

# Materials Matter

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## Lower Embodied Carbon at the Beginning of a Project Lifespan

### Project Overview

Our project involves compiling and comparing sustainable building materials and structural concepts to then use in building assemblies in various combinations. The assemblies will be optimized through testing and redesign, and compared on their performance data in comparison to their sustainable characteristics. The end goal is to find the optimal combination of form, material, thermal performance, structural efficiency, and cost.

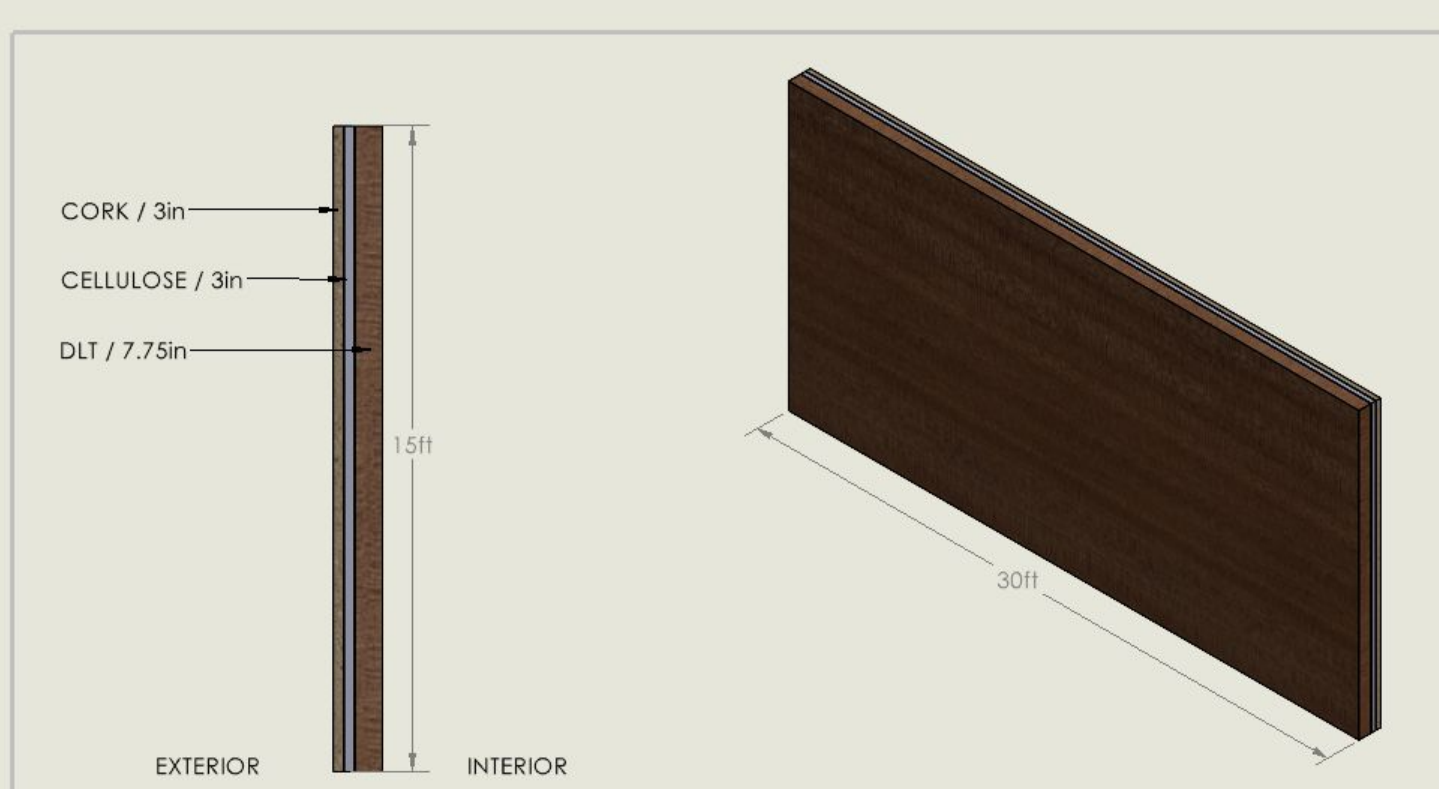
### Design Method

- Research various building materials and find environmental product declarations for each material
- Design walls and roofs based off of R-30: a measure of how well a material resists heat (the higher the R-value, the better the insulating properties of the material are)
- Obtain the R-values and GWP (global warming potentials) of each material
- Design walls with various materials and calculate the overall R-value and GWP of the wall

