chattanooga, TN, USA

Photo: © WATG Urban Architecture
Key perspectives on composite systems for either the whole or part of a building

Parts of buildings

- In addition to whole buildings, a wide range of composite systems are used for parts of buildings e.g. roofs, walls, floors
- Applications include all three areas of public, residential and commercial buildings
- Reinforcement of concrete using carbon fibre grids is growing fast
- There are several very large volume, long standing applications which are composites (in the broad definition): BUR roofing, shingles and decking
- Natural fibres can also be used in appropriate geographical zones
- Thermoplastic systems have also been launched in this area
Precast CF grid reinforced concrete panels and pillars
Producer: The Altus Group
Material: Concrete with CF grid (supplied by Chomarat)
Composite Basement Systems
Producer: Composite Panels Systems, USA with Fiber Tech Industries making the panels
Material: GRP
Some key observations on the composite systems for whole or parts of buildings

- Part of the challenge for composites in the field of construction of buildings is the fragmented and local nature of the building industry.
- The global aerospace and automotive industries have a limited number of OEMs, limited product range, global manufacturing platforms etc.
- Having said that, composites are finding applications where their advantages are used to the most.
- Light weight and off site pre-fabrication again appear as key reasons why composites are gaining penetration.
- Light weight and off-site fabrication mean faster construction, lower costs for heavy lifting gear, less material waste than on-site production, less labour on site, less weather impact to name but a few advantages.
- For whole house systems, it is important to provide a total solutions which includes the electrical and plumbing systems.
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Key perspectives on composite elements for buildings

- This is the sub-segment where composite moulders can use their creativity to a maximum
- A very wide range of elements are made from composites:
  - Translucent roofing panels, door skins, window frame elements, bathroom/shower room elements or even pods, beams, façade elements, special walls, wall coverings, domes, architectural textiles etc. etc.
- Growing applications include gypsum panels with glass veil facings and glass veil based flooring
- New applications with potential include GRP and WPC walls with built in anti bacterial properties for clinics and hospitals
- Light weight beams made from CF or Natural fibre
- Domes can be made from GRP or GRC
GRP hotel bathroom pod
Producer: Suzhou Cozy House Equipment Co, Suzhou, China
Material: SMC
Light weight concrete beams
Producer : C3 Carbon Concrete Composite Composite e.V, Dresden, together with Betonwerk Oschatz, Germany
Material: CF reinforced concrete beam
– same properties but 50% of the weight
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Key perspectives on composites for reinforcement and repair

- This final sub-segment highlights the applications of composites in reinforcement applications (as in reinforcing concrete via composite rebar) or in repair/strengthening.
- Significant volumes of carbon fibre fabric/epoxy used to strengthen floors and pillars either pre- or post-earthquake
- New ways of strengthening buildings against earthquake shock using intelligent textiles or novel form of CF
Temporary Church Roof after earthquake
Producer: TopGlass, Osnago, Italy
Material: Glass fibre/polyester resin
Strengthening of pillars
Producer: Mitsubishi, Japan
Material: Carbon Fibre fabric/ Epoxy
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Conclusions

- As has been shown, composites are already established in a wide variety of applications in the construction of buildings.
- There are a certain number of trends that are likely to further increase the chances of composites growing. These include:
  - Continued growing demand for housing due to urbanisation (90% in Asia/Africa)
  - Continued growing demand for affordable inner city housing
  - Growing awareness of composites in general
  - Growing understanding of the benefits of light weight and off-site prefabrication
  - 3D-printing and its fast development
  - Composites penetrating building codes and passing severe fire tests
  - Increasing use of Building Information Modelling (BIM)
- The importance of active participation in standards’ bodies and in promotion of composites within the whole industry chain cannot be emphasised enough.
- Overall the prospects for composites in building construction look very positive.
Thank you for your attention

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Managing Director

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Capability Presentation about Connectra
available upon request