Toward Safe and Natural High Performance Enclosures
Nature is toxic enough
Nature is toxic enough

Can we avoid making life more toxic?
Eat food. Not too much. Mostly plants.
# The Dose Makes The Poison

<table>
<thead>
<tr>
<th>Substance</th>
<th>Where you find it</th>
<th>Lethal Dose (mg substance / kg of body weight)</th>
<th>Lethal Dose (Oz per 100lbs of body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulin</td>
<td>Improperly canned foods</td>
<td>0.00001</td>
<td>1.6e-11</td>
</tr>
<tr>
<td>Cyanide</td>
<td>Cherry pits</td>
<td>10</td>
<td>0.016</td>
</tr>
<tr>
<td>Caffeine</td>
<td>Coffee</td>
<td>200</td>
<td>0.32 (100 cups)</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Beer, wine, spirits</td>
<td>7,000</td>
<td>11.2</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>Orange juice</td>
<td>12,000</td>
<td>19.2</td>
</tr>
<tr>
<td>Sucrose</td>
<td>Sugar cane, sugar beets</td>
<td>30,000</td>
<td>48</td>
</tr>
</tbody>
</table>
THIS IS WHERE
I DRAW THE LINE
The Red List

- Asbestos
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethylene
- Chlorofluorocarbons (CFCs)
- Chloroprene (Neoprene)
- Formaldehyde (added)
- Halogenated Flame Retardants
- Hydrochlorofluorocarbons (HCFCs)
- Lead (added)
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phthalates
- Polyvinyl Chloride (PVC)
- Wood treatments containing Creosote, Arsenic, or Pentachlorophenol
Buildings leaning green...

- USGBC LEED
- Green Seal
- Greenspec
- Greenguard
- Environmental Product Declaration EPD: ISO 14025
- California EPA Air Resources Board
- Perkins & Will’s Precautionary List
Buildings leaning green...

Declare Label
- A project of International Living Future Institute
- Label to serve as voluntary ‘nutrition-label’ for building materials
- Provides product ingredients in support of the program’s Red List and Appropriate Sourcing Imperatives
Buildings leaning green...

Pharos Project
• Evaluates building products & components
• Profiles chemicals and materials for 22 health and environmental hazards
• Rates over 250 product certifications and uses them in building product evaluations
• Meta-analysis of hazard lists from gov, NGO, and expert bodies
Buildings leaning green...

The SHI Health Passport

• Leader in health-conscious and allergy friendly construction
• Performance measures of individual components and whole-house analysis
• Free of aldehydes
• Free of SVOC and TVOC
• Strict measure of particulate matter, mold, \( \text{CO}_2 \) levels and radon
Balancing Material Considerations
The Future?

Plastics!
Greenpeace - Pyramid of Plastics

- PVC = Polyvinyl chloride
- PS = Polystyrene
- ABS = Other resins, like acrylonitrile butadine styrene
- PU = Polyurethane
- PC = Polycarbonate
- PET = Polyethylene terephthalate
- PE = Polyethylene
- PP = Polypropylene
- HDPE = High-density polyethylene
- LDPE = Low-density polyethylene
<table>
<thead>
<tr>
<th><strong>Materials Review</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insulations</strong></td>
</tr>
<tr>
<td>ccSpray foam</td>
</tr>
<tr>
<td>ocSpray foam</td>
</tr>
<tr>
<td>XPS foam/Polyiso</td>
</tr>
<tr>
<td>EPS foam</td>
</tr>
<tr>
<td>Fiberglass</td>
</tr>
<tr>
<td>Mineral wool</td>
</tr>
<tr>
<td>Wood Fiber Board/PU Binder</td>
</tr>
<tr>
<td>Cellulose</td>
</tr>
<tr>
<td>Hempcrete</td>
</tr>
<tr>
<td>Cork</td>
</tr>
<tr>
<td>Straw Bale</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Thermal Control

- Thermal Bridge Free Construction
- Continuous Insulation
  - Double-Stud
  - I-Joist Outrigger
  - Uninterrupted Board Insulation
Foam Insulation... Less is Best