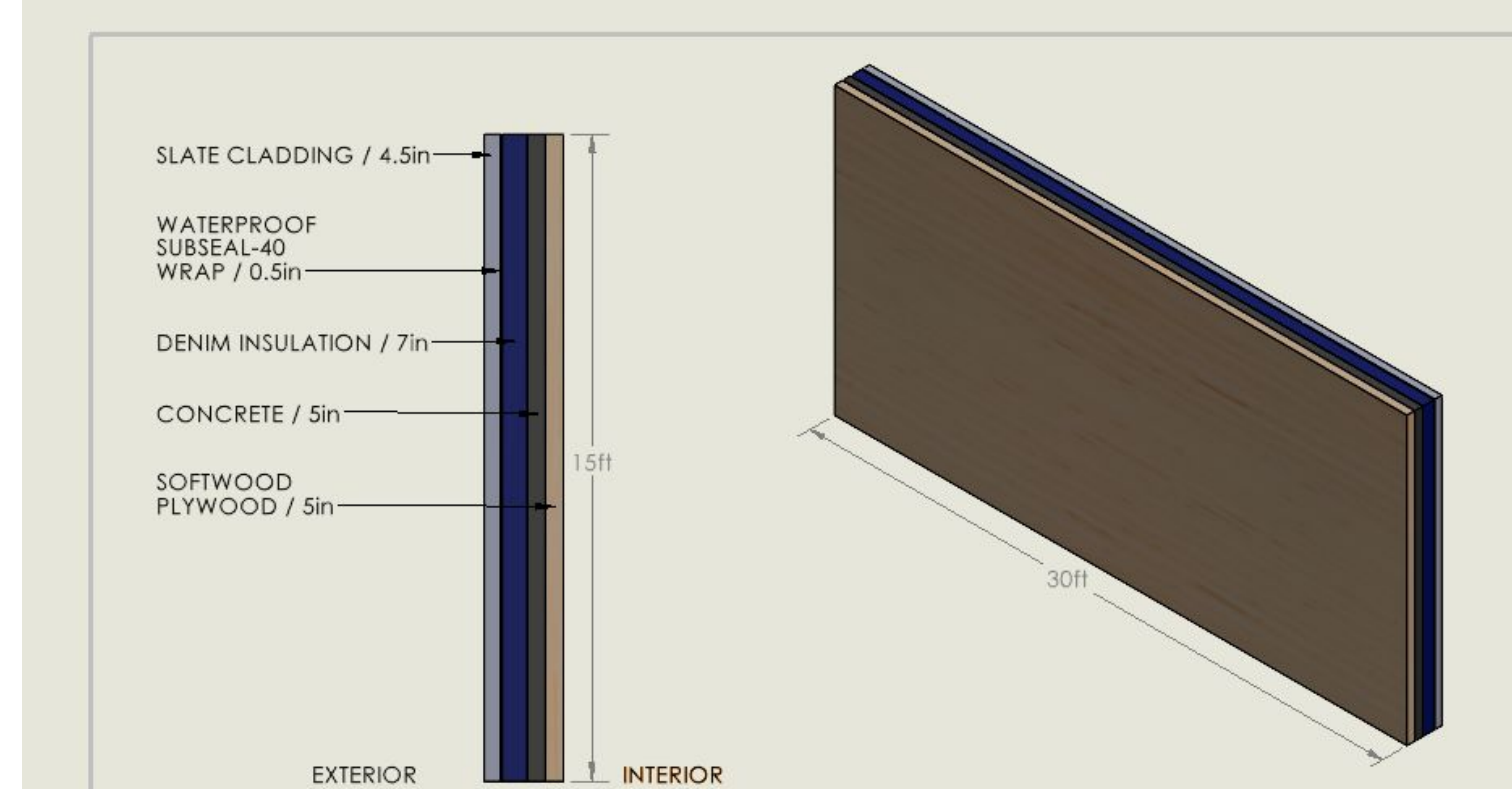
### Materials List

296	Material Address of Origin	R-value/inch	GWP kgCO2e (A1-A3)	WDP/fw (A1-A3, m3)	Assembly Configuration	Characteristics	Toxicity Levels	A4 Information	EPD Link	PCR	construction spec	other notes
Wood - Structural												
Softwood Plywood	Oregon		1.20E+02			Roseburg Forest Products, for formwork calculation			<a href="https://www.roseburg.com/wp-content/uploads/2021/01/EPD-">https://www.roseburg.com/wp-content/uploads/2021/01/EPD-</a>			
Thermopine (Wood)	Stockholm, Sweden	8	-5.42E+02	-7.54	panels/planks	thermally treated wood, enhanced stability, less substrate movement, less shrinkage/swelling	non-toxic	Timber grown, processed and treated in Scotland, transported to building site	<a href="https://epd-portal-api.azurewebsites.net/api/v1/EPDLibrary/Fil">https://epd-portal-api.azurewebsites.net/api/v1/EPDLibrary/Fil</a>			
AWC North American Softwood Lumber	anywhere (can be CA)	negligible	63.12		beams and columns of all sizes	default wood studs and planes	non-toxic : pure wood	anywhere wood is sold NA since it's based in Oregon, it's relatively accessible for California use	<a href="https://awc.org/wp-content/uploads/2021/11/AWC_EPDP_North_AmericanSoftwoodL">https://awc.org/wp-content/uploads/2021/11/AWC_EPDP_North_AmericanSoftwoodL</a>	ISO		
Mass Ply Panels	141 14th St, Lyons, OR 97358	1.25	259.16	0.58	panel	prefabricated panels	no information, since it's phenol formaldehyde resin it may be toxic	since it's based in Oregon, it's relatively accessible for California use	<a href="https://buildingtransparency.org/ec3/epds/ec3uyvwn4">https://buildingtransparency.org/ec3/epds/ec3uyvwn4</a>	FPIInnovations PCR for North American Structural and	<a href="https://freswood.co">https://freswood.co</a>	
