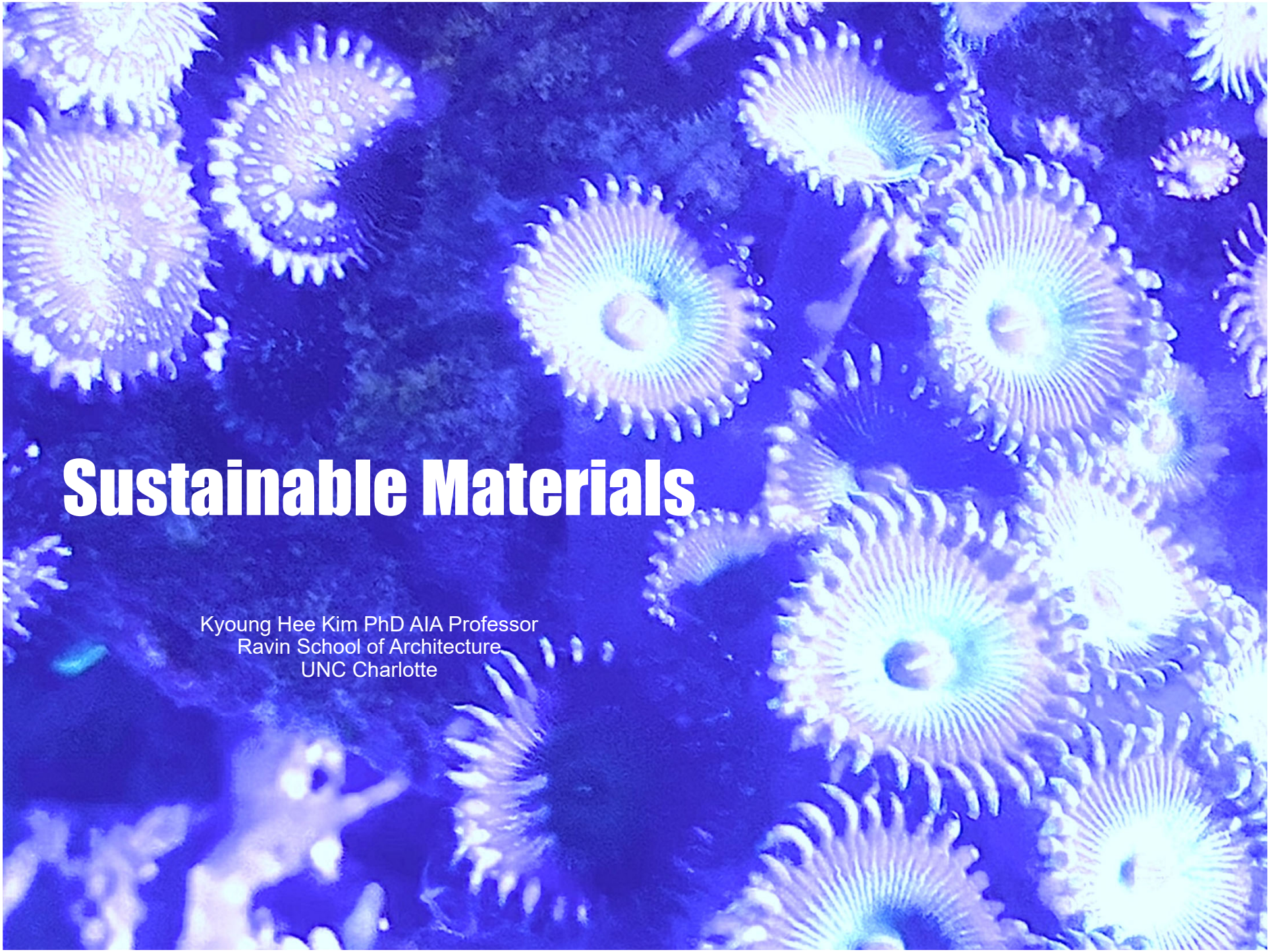
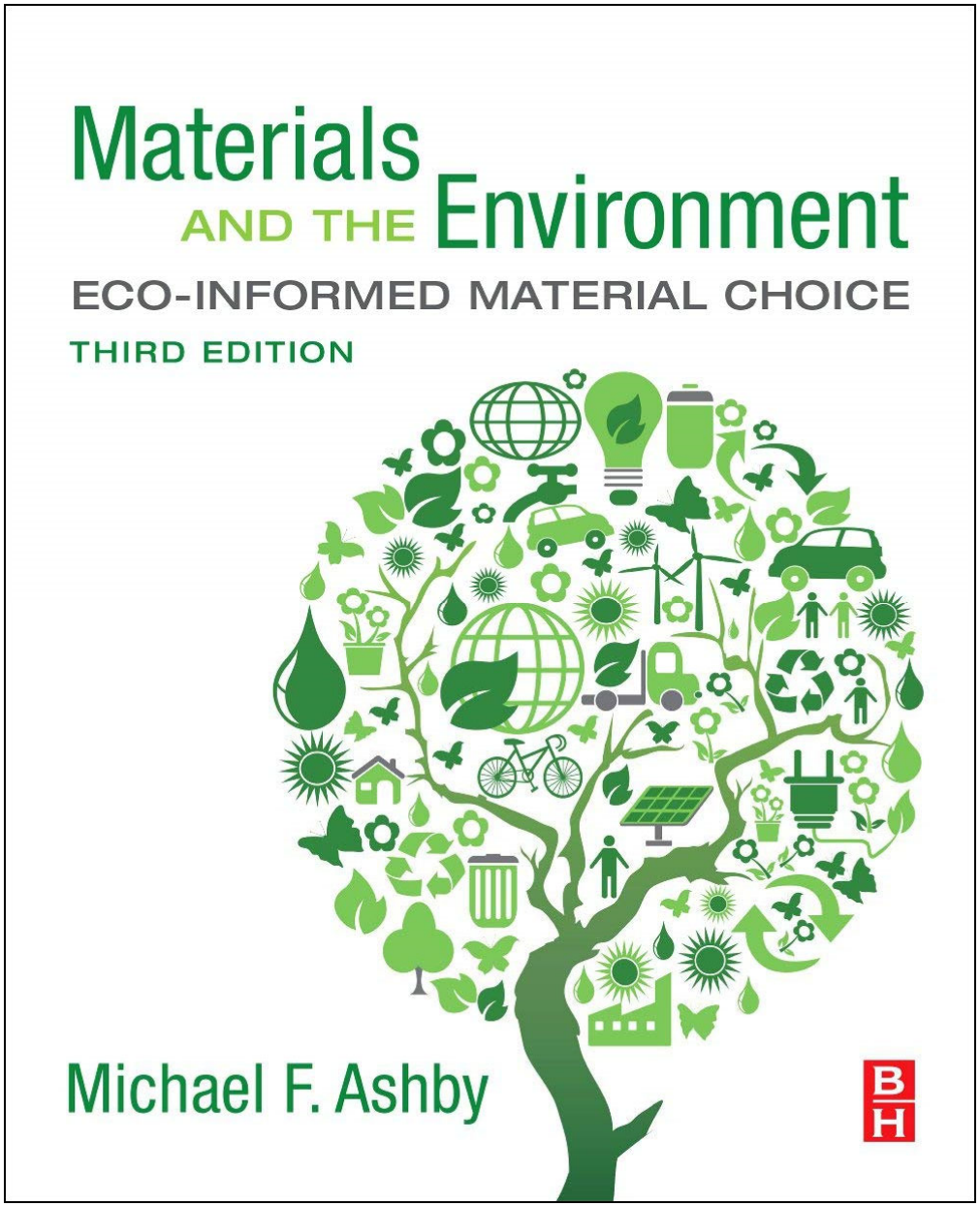
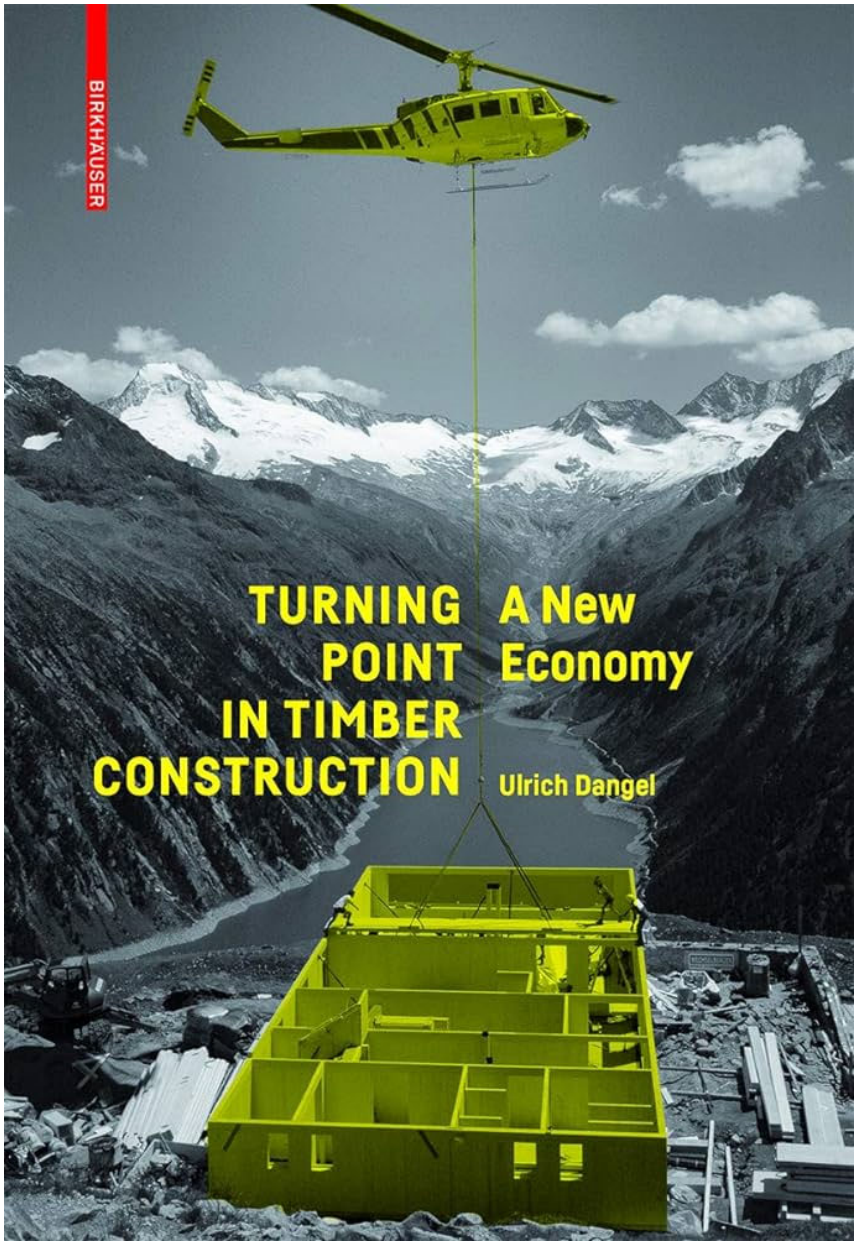


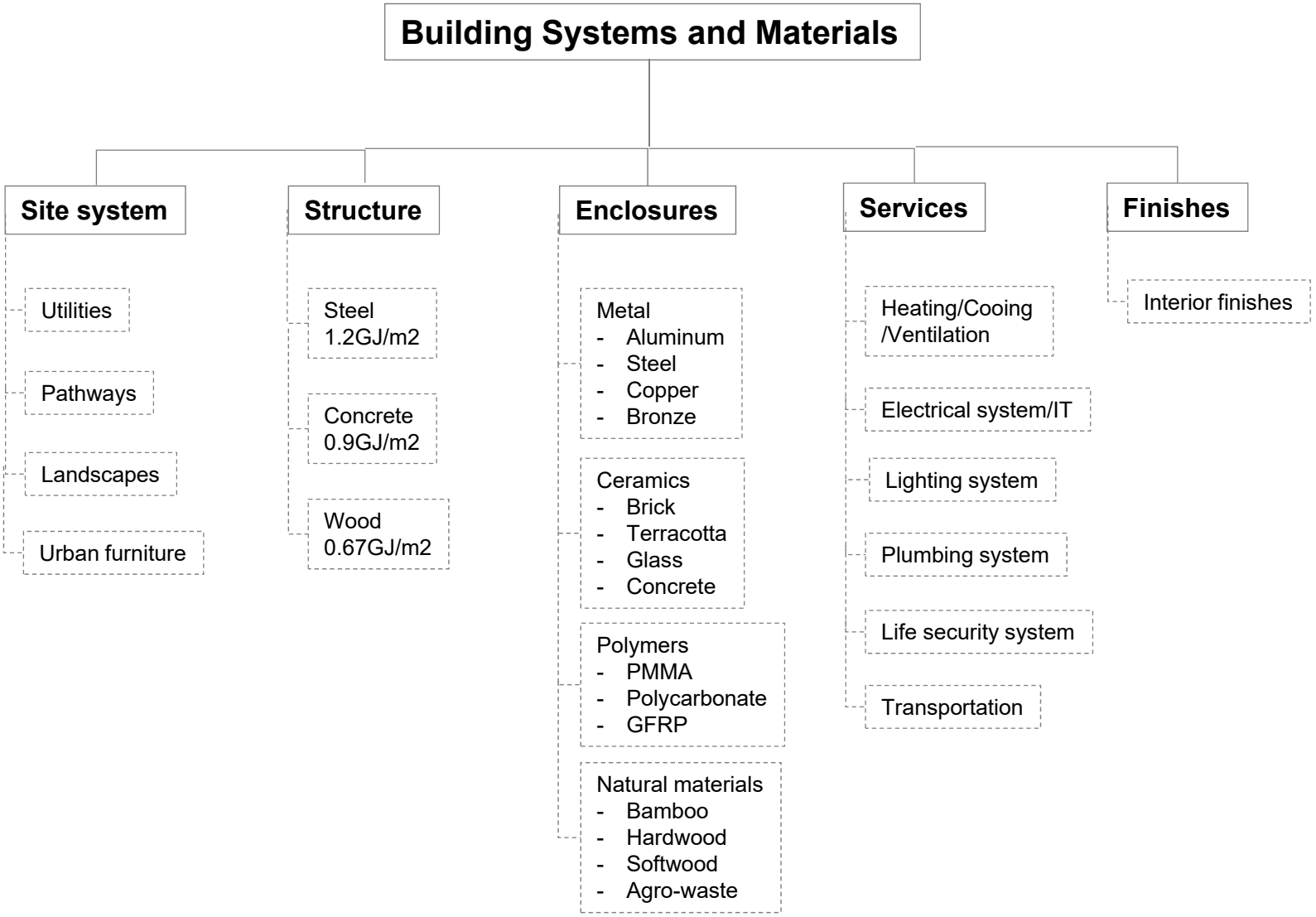
Sustainable Materials

Kyoung Hee Kim PhD AIA Professor
Ravin School of Architecture
UNC Charlotte

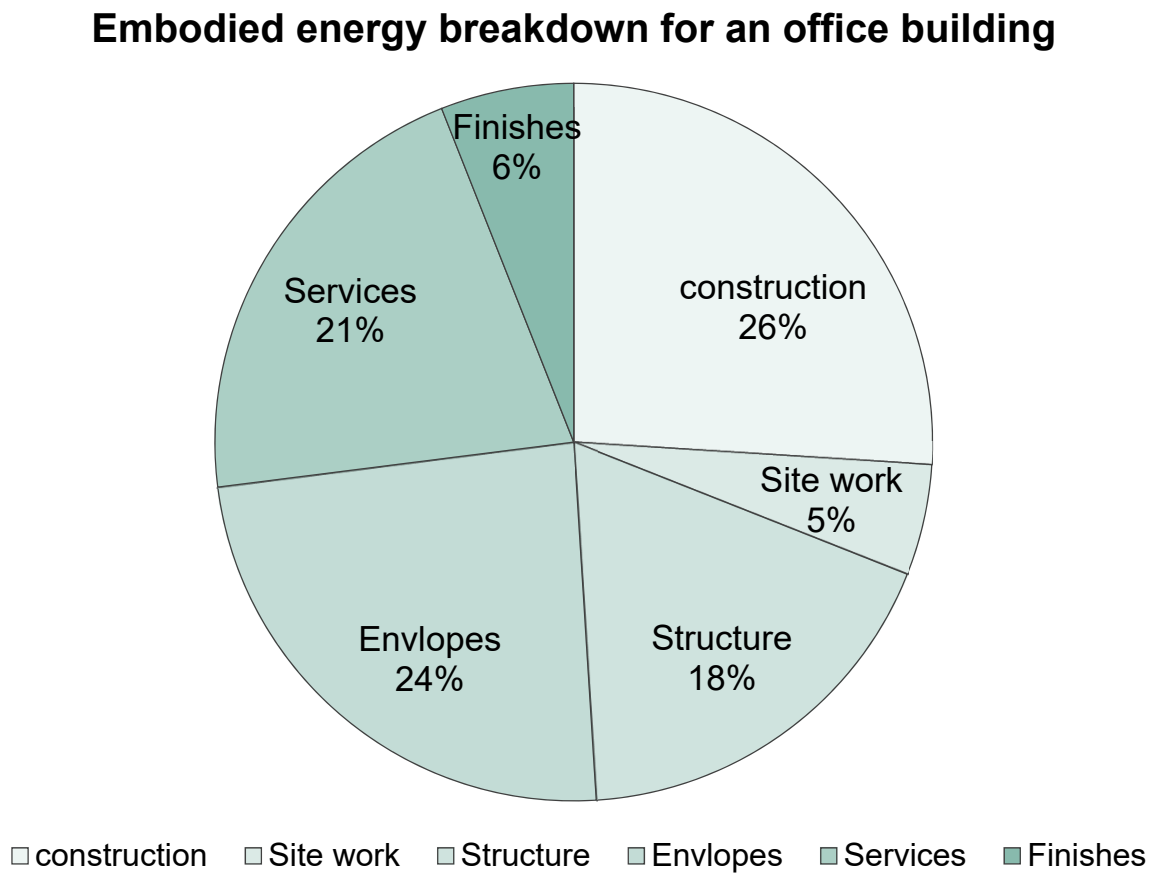

Materials
AND THE Environment
ECO-INFORMED MATERIAL CHOICE
THIRD EDITION
Michael F. Ashby
BH