Spray Foam
Part A:
• MDI (methylenediphenyl diisocyanate), aniline, formaldehyde, hydrochloric acid and phosgene
Part B:
• Flame retardants:
  • halogenated organic compounds (chlorine or bromine bonded to carbon)
• Catalysts:
  • Amine Compounds
• Blowing Agent:
  • closed cell - hydrofluorocarbon blowing agent (EXCEPT AT OPEN CELL/EPS)
Foam Insulation... Less is Best

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  • On-site manufacturing
  • Difficult quality control
  • Long term performance issues
  • Burning produces hydrogen cyanide
Foam Insulation... Less is Best

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- Burning produces hydrogen cyanide

**Board Foam**
- Part A: Same
- Part B: Same
- Better control in factory environment
Insulations

Mineral wool:
Roxul
Urea-extended phenol formaldehyde binder - very low ppm (Greenguard)
No flame retardants

Fiberglass:
Typically with phenol formaldehyde binder
Dense pack: Jet Stream Ultra binder free by Knauf
Below: JM Spider with hydrolyzed polyester binder

Alex Wilson, BuildingGreen
Insulations

Cellulose:

15% Borates for fire, pest and mold prevention.

Woodfiber Board:

Gutex & Agepan

High recycled content, ~1% PU binder
Insulations

Cork:
Heat process, natural binders, no additives

Straw bale:
No chemical processing.
Membranes/Barriers

- Liquid Asphalt: Tremco Enviro Dri
- OSB with 10% MDI Resin: Huber ZIP
- silyl-terminated-polyether (STPE): Prosoco R Guard, tyvek liquid etc
- TEEE thermoplastic elastomer ether ester: Pro Clima SOLITEX
- Polyethylene copolymer: Pro Clima INTELLO
- Nylon: CertainTeed MemBrain
- Superadobe, clay, lime plaster

Cal Earth

Superadobe Home
Connections

- Rubberized Asphalt: Grace Vycor Plus
- Butyl/MDI Adhesive: Dupont FlexWrap
- Butyl-Acrylic: Pro Clima EXTOSEAL
- silyl-terminated-polyether (STPE): ZIP Liquid Flash & Prosoco Fast Flash
- Acrylcopolymers: Pro Clima Contega HF caulk adhesive
- EPDM rubber gaskets: Pro Clima Roflex
- Acrylic Tape: Pro Clima, Siga, Huber, 3m
Sheathings

OSB
- Bind the fibers either with phenol formaldehyde or polymeric methylene diisocyanate (pMDI)

Plywood
- Phenol formaldehyde

Plank
- Local sourcing
- No chemical additives
Putting It All Together
High Performance Priorities
Airtightness

Ref http://passipedia.passiv.de/passipedia_en/

Inboard Airbarrier
Vapor - Moisture Loading

In winter constructions are exposed to moisture:

Only Diffusion is calculated during the planning process.

Conclusion:
There is no absolute protection against moisture.
Vapor Control

• Increase drying reserves
• Drying capacity > moisture stress = avoid damages

• As enclosures get colder, importance of vapor control grows

• Vapor drives need to be addressed

• Prevent the wetting and help the drying!
About Using WUFI Pro

• A relative risk assessment not an absolute risk assessment
• Examining for high moisture risk at critical components
• Five year look
• Using Moisture Content as proxy
  – <15%MC = safe/low risk OSB, plywood
  – <18%MC = acceptable risk for wood> OSB?
  – 20%MC = danger threshold, significant risk also for solid wood
  – >20%MC = rising risks
• Higher insulation values = Higher risks
• Don’t design safety factors out of the wall: maintain drying reserves
Making the Assembly

- Wood Frame - thickness varies
- R25 (ish)
- Stucco or OSB
- Airtight - location varies
- Vapor control - varies
- San Francisco Location with North Orientation
Climate - San Francisco
Climate - San Francisco