CLT	Conway, AR in US or in BC Canada		124.02	0.62	panels	panels, 2 way span		AR or BC Canada relatively close	<a href="Structuriam-Environmental-Product-Declaration-CLT.pdf">Structuriam-Environmental-Product-Declaration-CLT.pdf</a>		<a href="#">Technical Guide</a>	<a href="#">Website for more technical design st</a>
DLT	1929 Foy St., Abbotsford, BC	1.25	121.4	0.45	panel	prefabricated panels, all wood, can be used for wall/floor/ceiling, great for one-way spans, heavy timber	No other chemicals, VOCs, or metal nails	manufacturers are located right above Washington state	<a href="https://drive.google.com/file/d/1IGtdWokWgnirgOU6HKRv72M">https://drive.google.com/file/d/1IGtdWokWgnirgOU6HKRv72M</a>		<a href="#">dit design profile qu</a>	timbercrete compatible
Structural Bamboo	St. Louis, Missouri USA	0.72	need help reading specs, it says it	unable to estimate due to material	beams and columns of all sizes	laminated veneer bamboo (LVB/SEB), a composite of bamboo strand elements which are face-bonded to form finished	EQc2 Low emitting materials, no added formaldehyde	Fabricated in USA, but sourced from latin america through barge and rail	<a href="https://www.lambo.us/files/ugd/da42be8564e311c6fd4539">https://www.lambo.us/files/ugd/da42be8564e311c6fd4539</a>	LEED V-4 and BREEAM qualified, compliant to IBC.	<a href="#">ASTM International Standard - needs to be purchased</a>	although i don't have the loading table and modulus for this material, it's categorized with other
Glulam Beams	BC Canada		115.32	0.46	beam				<a href="Structuriam-Environ">Structuriam-Environ</a>		<a href="#">STRUC-13694-U.S.</a>	