BIRKHÄUSER
TURNING POINT IN TIMBER CONSTRUCTION
A New Economy
Ulrich Dangel

Building Systems and Materials

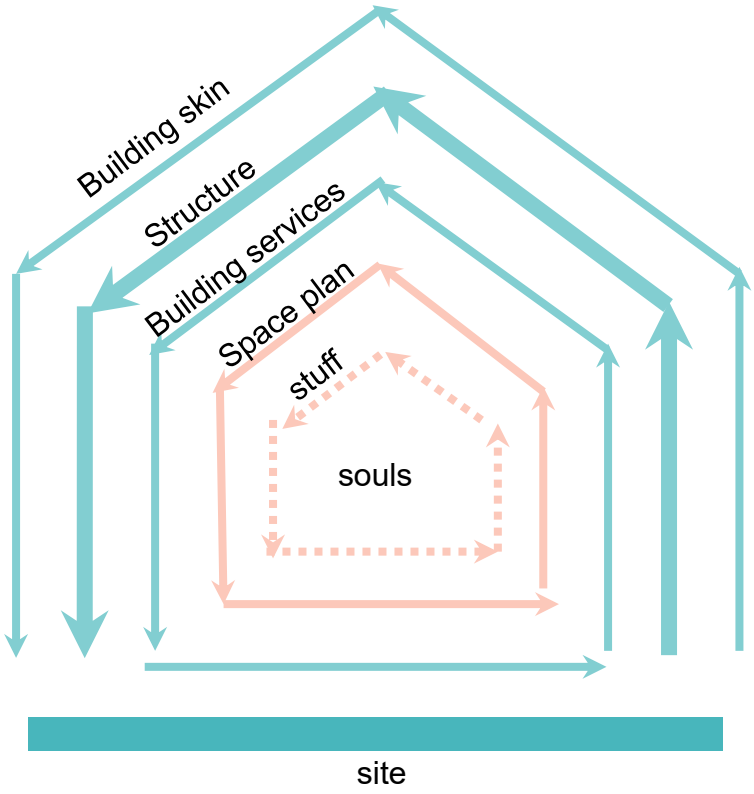


Embodied Energy Breakdown of Building Systems



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

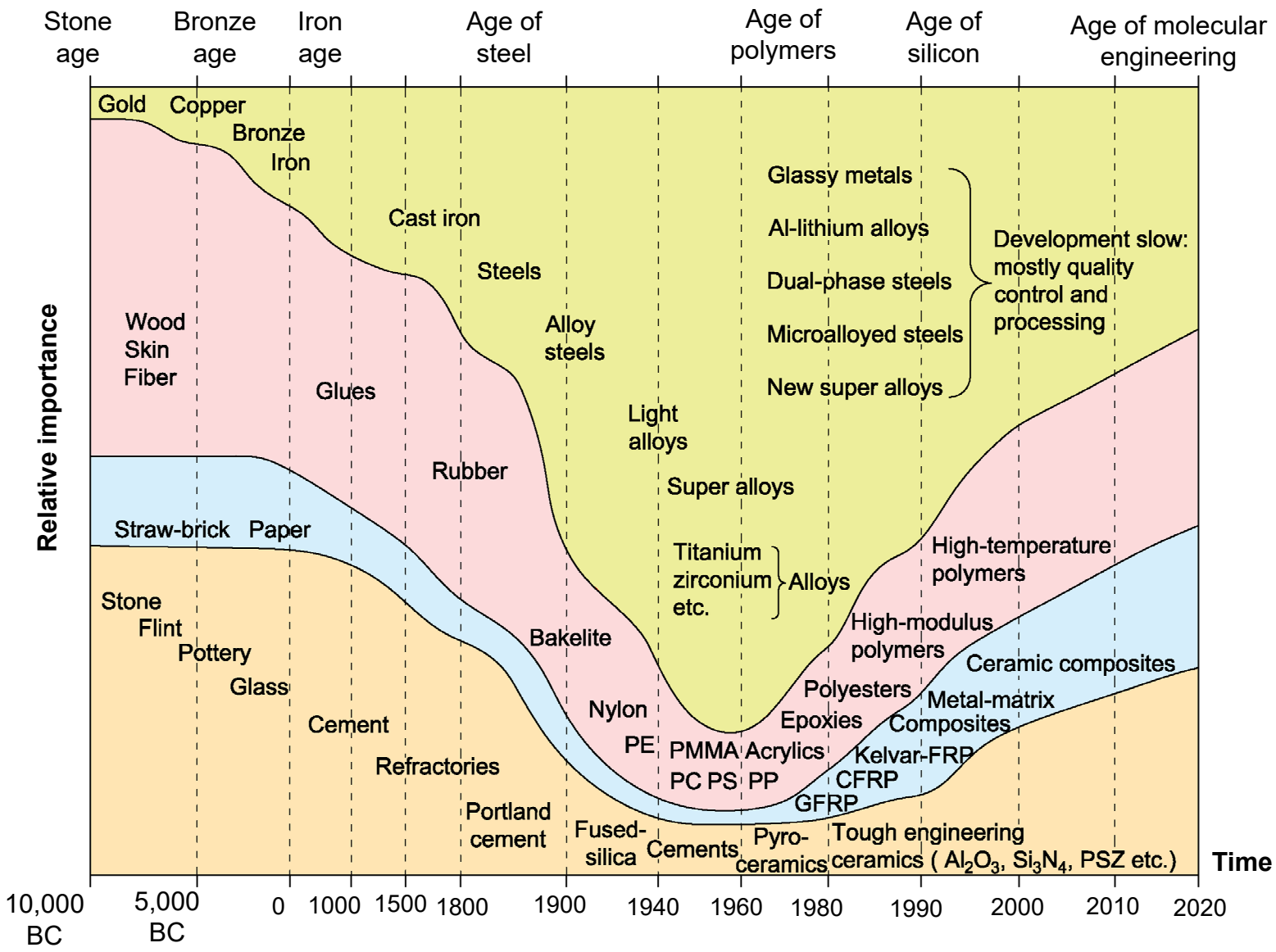
Building Systems: Sharing Layers of Change



Shearing layers	Description	Typical lifespan/activity
Site	Location and context	Permanent
Structure	Framework	30-300 years
Skin	Enclosures	20+ years
Services	Lifeblood	7-20 years
Space plan	Interior layout	3 years
Stuff	Furniture/equipment	Under 3 years
Souls		Daily

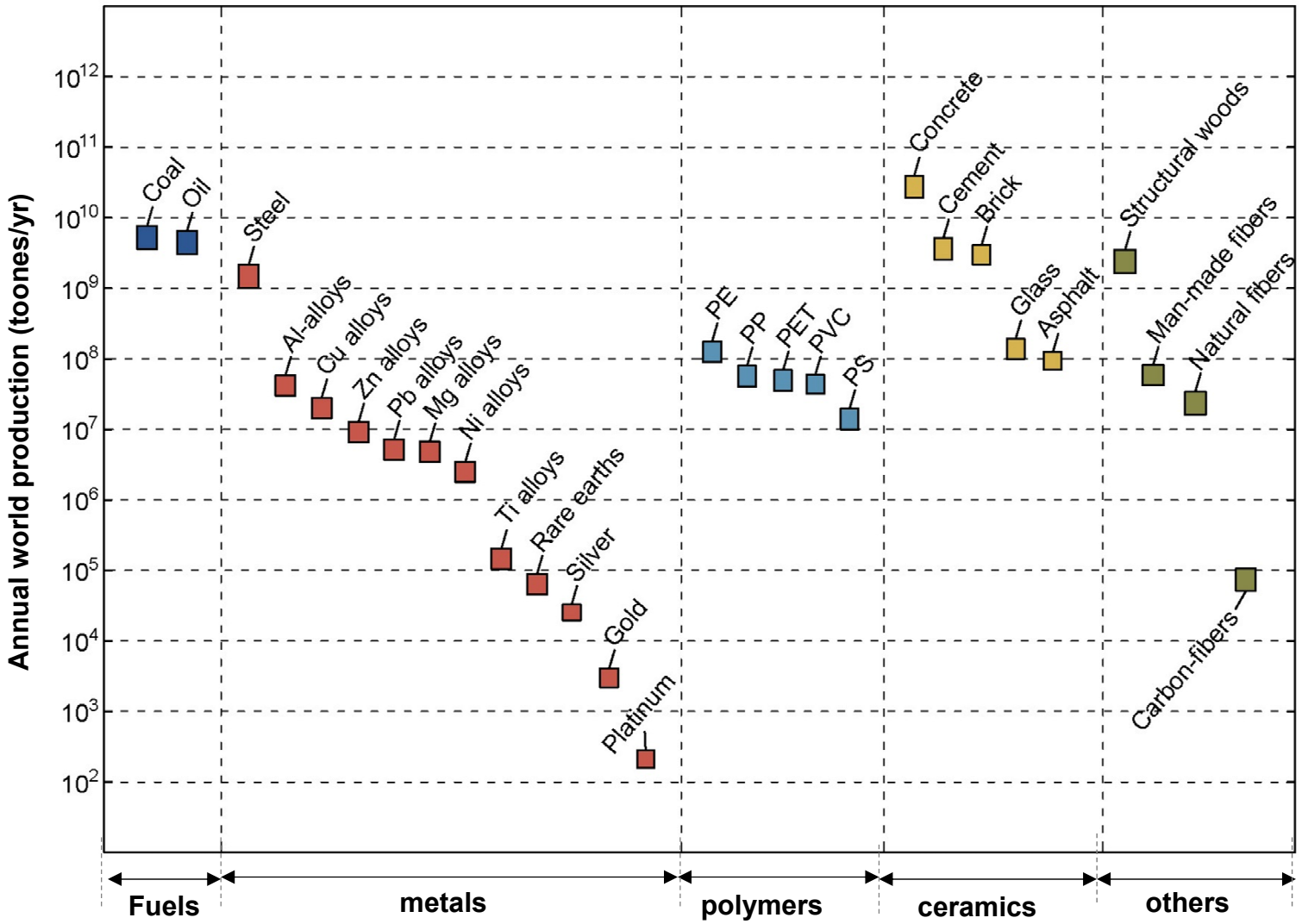
Brand, Stewart. *How buildings learn: What happens after they're built*. Penguin, 1995.

Historical Evolution of Engineering Materials



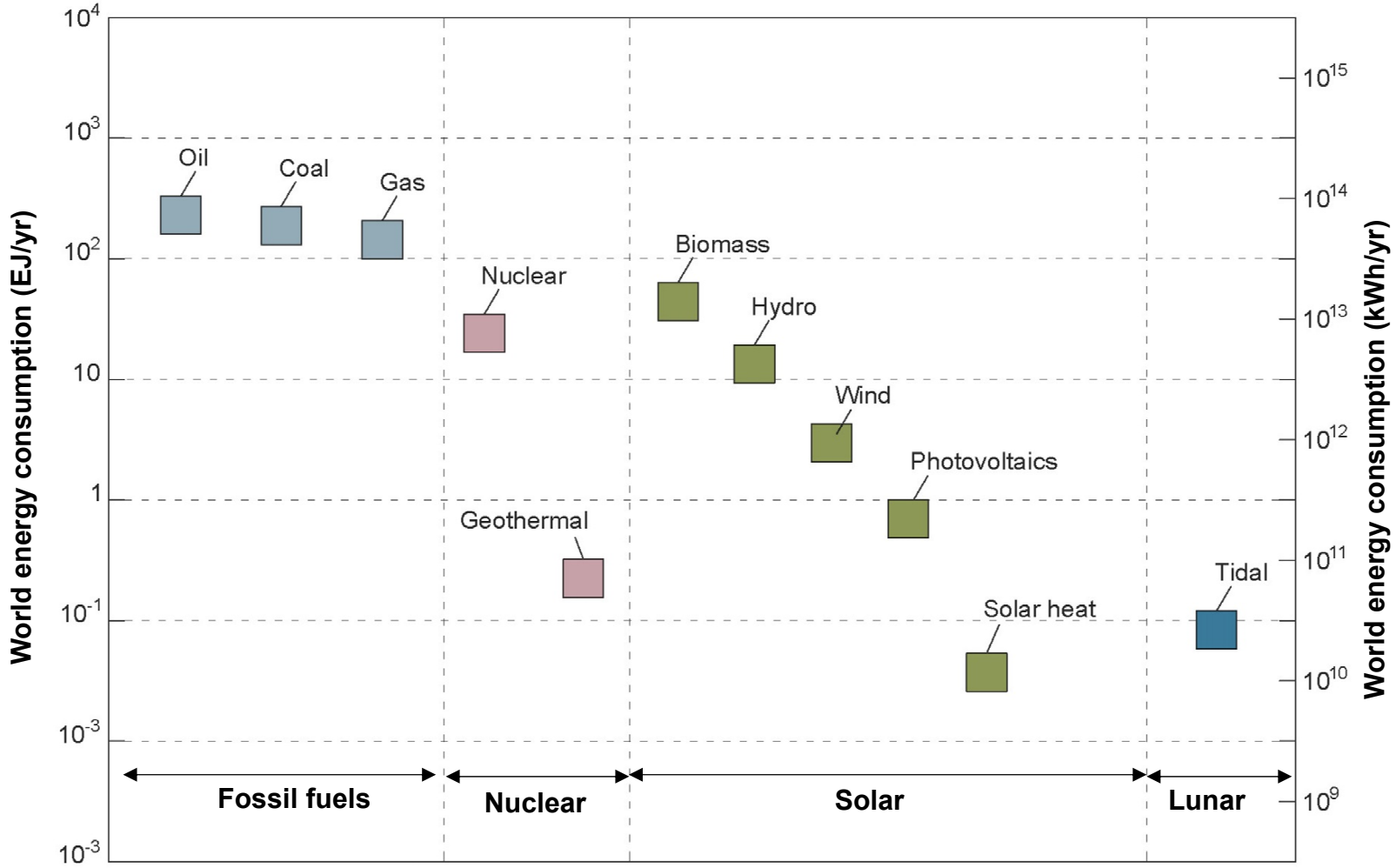
Murty et al. *High-entropy alloys*. Elsevier, 2019.