### Climate San Francisco - California

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average high in °F:</td>
<td>57</td>
<td>60</td>
<td>62</td>
<td>63</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>Average low in °F:</td>
<td>46</td>
<td>47</td>
<td>49</td>
<td>49</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>Av. precipitation in inch:</td>
<td>4.45</td>
<td>4.55</td>
<td>3.27</td>
<td>1.46</td>
<td>0.71</td>
<td>0.16</td>
</tr>
<tr>
<td>Days with precipitation:</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Hours of sunshine:</td>
<td>165</td>
<td>182</td>
<td>251</td>
<td>281</td>
<td>314</td>
<td>330</td>
</tr>
</tbody>
</table>

### San Francisco Climate Graph - California Climate Chart

- **Low**
- **High**
- **Precipitation**
Cellulose: Stucco, OSB outboard / GWB inboard

- Just crossing the line
- Wet months in risky territory
- Diagram of assembly:
Fiberglass: Stucco, OSB outboard / GWB inboard

- Well into the danger zone
- No inboard vapor control
- Diagram of assembly:

Stucco
Fiberglass: Rainscreen, OSB outboard / 2x6, GWB inboard

- Less danger than Stucco
- Still risky
- Diagram of assembly:

![Diagram of Fiberglass Rainscreen Assembly]

Water Content [M.-%]
Cellulose: Rainscreen, OSB outboard / 2x6, GWB inboard

- Within acceptable risk if all stays dry
- No vapor control
- Diagram of assembly:

![Diagram of assembly]

Oriented Strand Board (density 615 kg/m³)

Water Content [M.-%]

1/1/2014  1/1/2015  1/1/2016  1/1/2017  1/1/2018

Water Content [M.-%]

Cellulose

![Graph showing water content over time]
Cellulose: OSB outboard/smart vapor membrane inboard

- Cellulose is slow to dry from construction moisture loading.
- Diagram of assembly:
Fiberglass: OSB outboard/smart vapor membrane inboard

- Vapor variable membrane mitigates risk
- Diagram of assembly:

![Diagram of assembly]

Stucco
Smart Vapor Retarder
OSB/Vapor-open WRB
Cellulose: WRB outboard /9”l-joist OSB inboard

- Some wetting in winter
- Dries quickly
- OSB vapor control inboard
- Diagram of assembly:

![Diagram of assembly]

Water Content [M.-%]

[Graph showing water content over time]
Mineral Wool Over OSB
Mineral wool: 2” rigid, OSB outboard/ 2x6, GWB inboard

- Mineral wool does the job
- Diagram of assembly:

![Diagram of mineral wool assembly](image-url)

**Diagram of assembly:**

- Mineral wool
- Oriented Strand Board (density 615 kg/m³)
- Water Content [M.-%]

![Graph of water content](image-url)

**Graph of water content:**

- Water Content [lb/ft²]
- 1/1/2014 to 1/1/2018

**Graph details:**

- Water Content [M.-%]
- 12.37 to 15
- 1/1/2014 to 1/1/2018

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WUFI® Pro 5.2; 151109 PH CA net zero conference foam free.W5P; Case 7; 2x6 3in Mineral wool; 11/9/2015
Wood Fiberboard w/rainscreen outboard/ 2x6, Cellulose inboard

- 2-3/8” board +2x6 cell
- Works beautifully
- No inboard vapor control
- Diagram of assembly:

Water Content \[\text{M.-%}\]

Oriented Strand Board (density 615 kg/m^3)
Straw Bale
Straw bale w/rainscreen / OSB inboard

- 22” of insulation
- OSB (or plaster) inboard vapor control
- Diagram of assembly:

Oriented Strand Board (density 615 kg/m³)

Water Content [% M.-%]

Water Content [% M.-%]

1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
• Low toxicity is a vital high-performance goal.

• We can’t completely detoxify, but we can push the limit of acceptable risk.

• To the extent we keep potentially hazardous chemical out the less the rest of the worries matter.

• Performance ≠ toxicity. Greener choices can get higher performance.
THANK YOU...

More info @ foursevenfive.com
Details
Details