### Sample Wall Assemblies



ASSEMBLY BY: TERESA HOANG	TYPE: WALL	DRAWN BY: KIANA S.	DATE: 2/23/23	
Cork, Cellulose, DLT Drawing				
MATERIAL ASSEMBLY	THICKNESS (in)	GWP (kg CO2 eq)	R-VALUE (in)	EMBODIED H2O
CORK PANEL	3	-630.7	10.8	
CELLULOSE BATTING	3	1.2	11.4	
DLT PANEL	7.75	999	9.7	
<b>TOTAL</b>	<b>13.75</b>	<b>369.5</b>	<b>31.9</b>	<b>27.35</b>



ASSEMBLY BY: ETHAN WO	TYPE: WALL	DRAWN BY: KIANA S.	DATE: 2/23/23	
Cladding, SubSeal, Denim Insulation, Concrete, Plywood Drawing				
MATERIAL ASSEMBLY	THICKNESS (in)	GWP (kg CO2 eq)	R-VALUE (in)	EMBODIED H2O
SLATE CLADDING	4.5	282.9	0	
SUBSEAL-40	0.5	2.1	0	
DENIM INSULATION	7	5.9	26.6	
CONCRETE	5	1571.4	0.75	
PLYWOOD	5	20.9	0	
<b>TOTAL</b>	<b>22</b>	<b>1883.2</b>	<b>27.35</b>	

### EPD Example

EPDs give valuable information about cradle-to-gate technology and resources used in production of the given material

**Environmental performance**  
 The environmental performance results include the indicators and disclaimers of EN 15804:2012+A2:2019:AC:2021. The PCR requires that several parameters be reported in the EPD, including resource use, waste categories and output flows. The estimated impact results are only relative statements, which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins and/or risks.

Indicator name and abbreviation	Unit	Module	A1-A3	C1	C2	C3	C4	D
Climate Change - total	kg CO2 eq		3.18	0	2.04E-02	1.06E-02	1.08	8.04E-01
Climate Change - fossil	kg CO2 eq		4.74	0	2.04E-02	1.06E-02	5.17E-01	1.91E-01
Climate Change - biogenic	kg CO2 eq		-1.56	0	0	0	5.86E-01	3.96E-01
Climate Change - LULUCF	kg CO2 eq		8.54E-04	0	0	0	3.96E-06	0
GWP-GHG	kg CO2 eq		4.74	0	2.04E-02	1.06E-02	5.17E-01	1.91E-01
kg CFC-11 eq			1.89E-11	0	5.17E-13	2.99E-13	3.76E-13	3.33E-12
Acidification	Mole of H+ eq		5.27E-02	0	1.38E-04	1.20E-04	1.99E-03	1.09E-02
Eutrophication, freshwater	kg P eq		2.33E-04	0	5.96E-09	3.27E-09	5.96E-09	1.96E-08
Eutrophication, marine	kg N eq		1.74E-02	0	5.39E-05	5.27E-05	1.29E-03	4.89E-03
Eutrophication, terrestrial	mol N eq		1.89E-01	0	5.89E-04	1.76E-04	8.74E-03	3.29E-02
Photochemical ozone formation	kg NMVOC eq		4.34E-02	0	1.58E-04	1.71E-04	9.84E-04	1.36E-02
Abiotic depletion potential, minerals & metals <sup>1</sup>	kg Sb eq		1.84E-06	0	0	0	3.71E-09	0
Abiotic depletion potential, fossil resources <sup>2</sup>	MJ		59.25	0	5.90E-01	1.47E-01	4.65E-01	-4.1
Water use <sup>3</sup>	m³ world eq. adjusted		3.18E-01	0	0	0	-1.65E-02	-3.04E-02