Materials: World Production



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

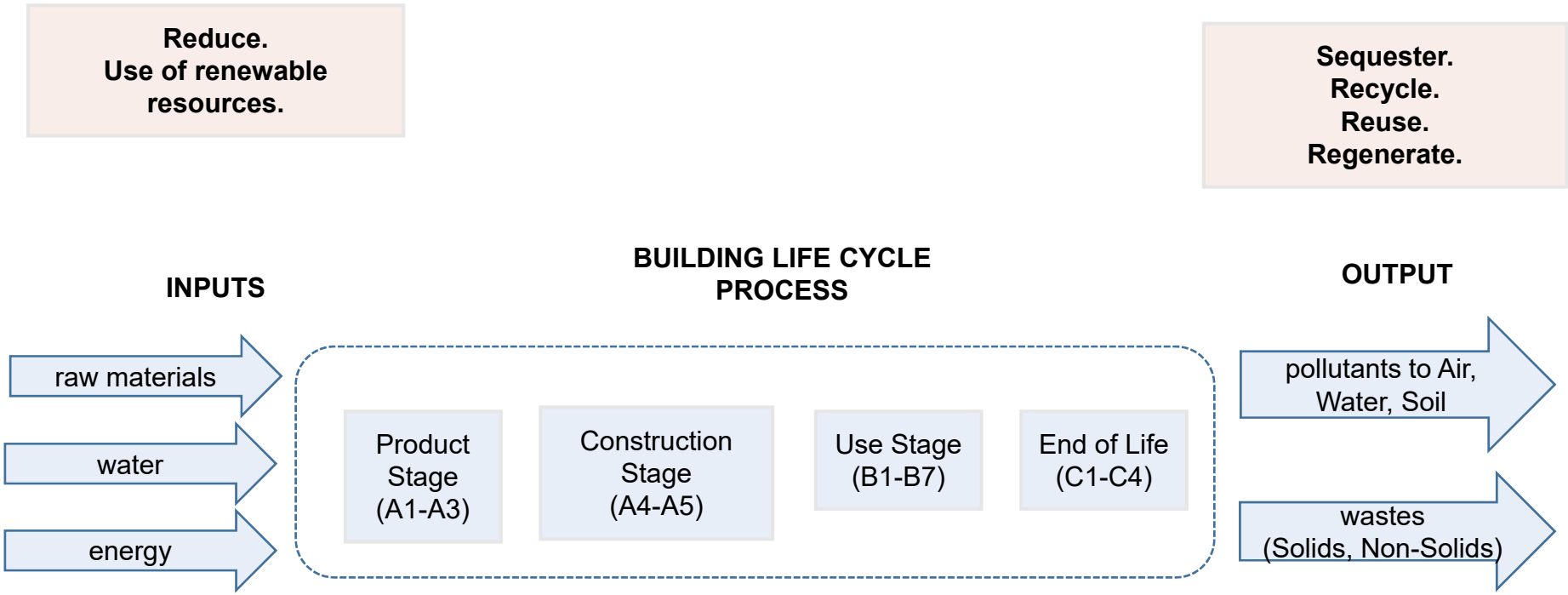
Energy: World Production



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

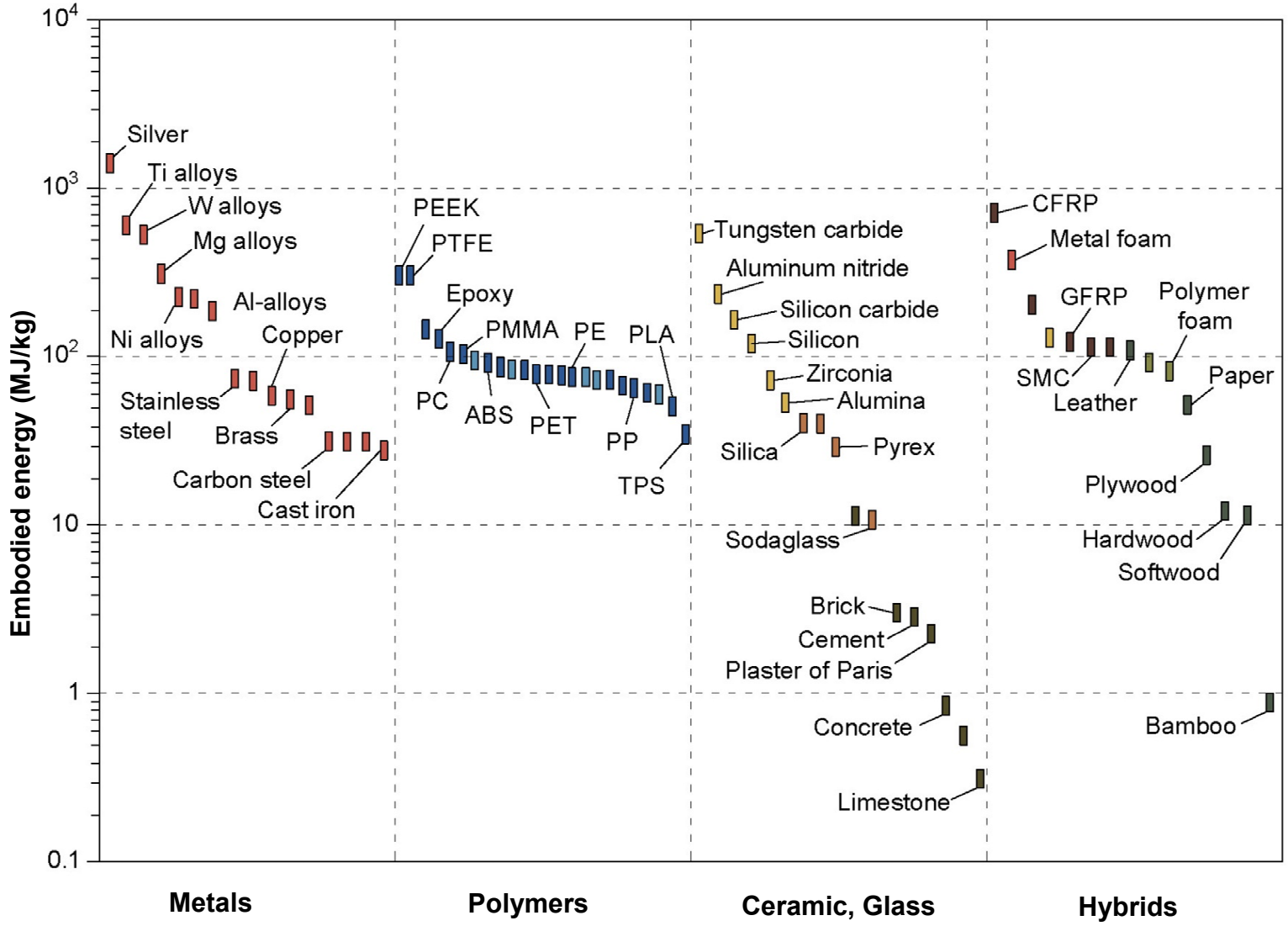
Eco-Properties

Eco-Properties from Building Life Cycle Perspective



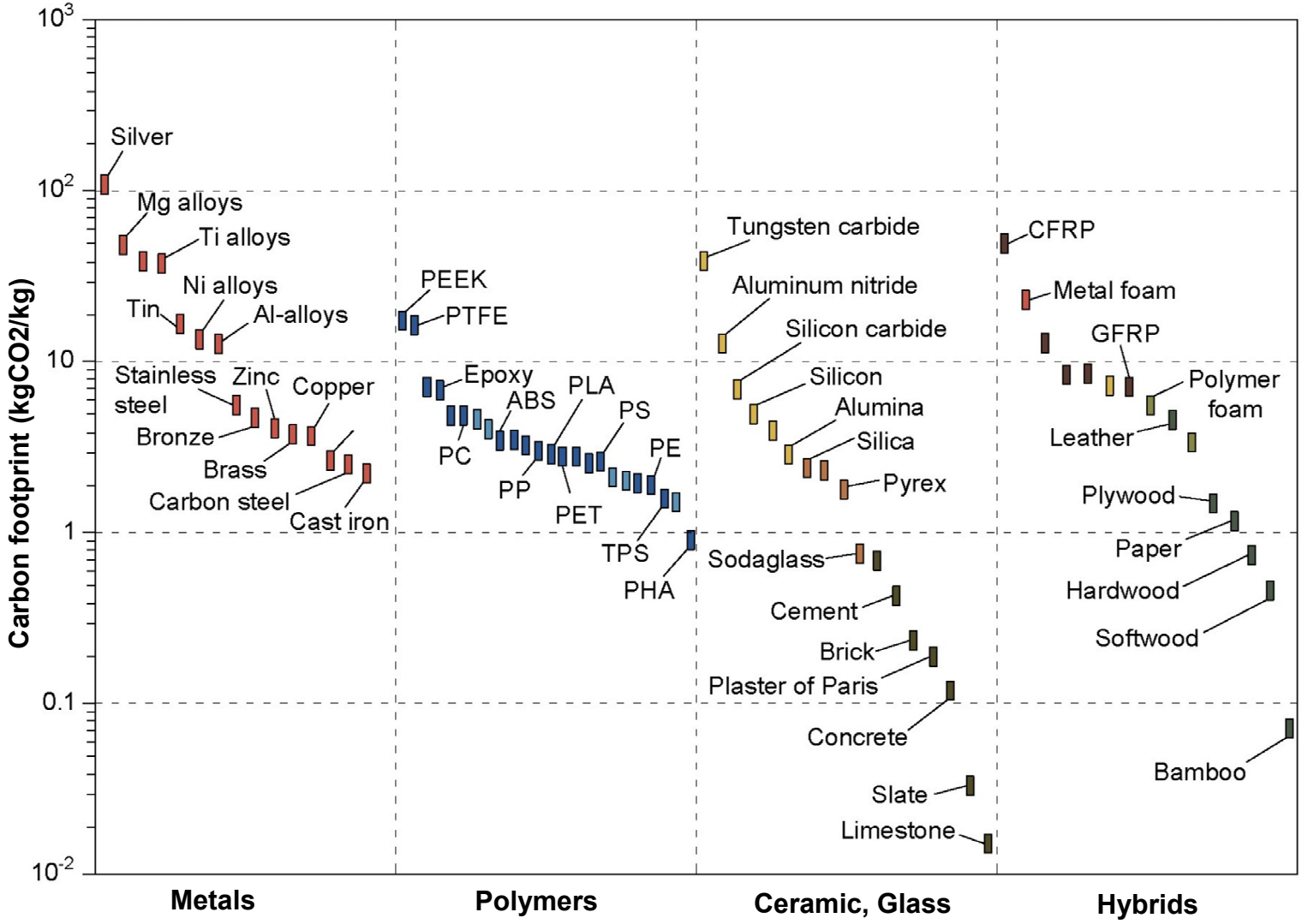
Building LCA Framework from European Standard EN 15978:2011

Embodied Energy per kg



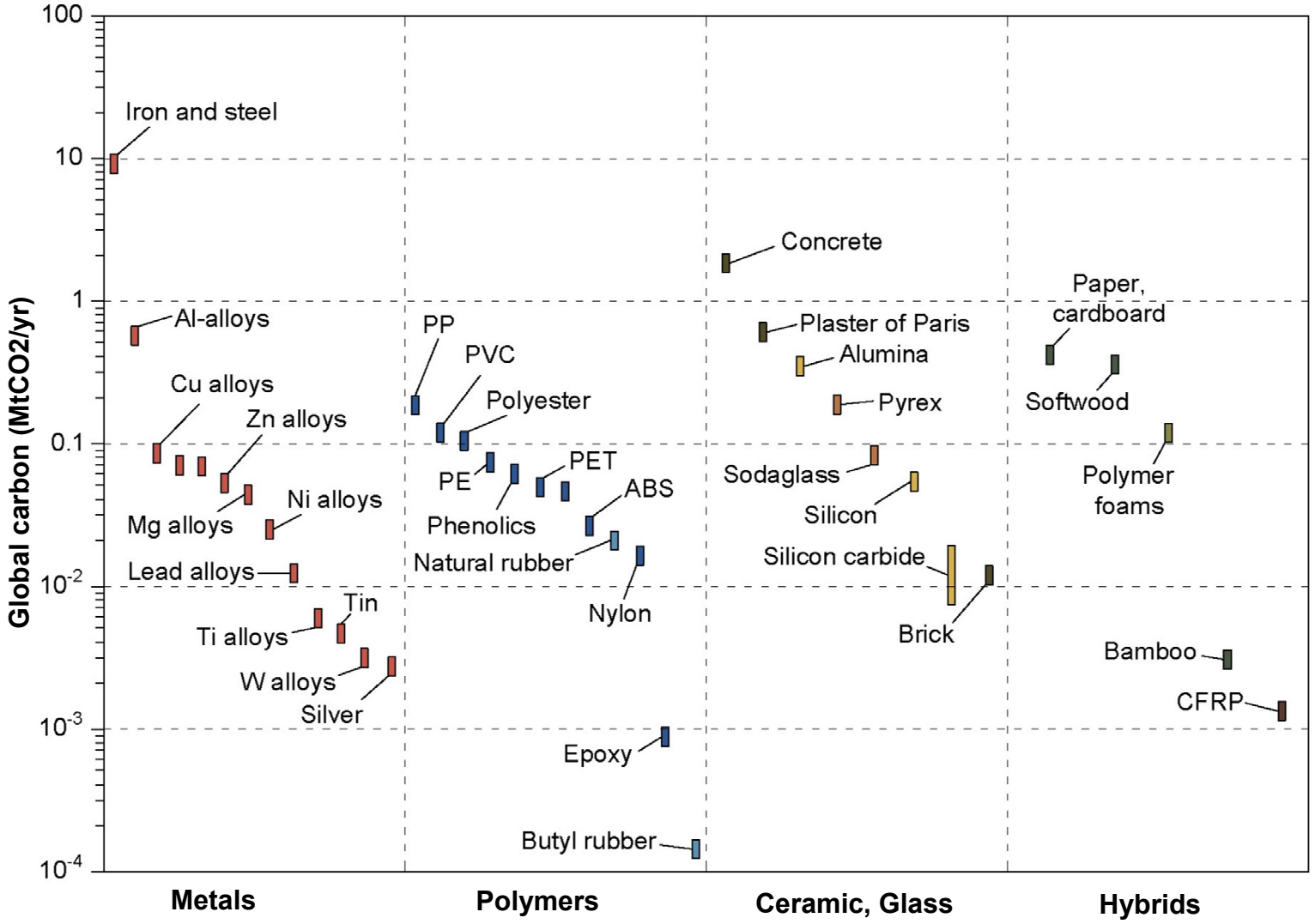
Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

Carbon footprint per kg



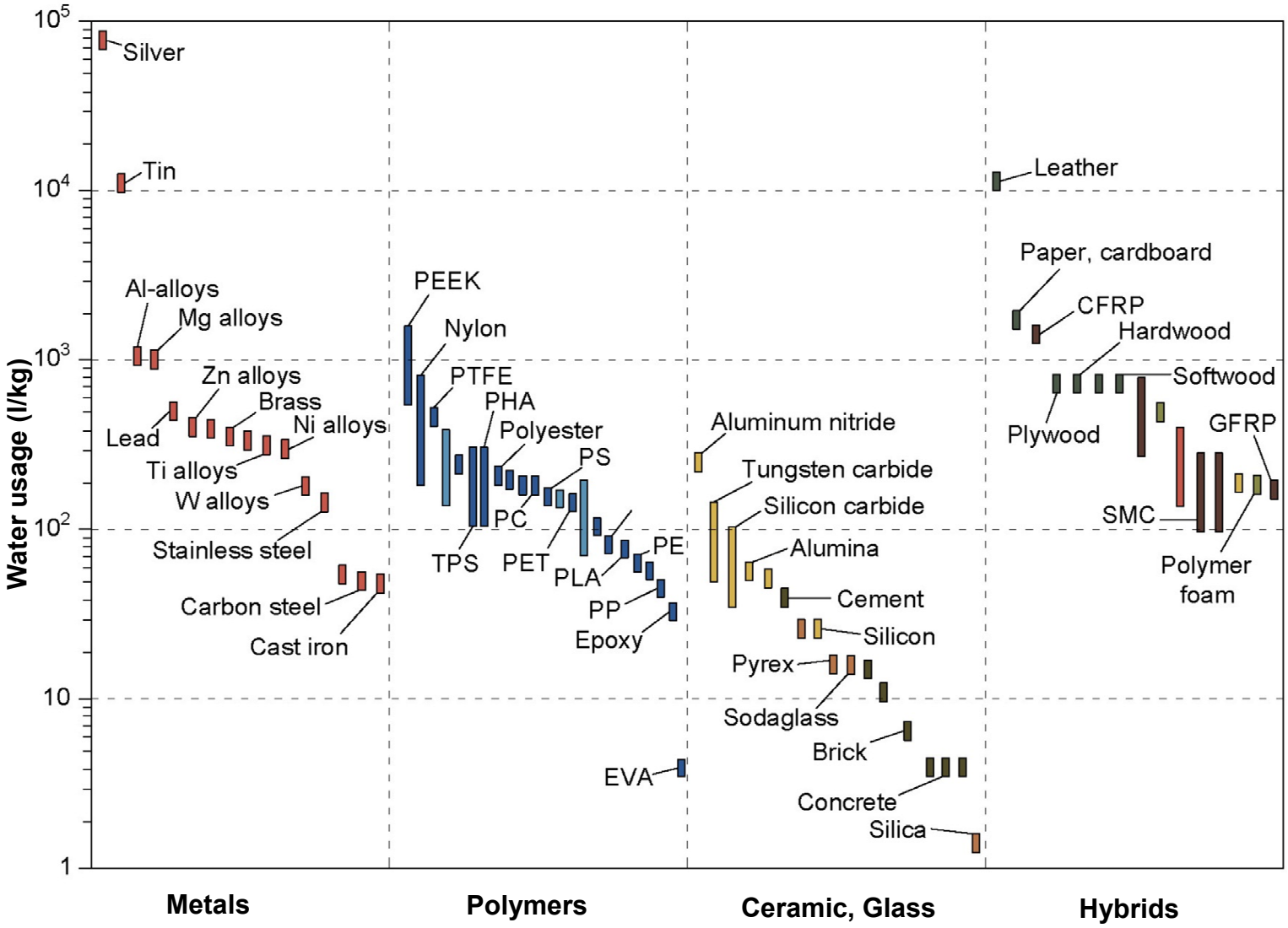
Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

Global Carbon Emissions



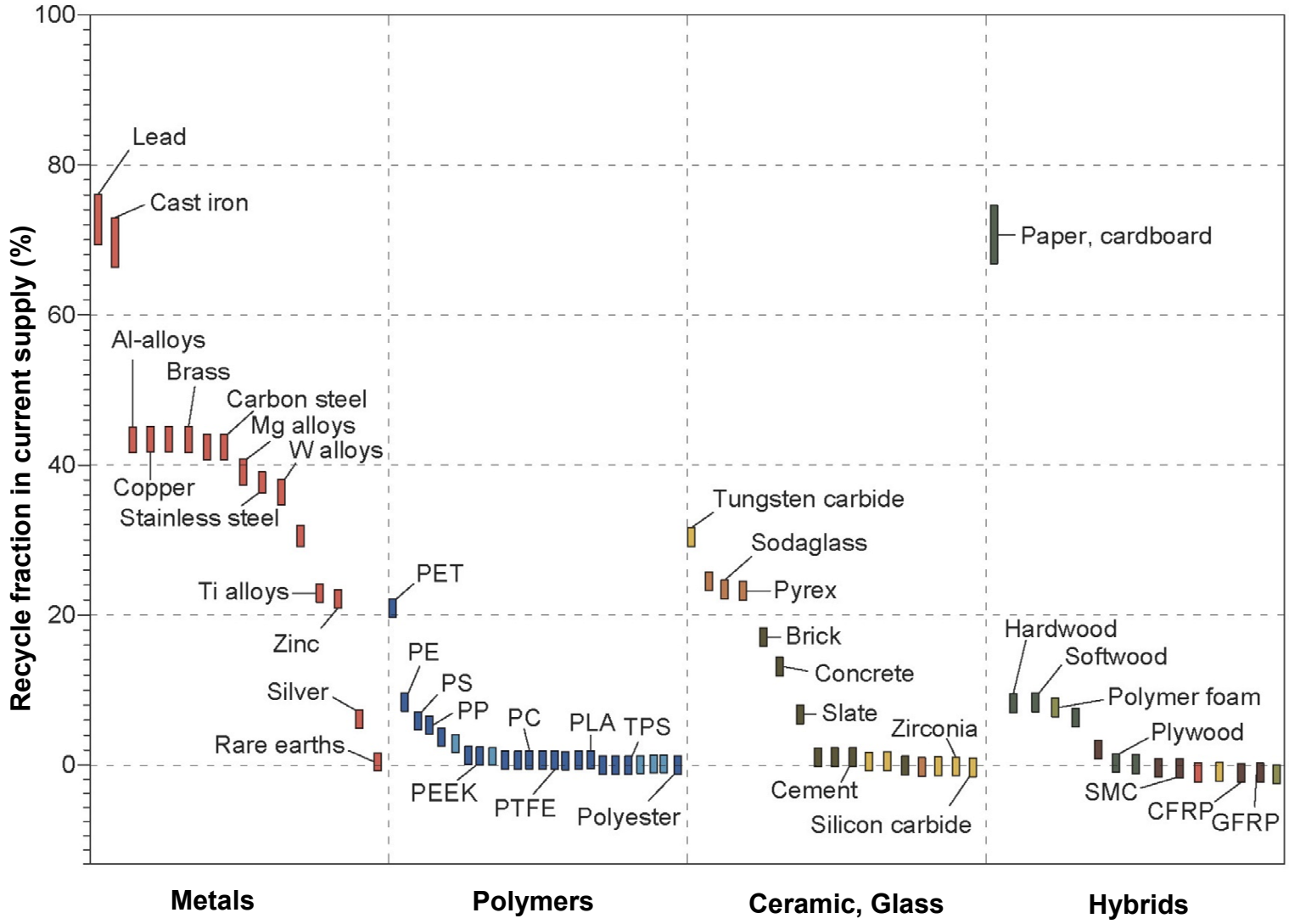
Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

Water Usage



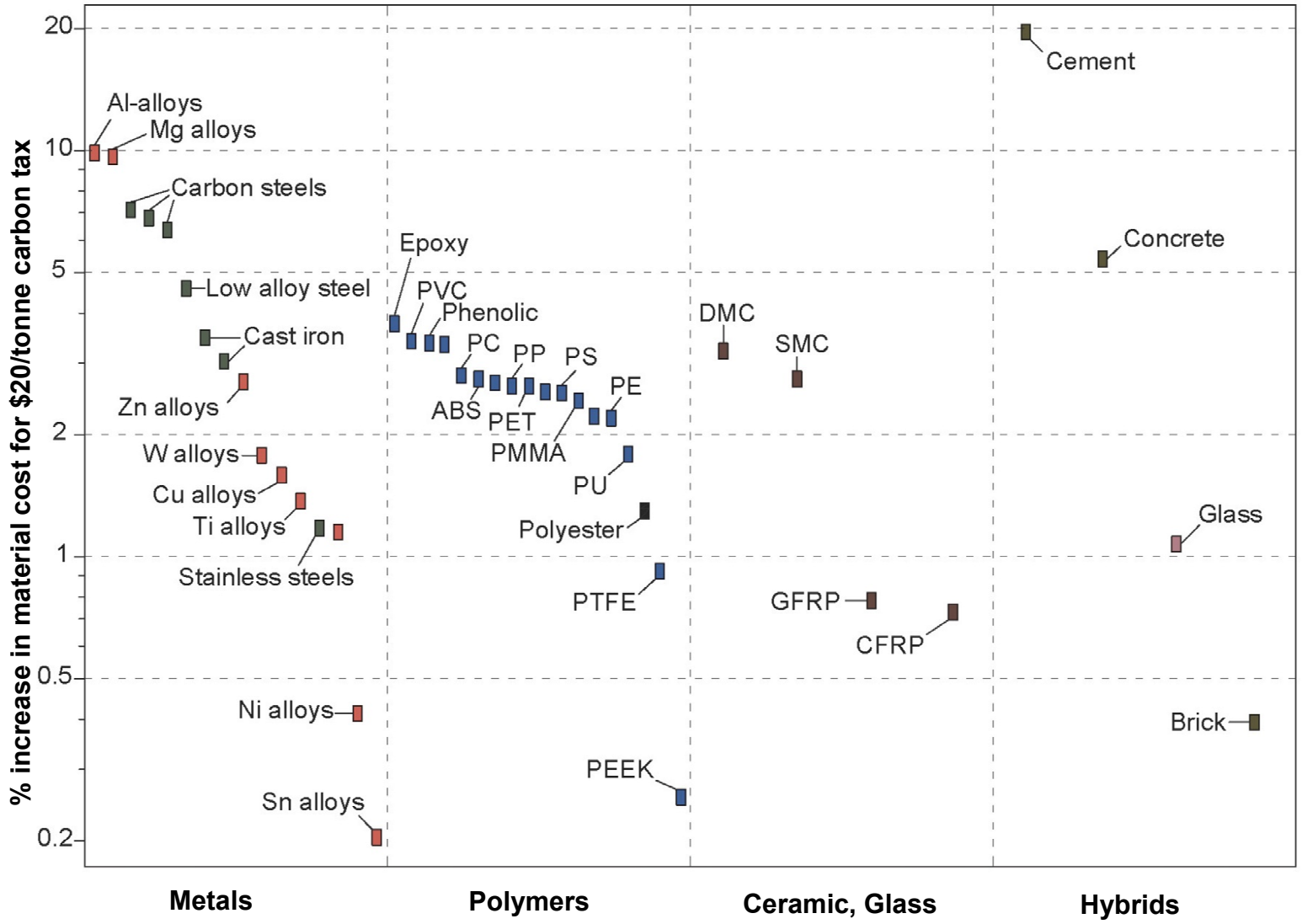
Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

Recycle fraction in current supply (%)



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

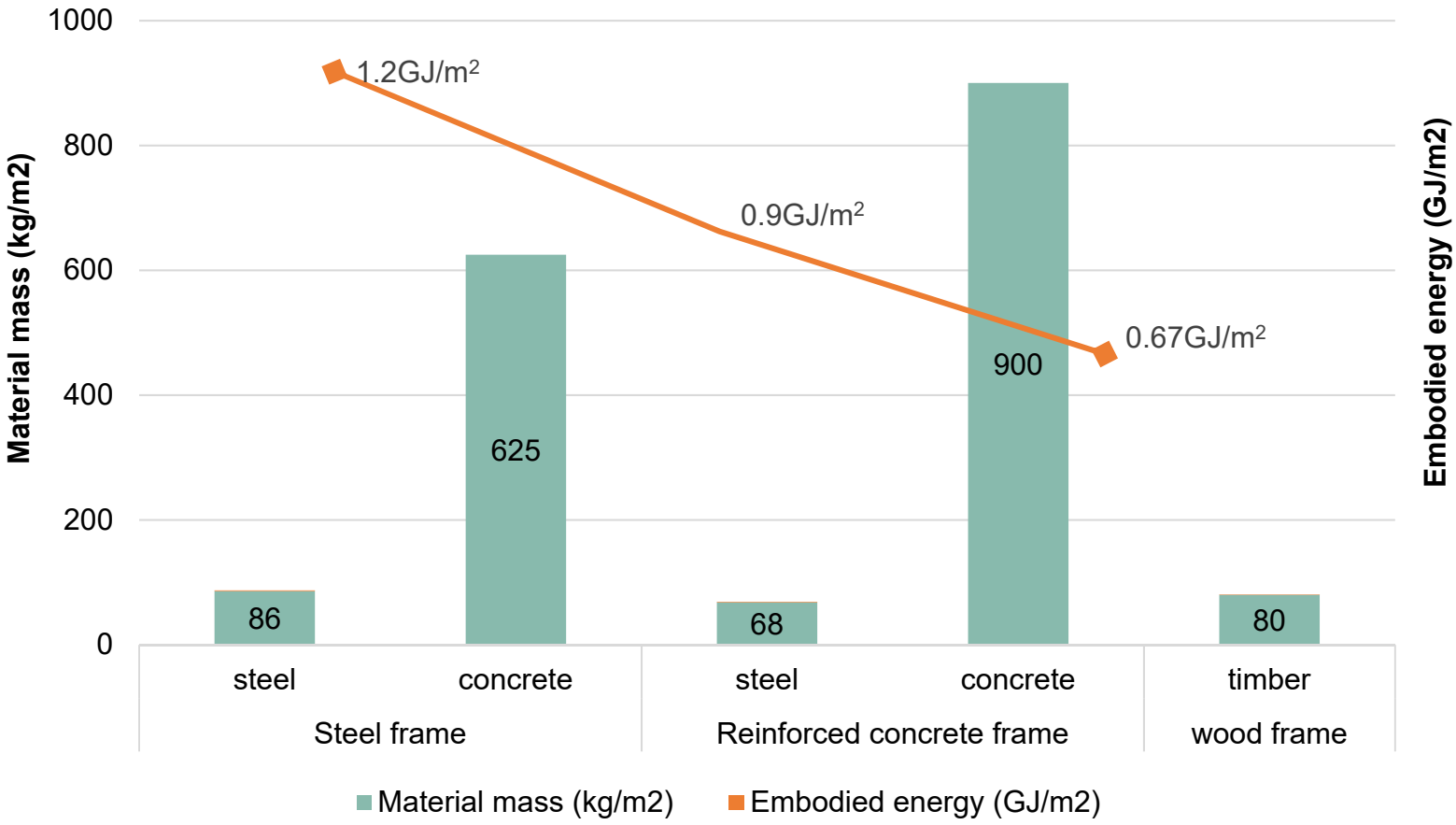
Carbon Tax Sensitivity



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

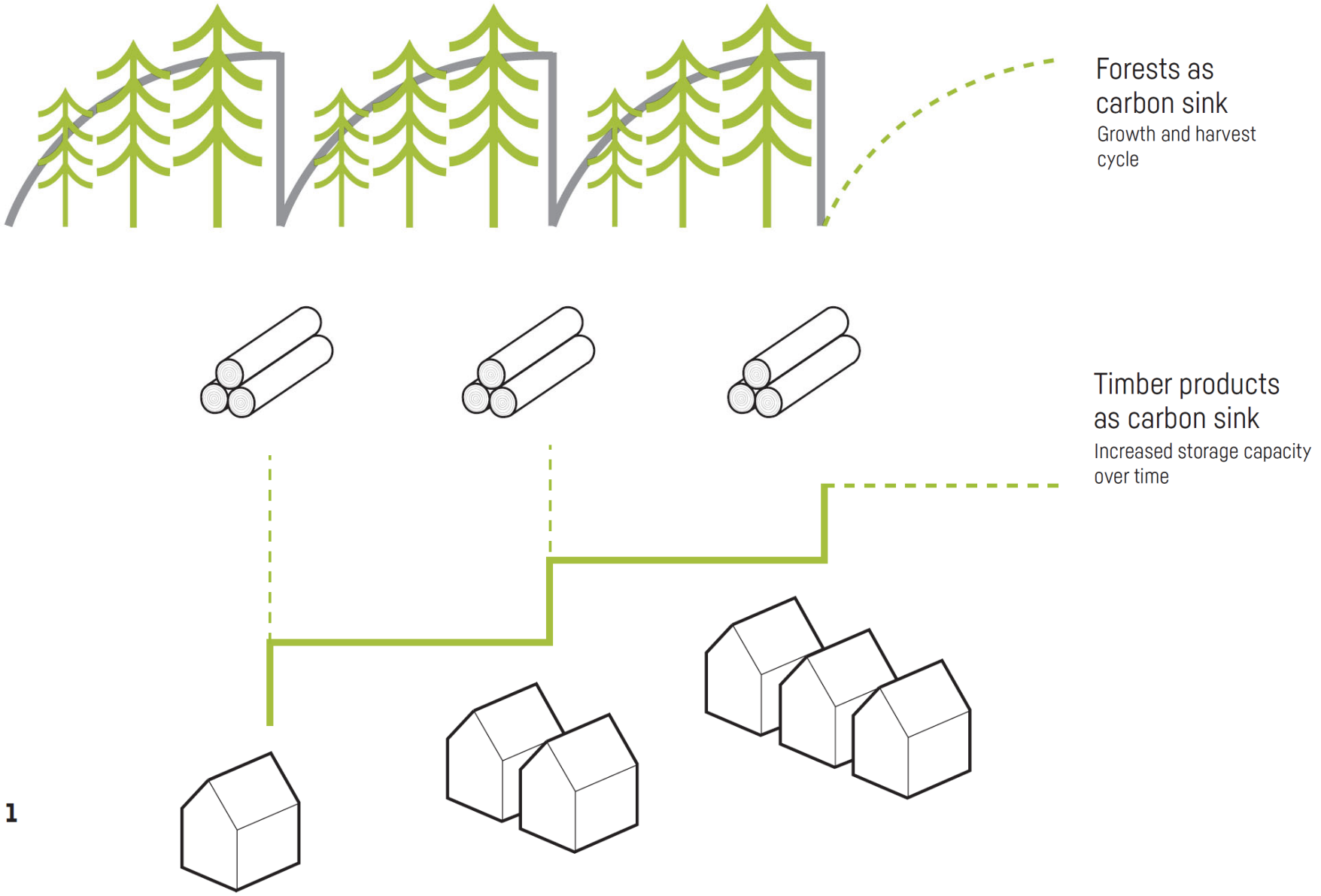
CARBON CAPTURE

Embodied Energy/m2 of Alternative Building Structures



Ashby, Michael F. *Materials and the environment: eco-informed material choice*. Elsevier, 2021.

Turning Point in Timber Construction, 2016 | U. Dangel



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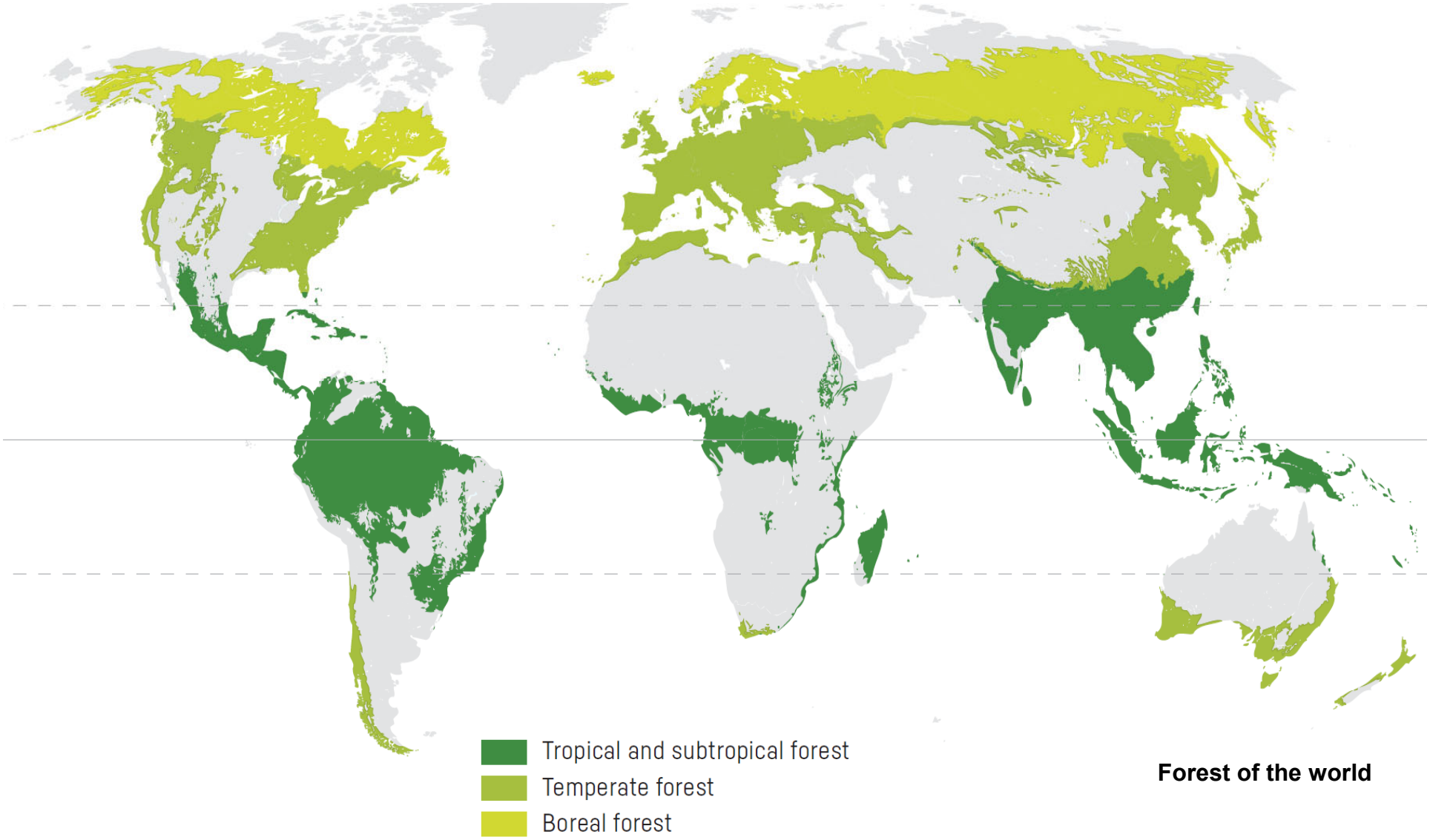
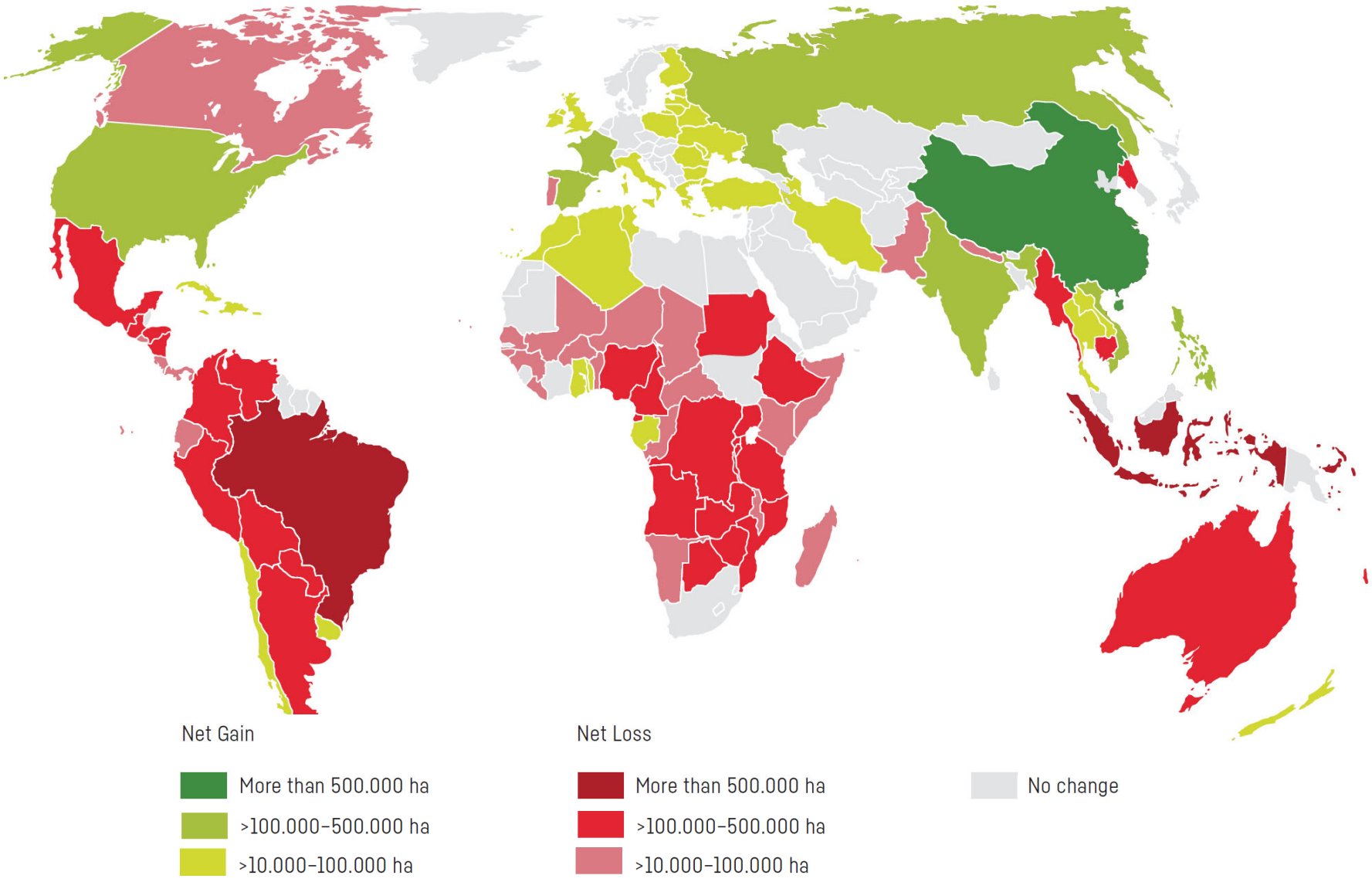
Turning Point in Timber Construction, 2016 | U. Dangel



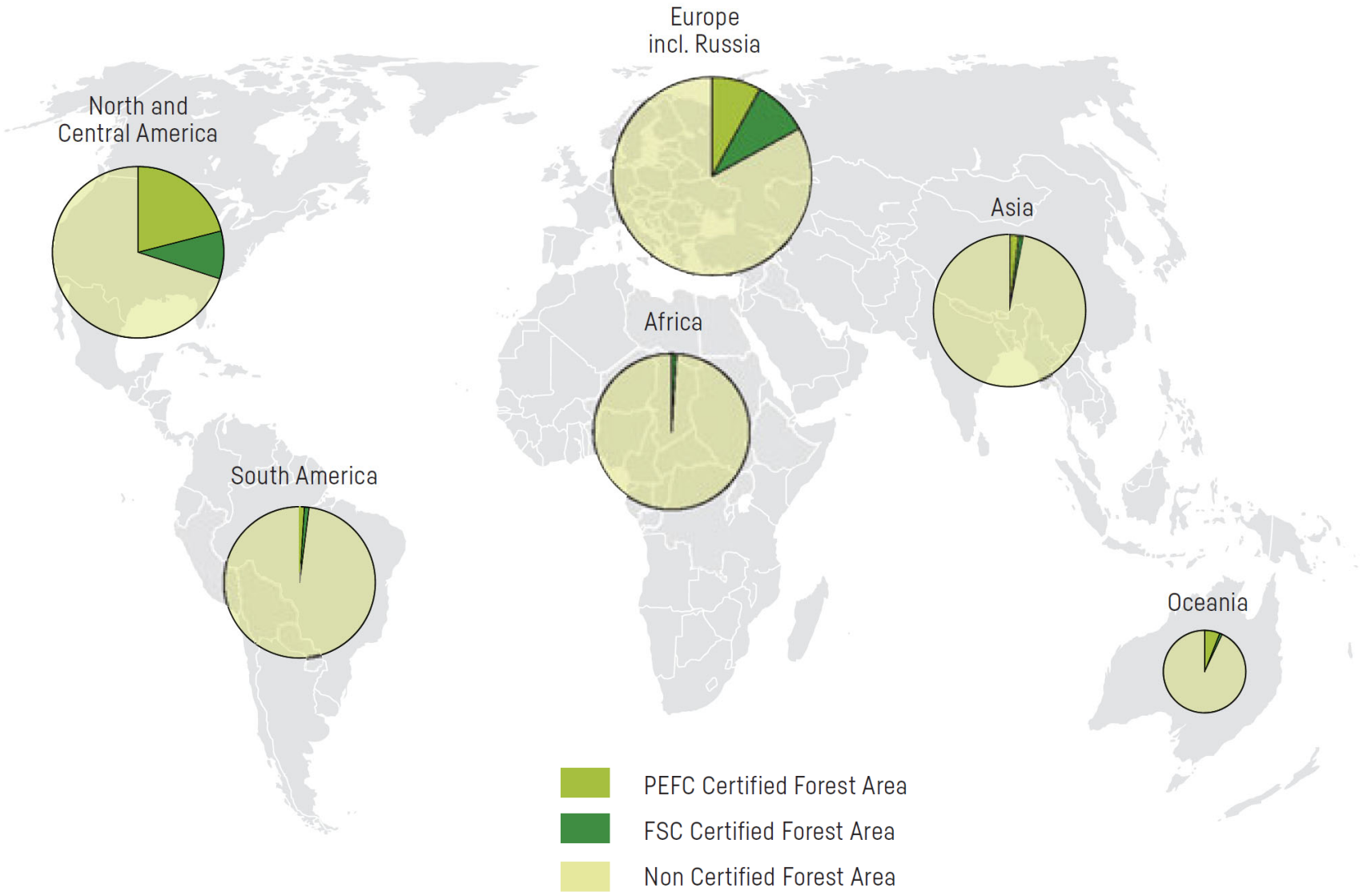
Forest of the world

Forest of the world
Turning Point in Timber Construction, 2016 | U. Dangel



Annual net forest gain and loss by country (1990-2015)

Turning Point in Timber Construction, 2016 | U. Dangel



Certified forest areas
Turning Point in Timber Construction, 2016 | U. Dangel

FSC

PEFC
PEFC/01-00-01
Promoting Sustainable Forest Management
www.pefc.org

SUSTAINABLE FORESTRY INITIATIVE
SFI-01669

PEFC
PEFC/01-4-16

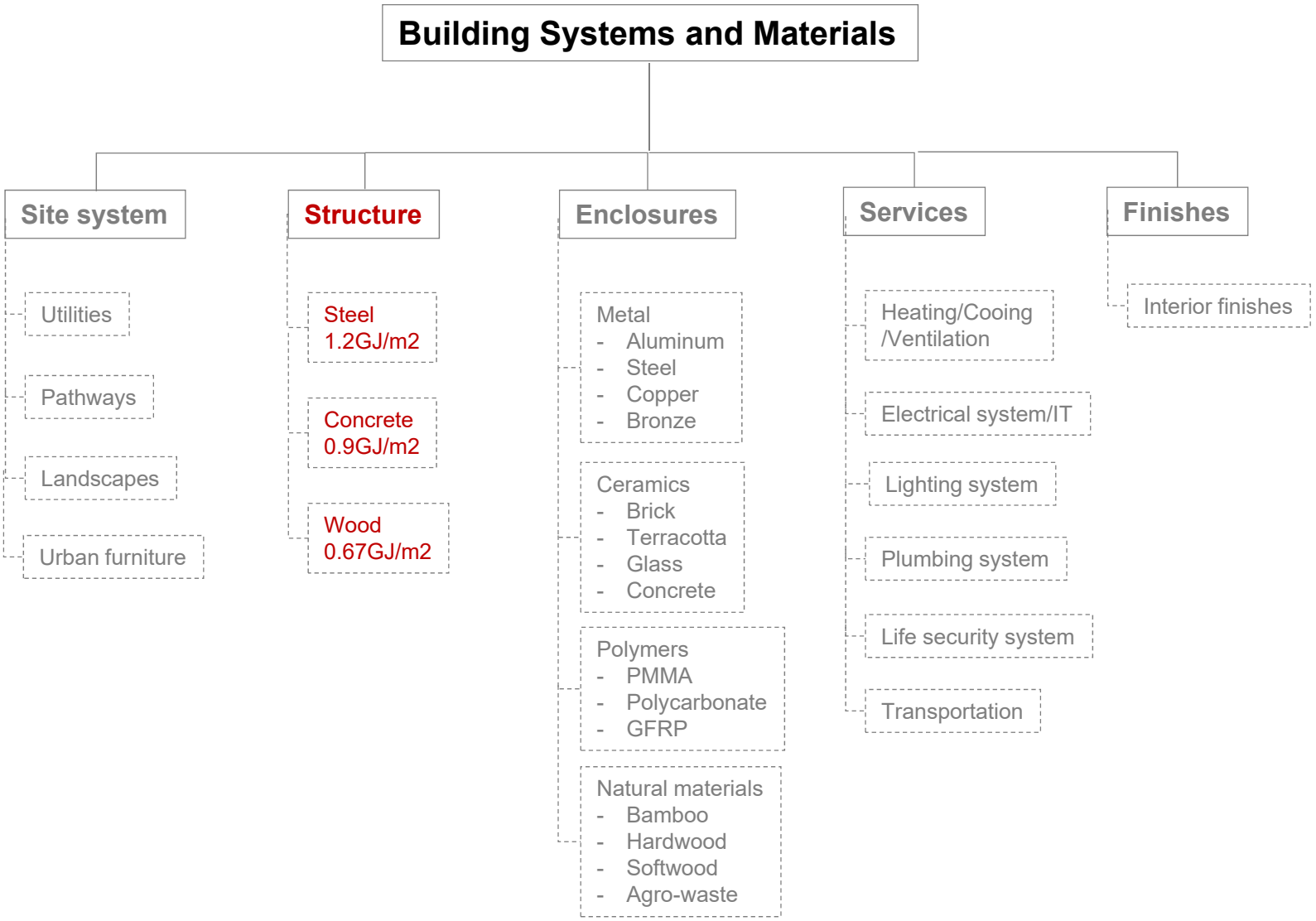
Canadian Sustainable Forest Management

Supporting CSA Z809 – Canada's SFM Standard

Wood product certification

Turning Point in Timber Construction, 2016 | U. Dangel

Wood Structural System



Five Building Systems

Wood Structure

Primary Frames

- Glulam
- Solid Sawn Lumber
- Structural Composite Lumber
- Other Buildup Lumber

Glulam

Solid Sawn Lumber

Composite lumber

Load bearing walls & floors

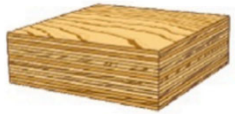
- Cross Laminated Timber (CLT)
- Laminated Veneer Lumber (LVL)
- Laminated Stranded Lumber (LSL)
- Parallel Strand Lumber (PSL)
- Mass Plywood Panel (MPP)

CLT

LVL

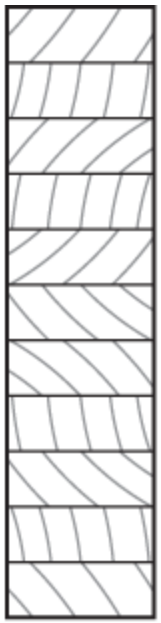
LSL

PSL



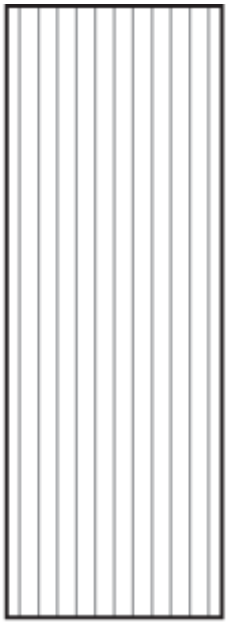
MPP

https://doi.org/10.1016/j.buildenv.2022.109320

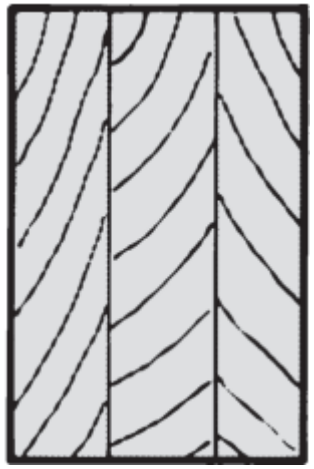


Glue laminated beam

Solid beam

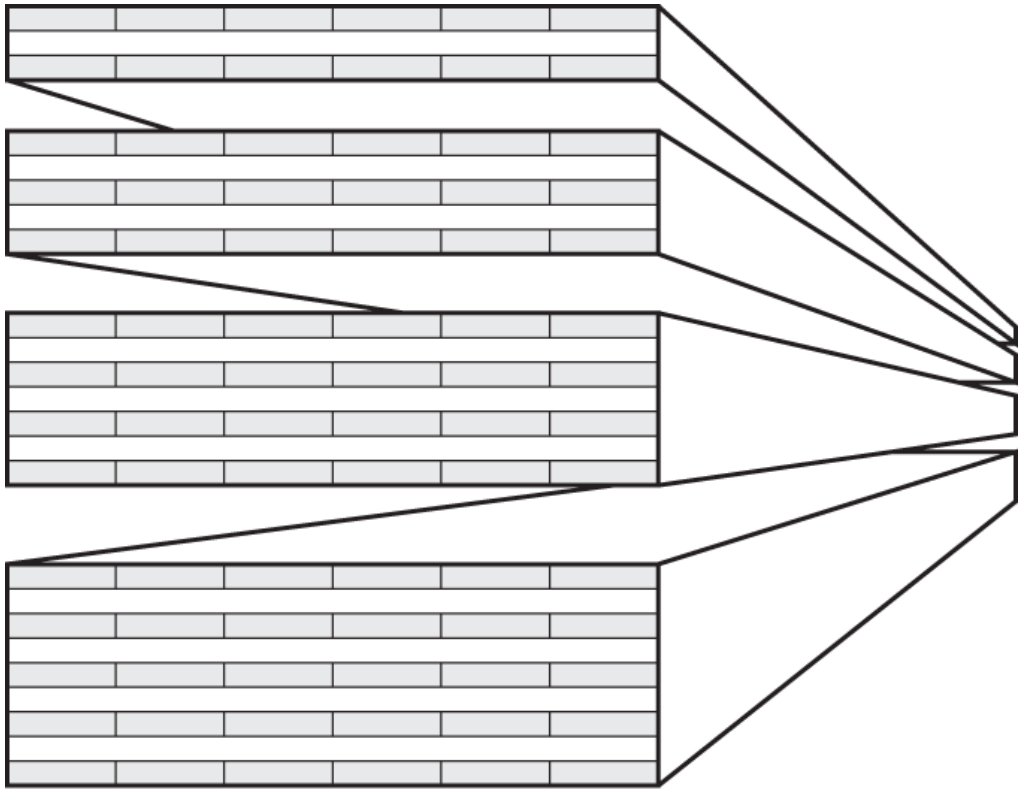


Composite beam



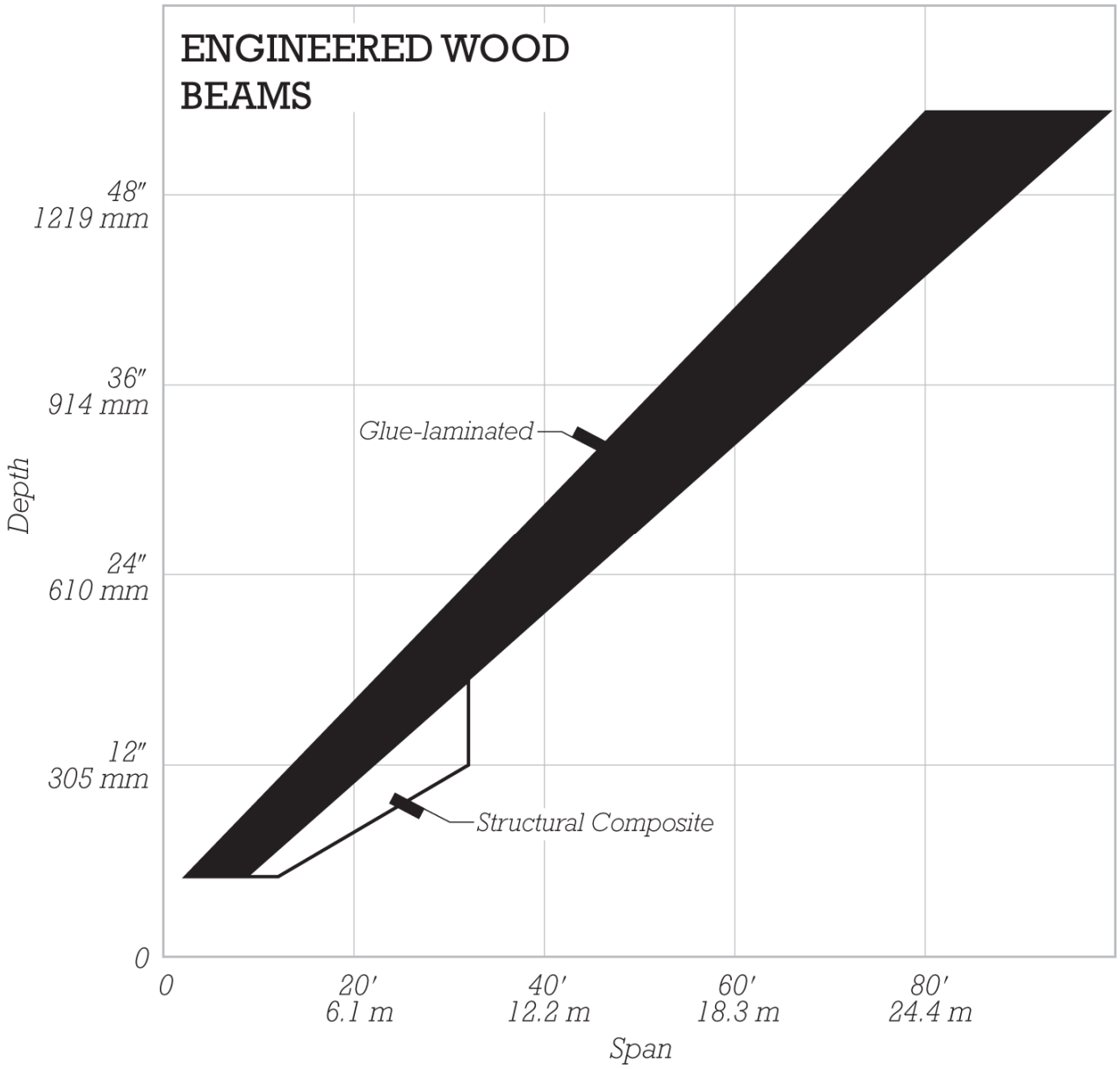
Built-up beam

Iano and Allen. *The architect's studio companion: rules of thumb for preliminary design*. John Wiley & Sons, 2022.



3-layer 4” thick
5-layer 7” thick
7-layer 9” thick
9-layer 12” thick

Iano and Allen. *The architect's studio companion: rules of thumb for preliminary design*. John Wiley & Sons, 2022.



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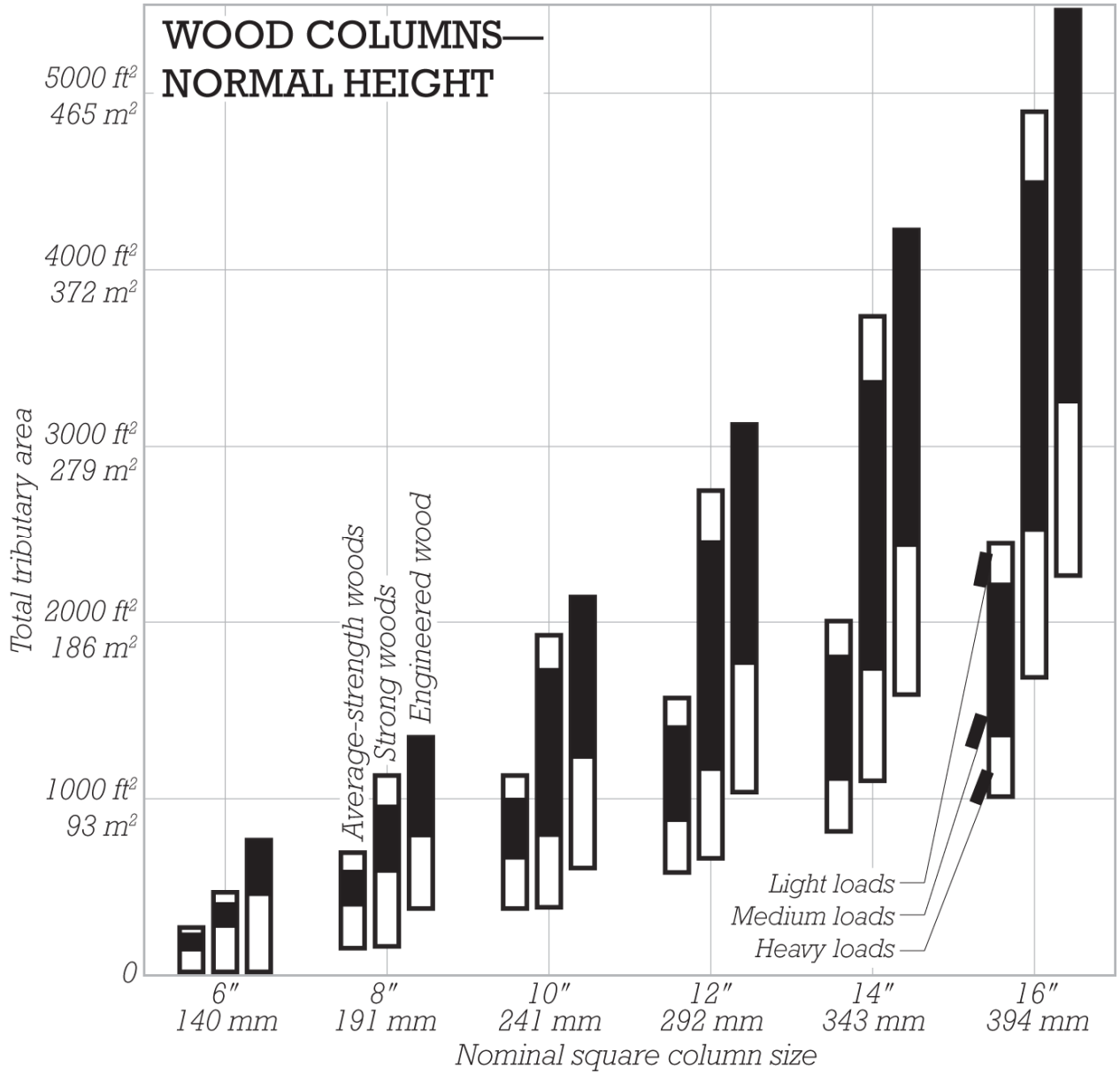

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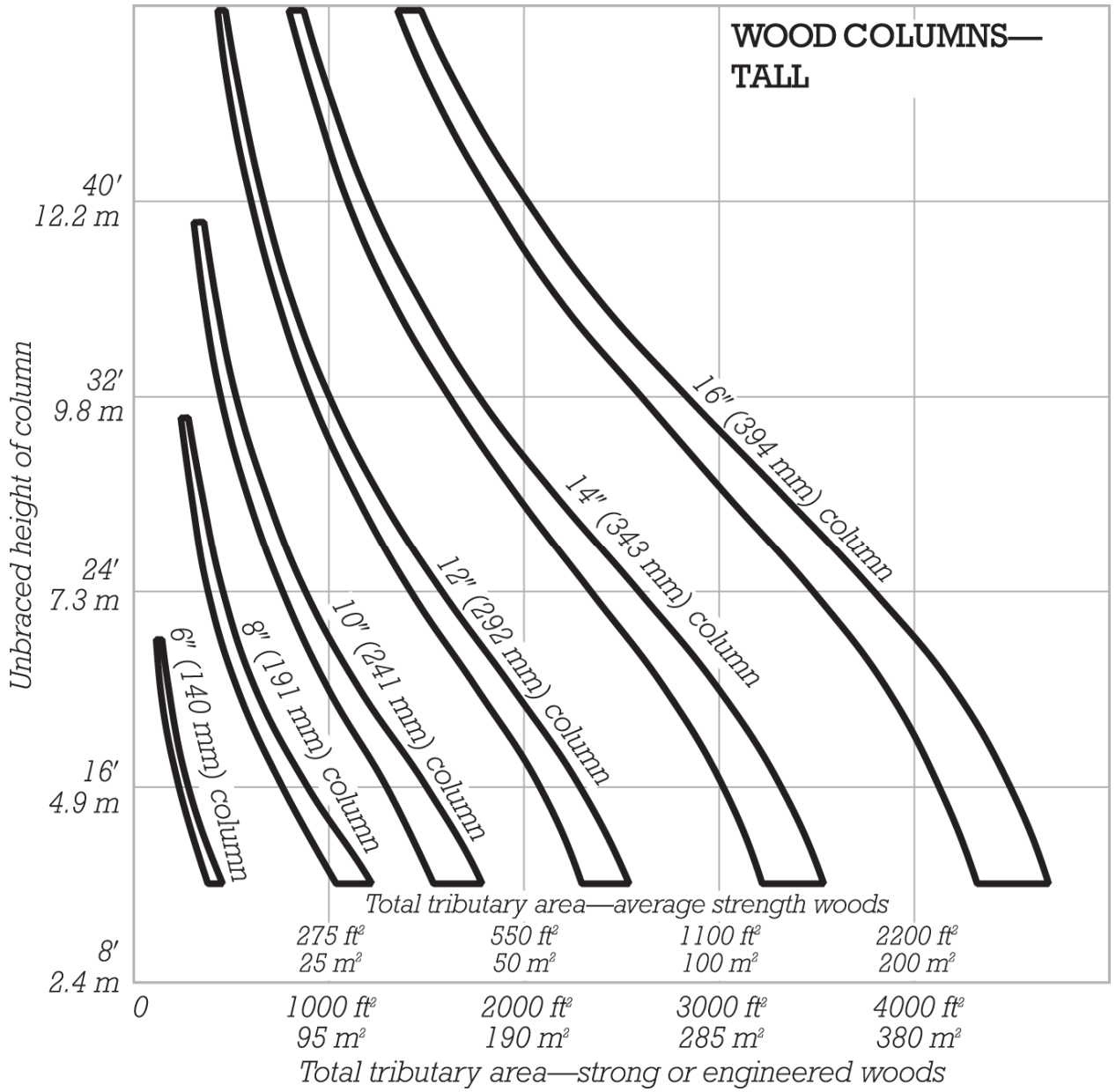
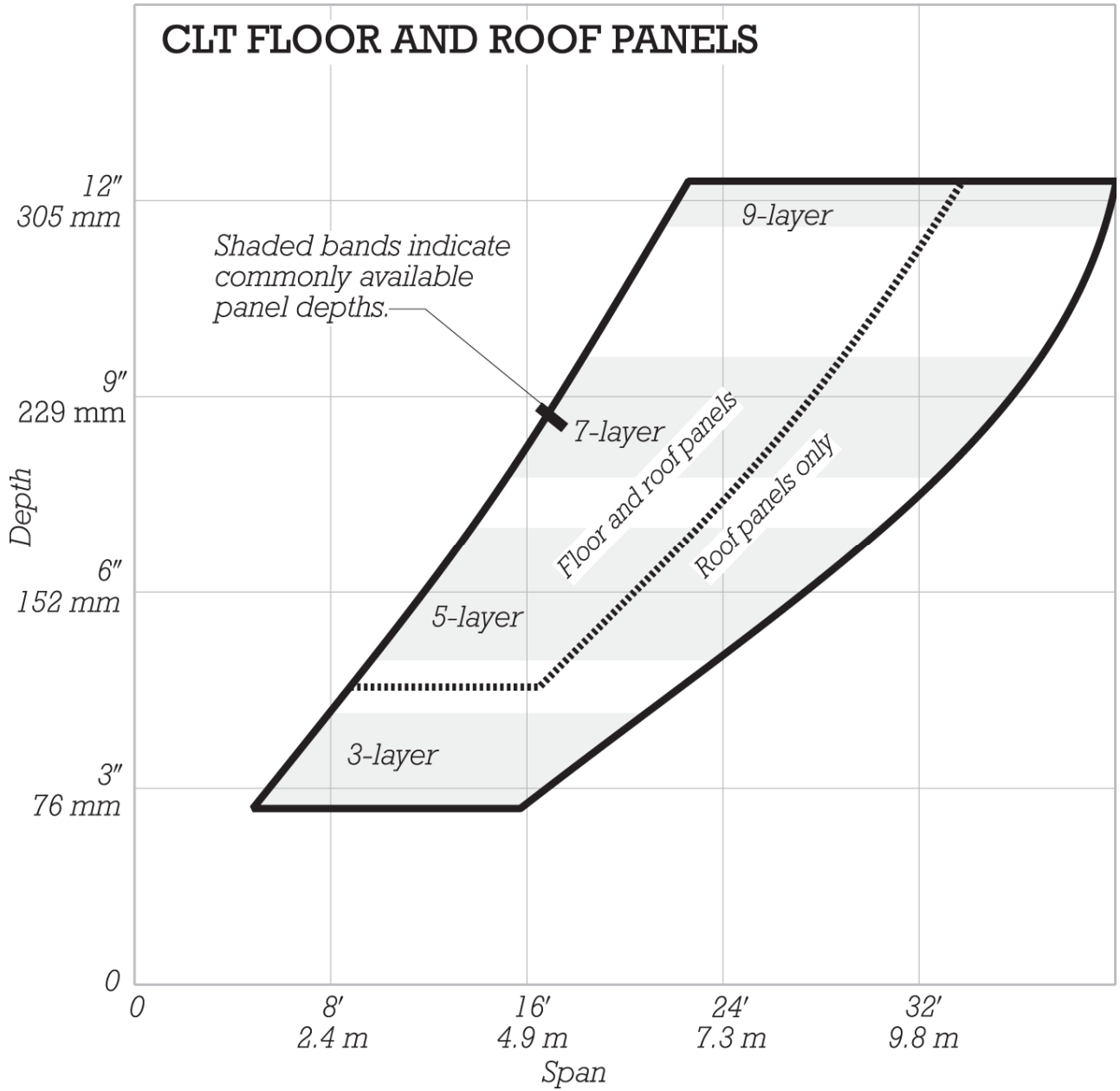
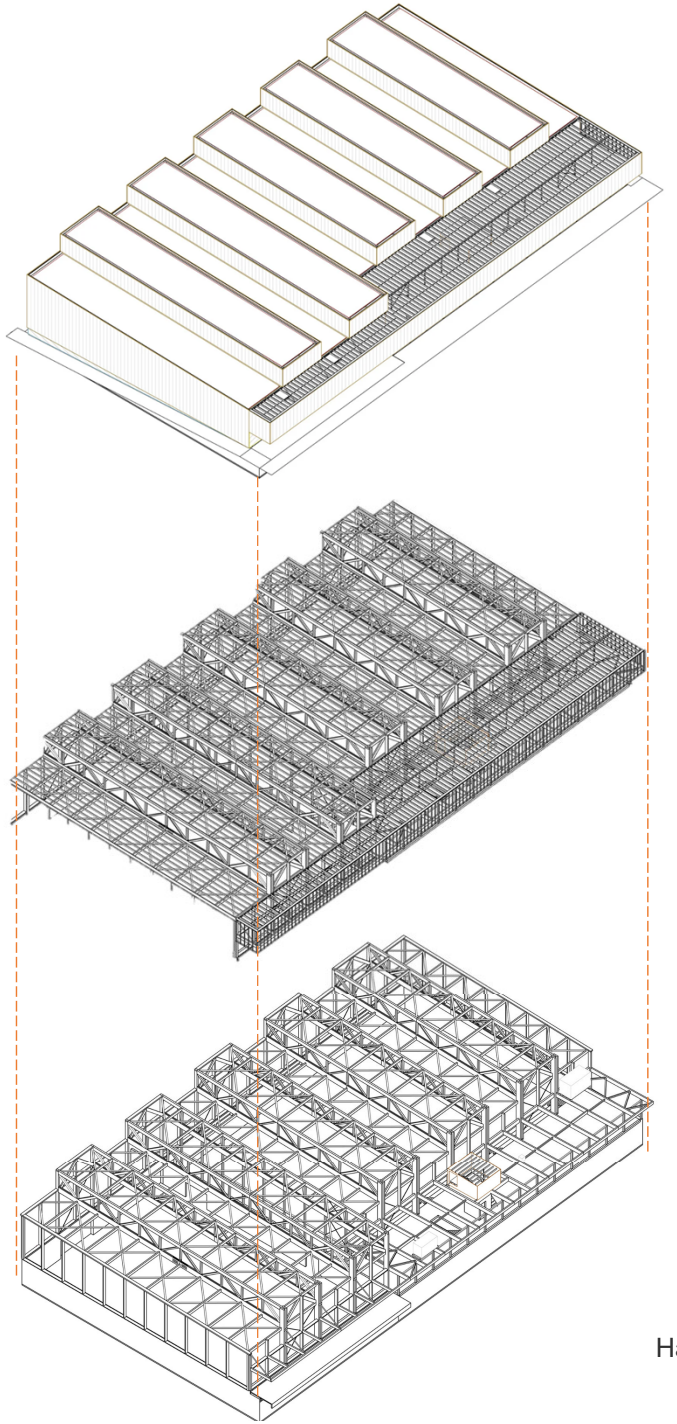


Iano, J., & Allen, E. (2022). *The architect's studio companion: rules of thumb for preliminary design*.



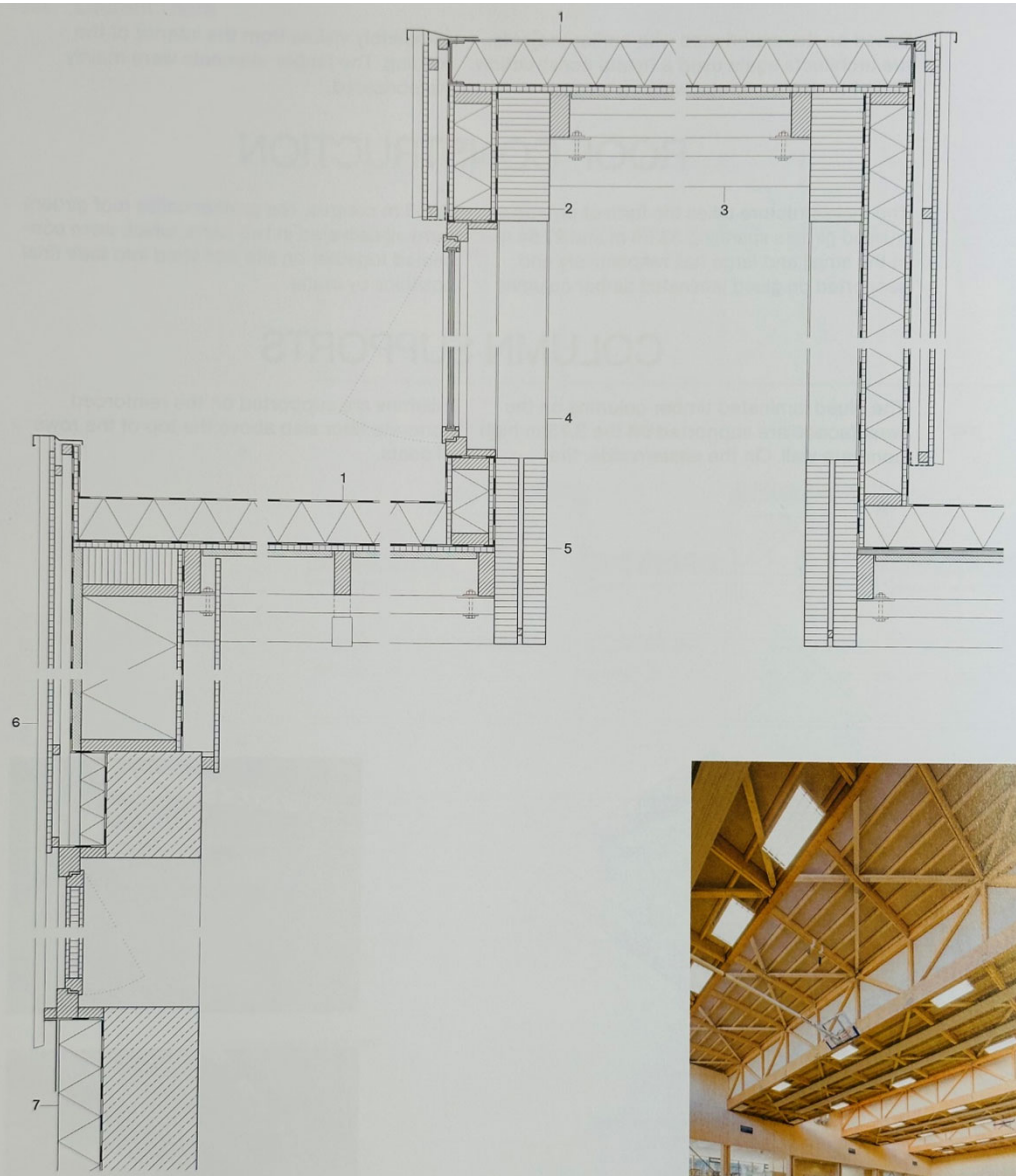
Iano and Allen. *The architect's studio companion: rules of thumb for preliminary design*. John Wiley & Sons, 2022.

Hacine Cherifi Gymnasium, France | Tectoniques



Hacine Cherifi Gymnasium, France | Tectoniques

Hocine Cherifi Gymnasium, France | Tectoniques



vertical section
through roof and facade
scale 1:20

1 roof waterproofing: PVC membrane 160 mm thermal insulation; vapour barrier
2 200/450 mm trussed girder top chord 22 mm veneered plywood board 170/70 mm rafters 25 mm wood wool acoustic panel
3 170/70 mm transverse timber beam
4 180 mm glulam truss diagonal
5 2× 90/720 mm trussed girder bottom chord
6 63 mm Douglas fir 19 mm 3-ply plywood 27/38 mm horizontal laths; 38/38 mm vertical laths membrane; 35 mm wood wool lightweight building board 360/140 mm cross beams, between them 360 mm straw bale thermal insulation in timber framing vapour barrier
7 120 mm vertical laths 19 mm 3-ply spruce plywood 160 mm PU thermal insulation waterproofing layer; 360 mm

Hacine Cherifi Gymnasium, France | Tectoniques

Hacine Cherifi Gymnasium, France | Tectoniques

Hacine Cherifi Gymnasium, France | Tectoniques

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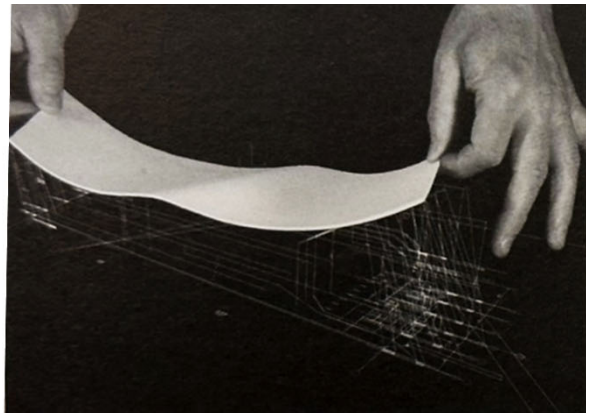
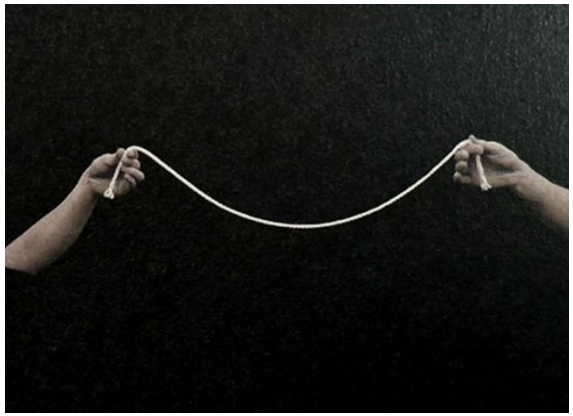
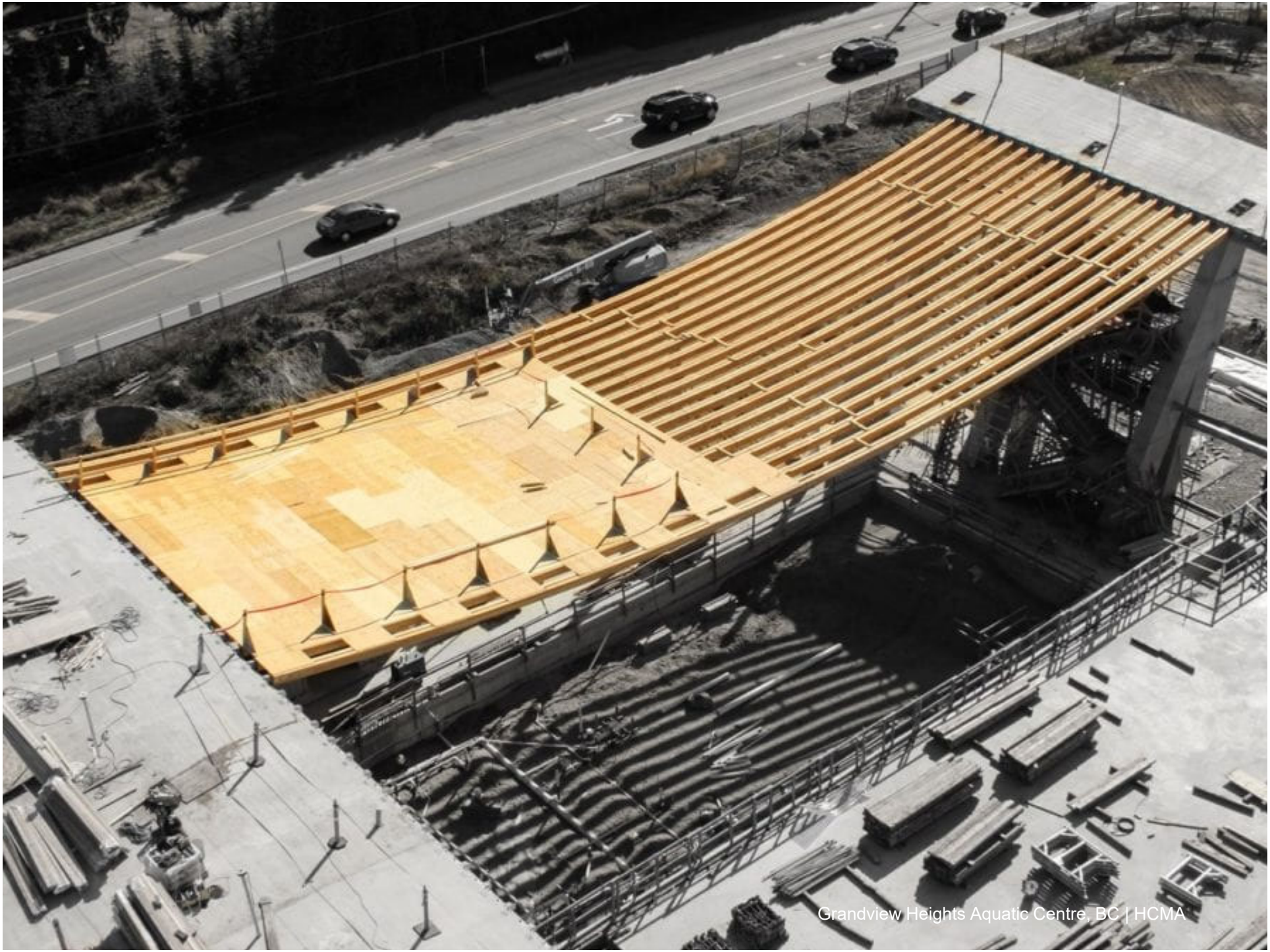



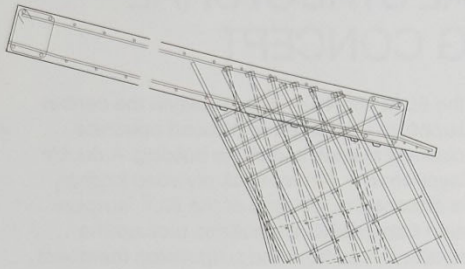

Grandview Heights Aquatic Centre, BC | HCMA

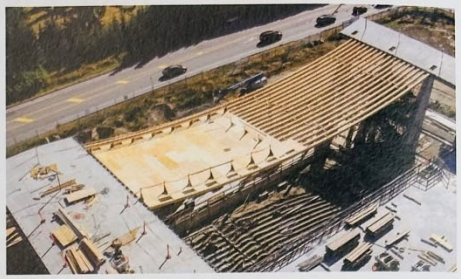


Grandview Heights Aquatic Centre, BC | HCMA

Grandview Heights Aquatic Centre, BC | HCMA

G





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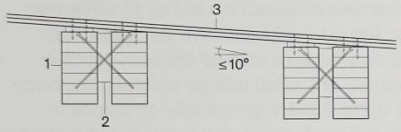

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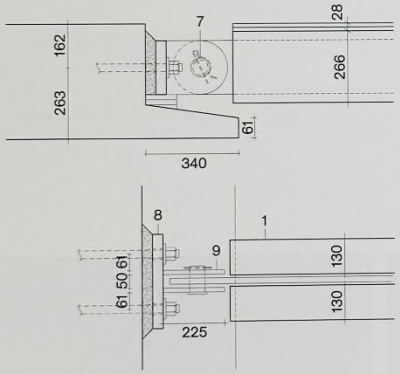

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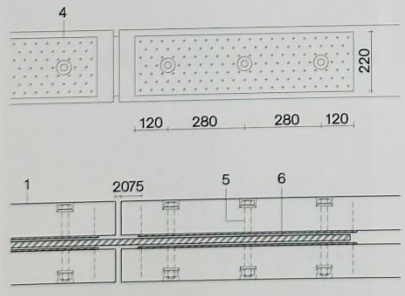
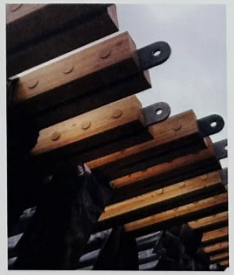
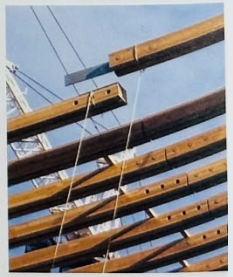


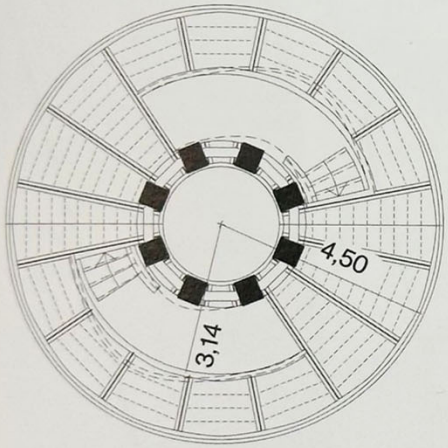




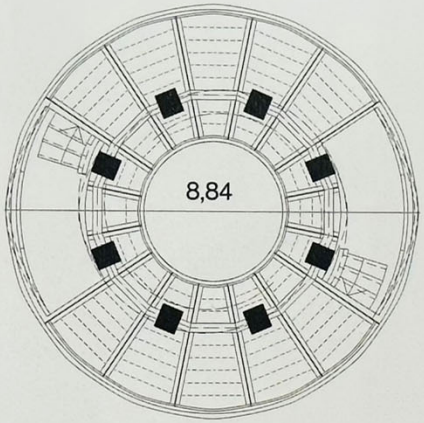
Schönbuch Tower, Germany | schlaich bergermann partner

Grandview Heights Aquatic Centre, BC | HCMA

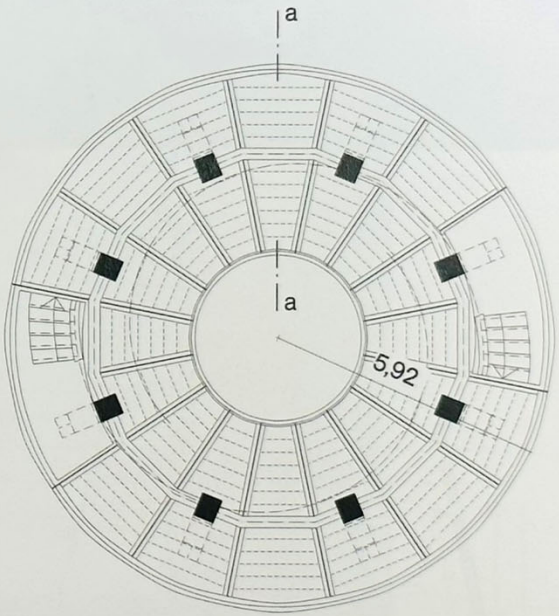
Schönbuch Tower, Germany | schlaich bergermann partner



platform 1



platform 2

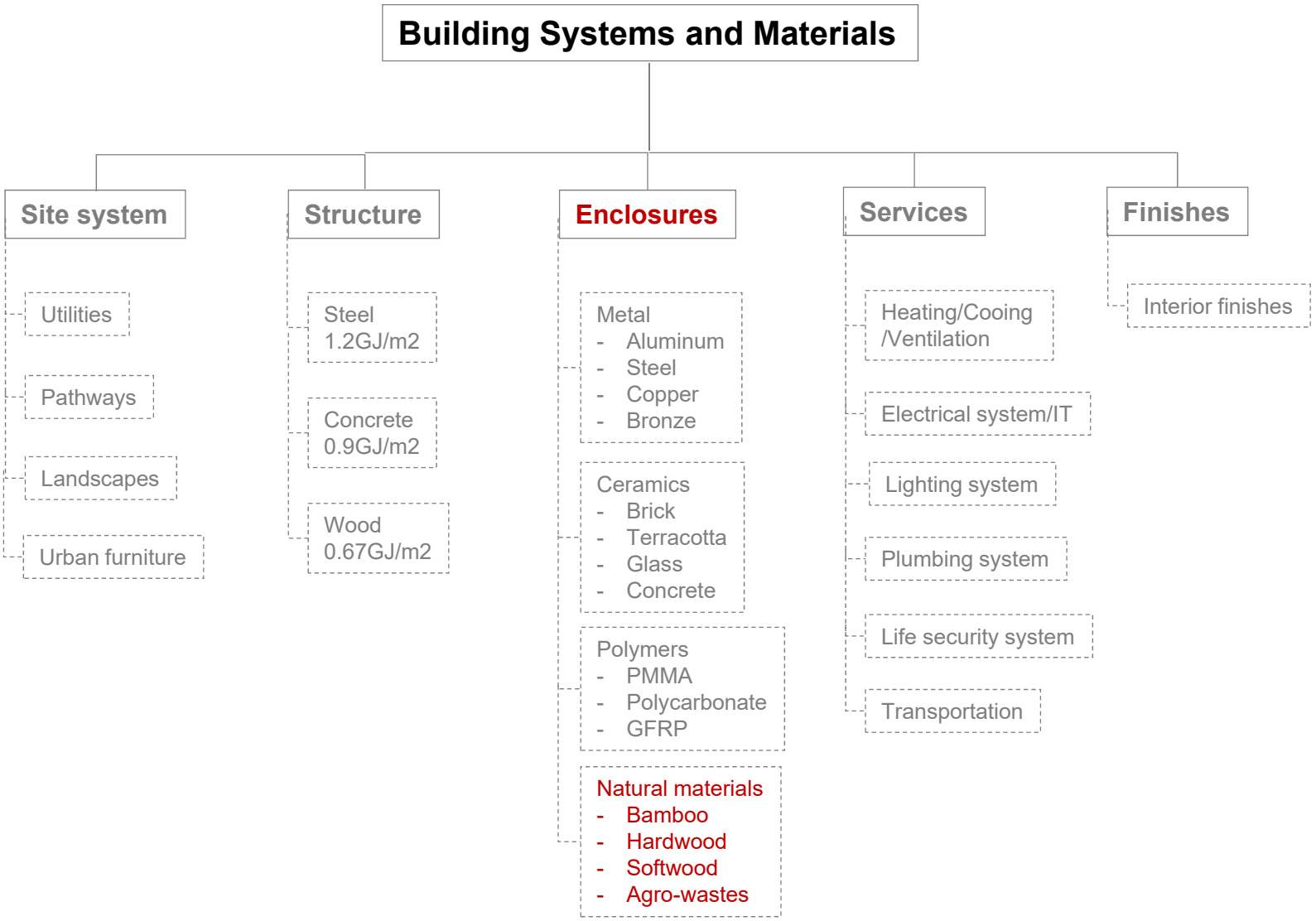


platform 3

Schönbuch Tower, Germany | schlaich bergermann partner

Schönbuch Tower, Germany | schlaich bergermann partner

Wood Facades



Five Building Systems

Functions of Sustainable Building Envelopes*
Protect-Promote-Re/Generate

*Sustainable Façades lecture slide is available here

Protect

Structural performance
- a. Strength
- b. Serviceability

Energy requirement
- Heat Transmission
- Solar Heat Gain
- Daylighting illumination
- Air Infiltration

Water proofing
Durability
Life safety
Impact resistance
OSHA requirements
Condensation resistance
Acoustic protection (OITC)
Bird anti-collision
Sea turtle protection
Blast resistance

Promote, Re/Generate

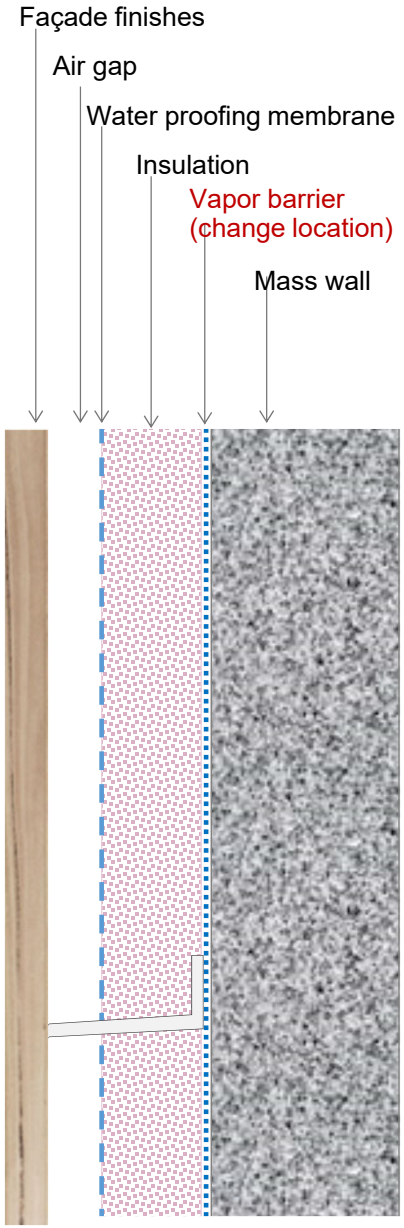
Indoor Environment Quality
- Glare control
- View-out/daylight illumination
- good air quality

Biophilic quality
Renewable energy generation
Carbon Sequestration
User experience
Aesthetics

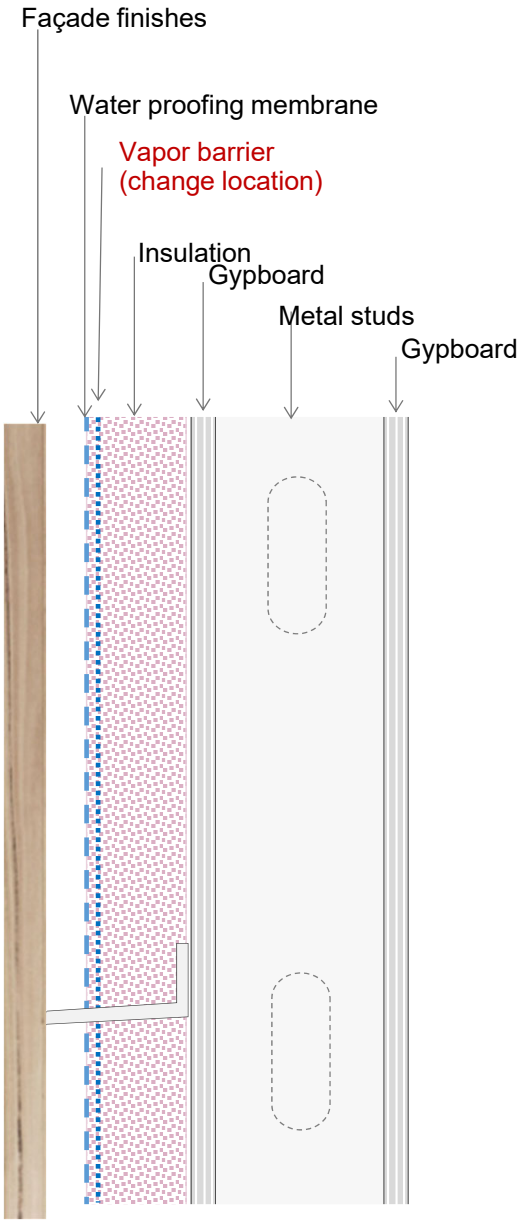
Bath House, Austria

Opaque Envelopes

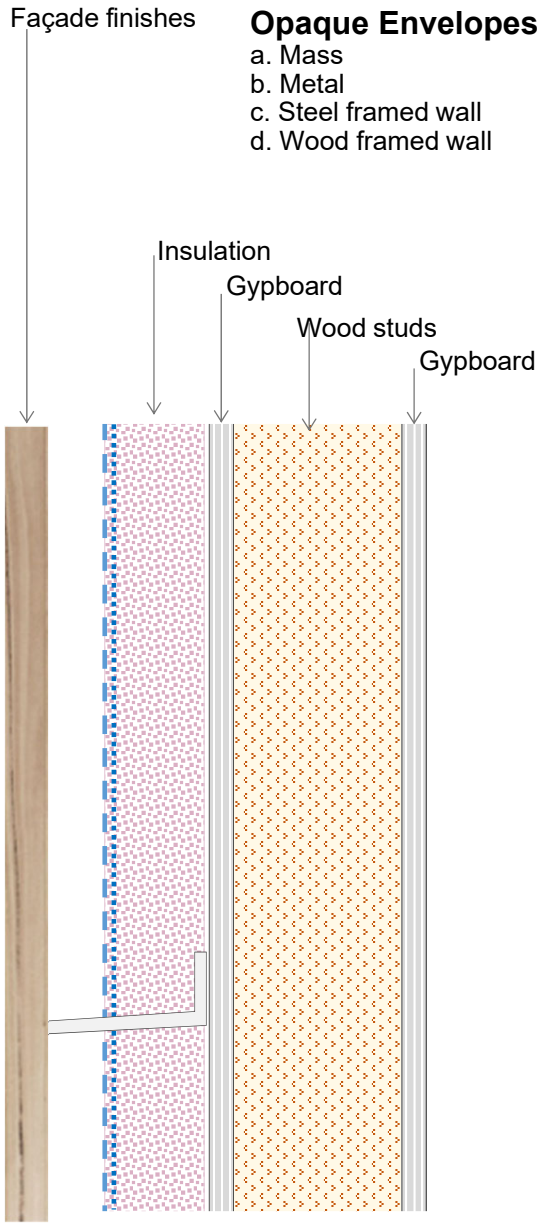
a. Mass
b. Metal
c. Steel framed wall
d. Wood framed wall



Mass wall

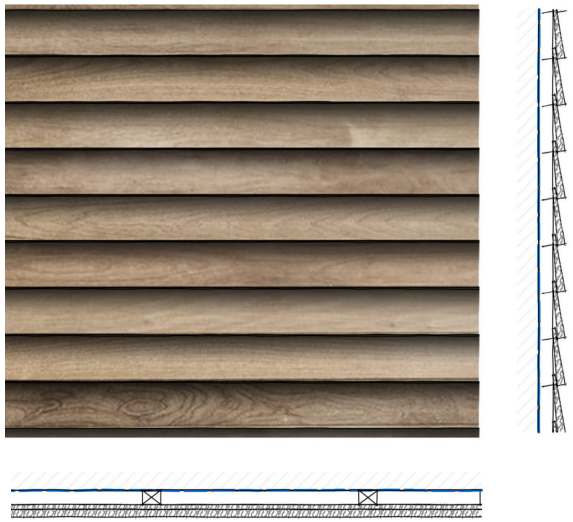


Steel framed wall

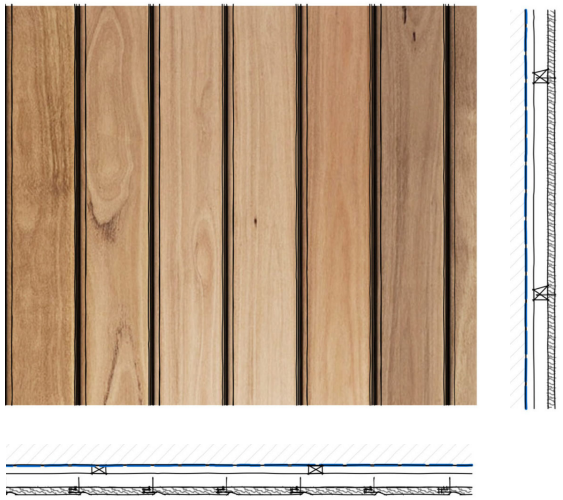


Wood framed wall

Feather Edges

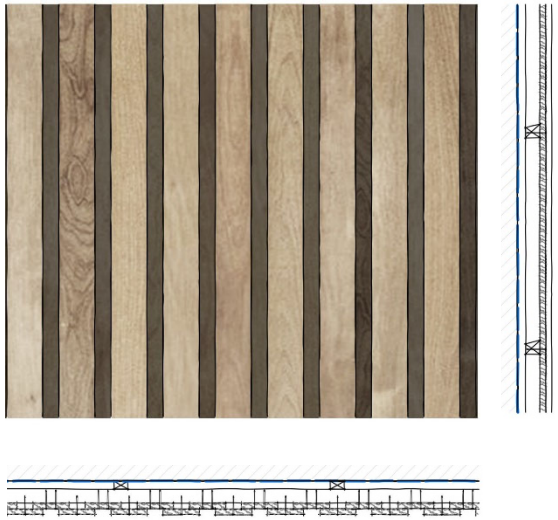


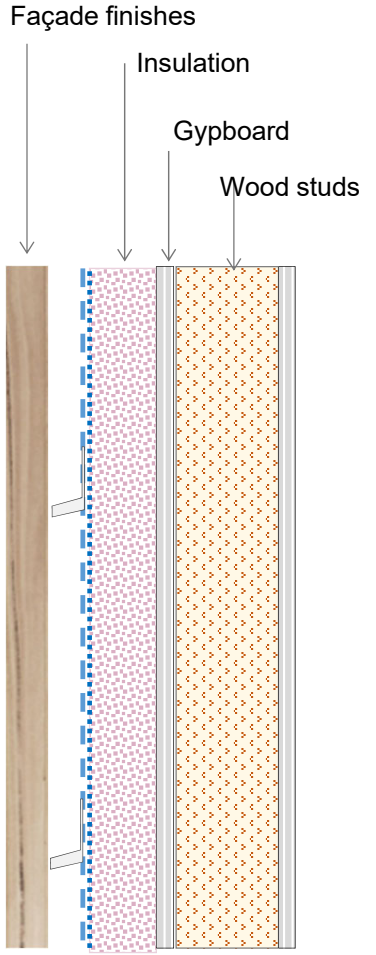
Tong and Groove



Shiplap

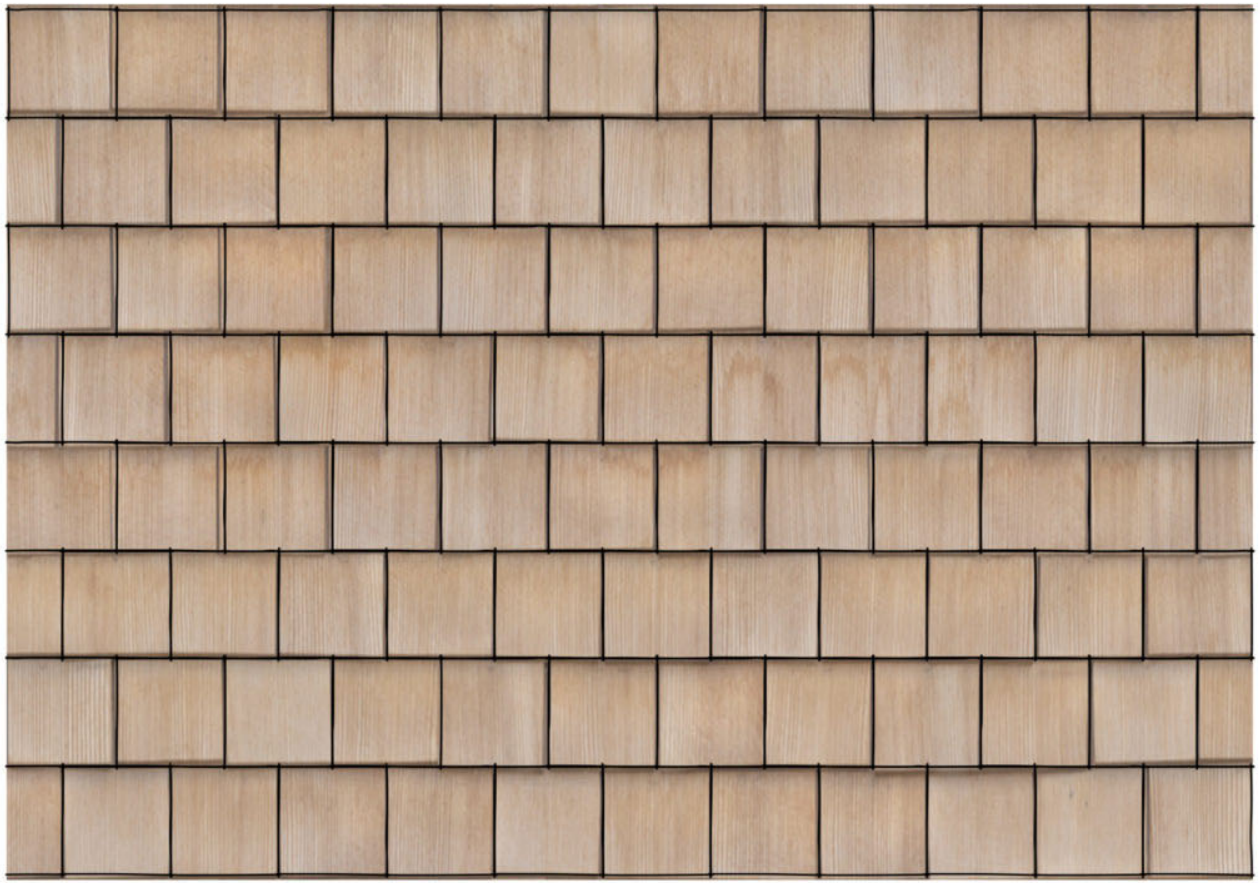
Board on Board

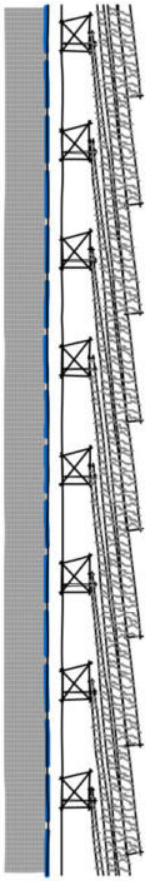


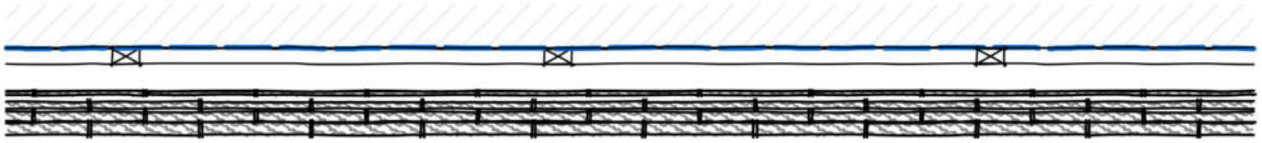


Wood framed wall

https://architizer.com/blog/practice/materials/detailing-timber-cladding/



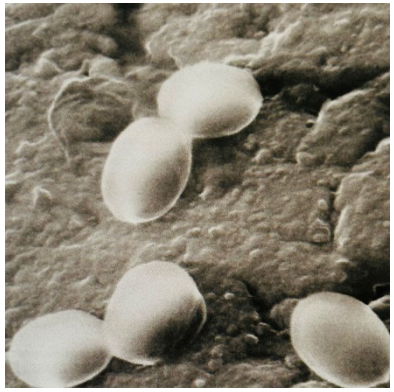




https://architizer.com/blog/practice/materials/detailing-timber-cladding/

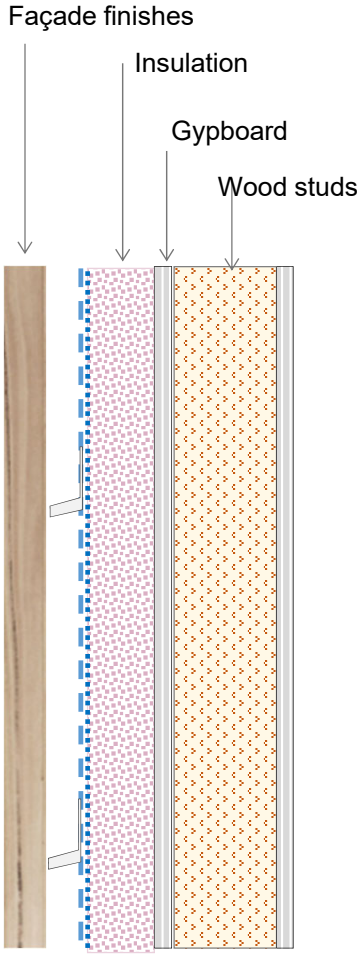
** Circularity lecture slide is available here*

GR Green Slate, GR Green Cedar Tiles
Waterproofing Tiles.
Discarded milk bottles, plastic bags, limestone waste.
GR Green Building Products, Canada



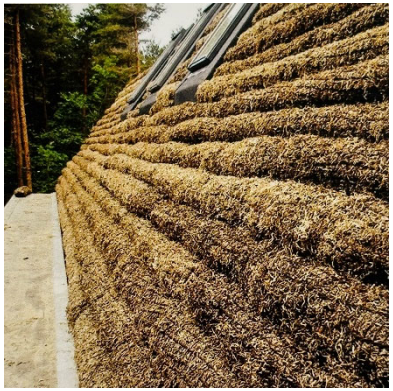
Bacteria-based Self-healing concrete
Waterproofing sealing material.
Microlab, The Netherlands.

Agrofiber biocomposites
Waterproofing tile.
University of Stuttgart



Wood framed wall

Mycotecture
Insulation Bricks.
Mycelium, sawdust
MycoWorks, CA, USA.



Seaweed Insulation
Insulation Infill.
Eradicated seaweed, ib Ungermand, Denmark.

Ecococon Panels
Insulating Infill.
Straw waste.
Ecococon Ltd., Lithania.

Hebel, Wisniewska, & Heisel. *Building from waste: recovered materials in architecture and construction*. Birkhäuser, 2014.

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