**Additional environmental impact indicators**

Indicator name and abbreviation	Unit	Module	A1-A3	C1	C2	C3	C4	D
Particulate Matter emissions	kg PM10 eq		1.18E-06	0	4.41E-10	3.41E-10	3.61E-08	2.98E-08
Ionizing radiation, human health <sup>4</sup>	Mbq U235 eq		1.38E-02	0	4.69E-21	2.99E-21	4.38E-04	1.65E-20
Eco-toxicity (freshwater) <sup>5</sup>	CTUe		46.59	0	1.08	6.22E-01	8.88	-8.21
Human toxicity, cancer effects <sup>6</sup>	CTUh		2.56E-09	0	3.98E-12	4.00E-12	1.09E-10	5.69E-10
Human toxicity, non-cancer effects <sup>6</sup>	CTUh		1.84E-07	0	5.95E-10	5.29E-10	2.57E-09	1.19E-08
Land use related impacts <sup>7</sup> Soil quality <sup>8</sup>	dimensionless		103.01	0	0	0	2.38E-02	0

**Use of renewable primary energy as energy carrier:**

Indicator name and abbreviation	Unit	Module	A1-A3	C1	C2	C3	C4	D
Use of renewable primary energy as energy carrier	MJ		78.90	0	0	0	2.67E-02	0

### R Value and GWP Calculations

Assembly 1 - Wall	Exterior	Waterproof	Insulation	Interior	Formwork
Material	Panel	Wrap	Insulation	Block	Panel
Product	Slate Cladding	SubSeal-40	Denim Insulation	Concrete	Softwood Plywood
Dimensions	comes in 3.5" sheets				
Length (ft)	30	30	30	30	30
Height (ft)	15	15	15	15	15
Thickness (in)	4.5	0.5	7	5	5
R-value/in	0	0	3.8	0.15	0
R-Value total	0	0	26.6	0.75	0
Volume Wall (m³)	4.778011074	0.5308901193	7.432461671	5.308901193	5.308901193
GWP/m³	59.2	3.94	0.8	296	3.94
GWP Total (kgC)	282.8582556	2.09170707	5.945969337	1571.434753	20.9170707
<b>TOTAL</b>					<b>1883.247756</b>

Assembly 2 - Wall	Exterior	Waterproof	Insulation	Interior	Formwork
Material	Panel	Wrap	Insulation	Block	Panel
Product	Slate Cladding	SubSeal-40	Havelock Wool	Concrete	Softwood Plywood
Dimensions	comes in 3.5" sheets				
Length (ft)	30	30	30	30	30
Height (ft)	15	15	15	15	15
Thickness (in)	4.5	0.5	7	5	5
R-value/in	0	0	4.3	0.15	0
R-Value total	0	0	30.1	5.04	0
Volume Wall (m³)	4.778011074	0.5308901193	7.432461671	7.432461671	7.432461671
GWP/m³	59.2	3.94	2.63	318	3.94
GWP Total (kgC)	282.8582556	2.09170707	19.54737419	23.63522811	20.9170707
<b>TOTAL</b>					<b>328.132565</b>

### Next Steps

- Calculate the load that our wall assemblies can withstand
- Design roof assemblies within the load parameters
- Calculate the embodied carbon for material transportation and add it into our GWP calculations
- Calculate the embodied water for each assembly
- Create the full assembly of a building using AutoCAD softwares

### System diagram:

