2009 Frame Building Expo

Post Frame As "Green" As It Gets

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What I Was Asked To Talk About

- What does it truly mean to be green?
- What are those attributes that make post-frame a green alternative?

Presentation Overview

- Presentation Topics
  - Definitions
    - Environmentally-Friendly Construction
    - Sustainable Construction
  - Life Cycle Analysis
  - Environmentally-Friendly Construction
    - Use Environmentally-Friendly Materials
    - Minimize Total Material Usage
    - Conserve Energy
    - Provide for Healthy Living
    - Design for Durability
    - Design with Eventual Reuse in Mind

Presentation Overview

- Green Rating Systems
  - Are not covered in today's presentation
  - Like *prescriptive* building codes, they are largely for people who do not understand ***why*** they are doing what they are doing
  - People do very non-environmentally-friendly things in pursuit of "building rating points"
  - Can stifle advancement (just like codes and standards) if not properly administered
  - Fail to adequately address some building features that have significant environmental impact
  - Politics often trumps good science

Definitions

- The words **'Green'** and **'Carbon Footprint'** topped the 34th annual *List of Words to Be Banished from the Queen's English for Mis-use, Over-use and General Uselessness* (http://www.lssu.edu/whats_new/articles.php?articleid=1695)
- We now have ***green*** lifestyles, ***green*** initiatives, ***green*** legislation and policies, ***green*** solutions, ***green*** technology, etc.

Definitions

- **Gangrene** – An overuse/misuse of the word **'Green'** that makes your skin crawl

Gangrene is a complication of necrosis (i.e., cell death) characterized by the decay of body tissues, which become black (and/or green) and malodorous. It is caused by infection or ischemia, such as from thrombosis (blocked blood vessel). It is usually the result of critically insufficient blood supply (e.g., peripheral vascular disease) and is often associated with diabetes and long-term smoking

Diabetic with severe infection and loss of toes - wet gangrene in center

Definitions

- **Green** = ***Environmentally-Friendly***
- Other synonyms
  - Low Impact
  - Low-Environmental Impact
  - Ecological
- Green in today's context
  - Environmentally-friendly construction
    - Environmentally-friendly building design
    - Environmentally-friendly building materials

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Definitions

- **Environmentally-friendly construction** is herein defined as construction that during **original building erection**, **operation**, and eventual **demolition:**
  - ✓ **Minimizes emissions that are harmful to the environment**
  - ✓ **Uses natural resources at rates that do not exceed their regeneration rates**

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Definitions

- Why Environmentally-Friendly Construction?
  - Save natural resources for future generations
  - Improve your personal health
  - Become more financially solvent
    - True environmentally-friendly construction tends to be more affordable
  - Hedge against future inflation
    - Very high probability that energy costs will increase

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Definitions

- You goal should not be building GREEN buildings. Your goal should be building SUSTAINABLE buildings.

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Definitions

- **Sustainable Construction**
  - Based on definition of "**sustainable development**" appearing in "Our Common Future" published in 1987 by United Nation's World Commission on Environment and Development
    - **Sustainable development:** development that meets the needs of the present without compromising the ability of future generations to meet their own needs

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Brundtland Report Quote

Environmental stress has often been seen as the result of growing demand on scare resources and the pollution generated by the rising living standards of the relatively affluent. But poverty itself pollutes the environment, creating environmental stress in a different way. Those who are poor and hungry will often destroy their immediate environment in order to survive: They will cut down forests; their livestock will overgraze grasslands; they will overuse marginal land; and in growing numbers they will crowd into congested cities. The cumulative effect of these changes is so far-reaching as to make poverty itself a major global scourge.

Page 40 U.N. Brundtland Report

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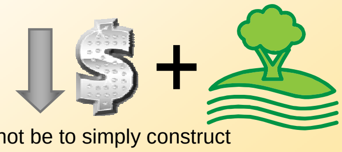
Definitions

- **Sustainable Construction** is construction that meets the needs of the present without compromising the ability of future generations to meet their own needs

Definitions

- *For construction to* meet the definition of sustainability, it must first and foremost be both ***affordable*** and ***environmentally- friendly*** in addition to being safe and functional

Sustain-ability =



- Your goal should not be to simply construct environmentally-friendly buildings, but to construct sustainable buildings (i.e. low-cost, environmentally friendly buildings)

Definitions

- ***Affordable*** *construction* and ***environmentally-friendly*** *construction* are not mutually exclusive

  The most affordable construction tends to be the most environmentally-friendly

- Based on cost/ft^2, applications involving post-frame buildings tend be among the most sustainable systems constructed

Life Cycle Assessment (LCA)

- **Life Cycle Assessment**
  - a.k.a. Life Cycle Analysis or LCA for short
  - Used to determine environmental impact of materials over their life (cradle-to-grave)
  - A two step process

    Step 1: life cycle inventory or LCI

    Step 2: life cycle impact assessment or LCIA

Life Cycle Assessment (LCA)

- **Life Cycle Inventory** (LCI): A life cycle (a.k.a. cradle-to-grave) inventory (i.e., accounting) of the energy and mass flows into and out of the environment that are associated with a material or system
- **Life Cycle Impact Assessment** or LCIA: The assignment of a cost to each "inventoried" mass and energy flow into and out of the environment
  - Costs are selected to represent or reflect the potential harm each flow has on the environment

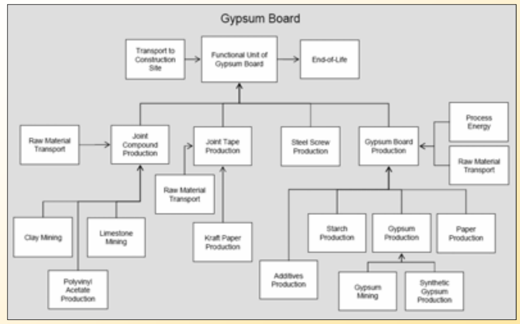
Life Cycle Assessment (LCA)

- **LCA Software**
  - Building for Environmental and Economic Sustainability (BEES)
    - From National Institute of Standards and Technology (NIST)
    - Does LCA for single materials only (not assemblies)
    - Current version includes actual environmental and economic performance data for 230 building products
    - Can be downloaded for free from: http://www.bfrl.nist.gov/oae/software/bees/

Life Cycle Assessment (LCA)

- **LCA Software**
  - Athena *Impact Estimator* for Buildings
    - Only software tool in North America that evaluates whole buildings and assemblies
    - Started in Canada with public funding
    - Being integrated into rating systems by Green Globes and LEED rating systems
    - Demo version can be downloaded at no cost from: http://www.athenasmi.ca/tools/impactEstimator/index.html
    - Athena EcoCalculator for Assemblies is a spreadsheet program that has LCA data for common building assemblies. It can be downloaded for free at: http://www.athenasmi.ca/tools/ecoCalculator/index.html

Life Cycle Assessment (LCA)



Gypsum Board System Boundaries

Life Cycle Assessment (LCA)

- Environmental Impacts (assessed with BEES)
  - Acidification
  - Criteria Air Pollutants
  - Ecological Toxicity
  - Eutrophication
  - Fossil Fuel Depletion
  - Global Warming
  - Habitat Alteration
  - Human Health
  - Indoor Air Quality
  - Ozone Depletion
  - Smog
  - Water Intake
- Embodied Energy
  - Amount of energy used to transform and transport raw materials into products
  - At a higher level, it includes the amount of energy used in building fabrication and demolition

Life Cycle Assessment (LCA)

- **Embodied Energy**
  - Often broken into categories of fuel vs. feedstock, and of renewable vs. nonrenewable
    - Feedstock energy: Energy content of fuel resource extracted from the earth that is used as a raw material (i.e., not burnt). Example: the energy content of natural gas is a feedstock energy when used as a raw material in the production of various plastic (polymer) resins
    - Fuel energy: Amount of energy released when fuel is burned
    - Non-renewable energy: Energy from fossil fuels (e.g. petroleum, natural gas, coal)
    - Renewable energy: All other energy (e.g. hydropower, wind, nuclear, geothermal, biomass)

Life Cycle Assessment (LCA)

- LCA will continue to improve as:
  - LCA databases for building materials are expanded
  - Mass and energy flows associated with the assembly of materials (construction), building operating, and demolition are better quantified for various systems

Life Cycle Assessment (LCA)

- Cost is always a red flag when it comes to environmental-friendliness
  - The more expensive an option, the more likely it is to have a higher embodied energy (and thus is probably less environmentally-friendly). That said, it is important to realize that virtually all renewable forms of energy cost more than non-renewable forms, thus the type of energy must be taken into account

Environmentally-Friendly Construction

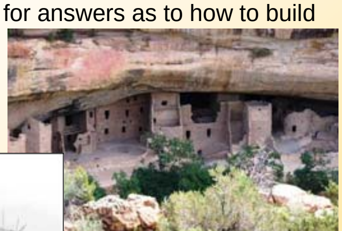
- Use Environmentally-Friendly Materials
- Minimize Total Material Usage
- Conserve Energy
- Provide for Healthy Living
- Design for Durability
- Design with Eventual Reuse in Mind

Environmentally-Friendly Construction

- Look to the past for answers as to how to build for the future

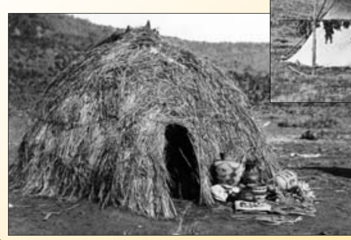

Environmentally-Friendly Construction

- Look to the past for answers as to how to build for the future




Environmentally-Friendly Construction

- Look to the past for answers as to how to build for the future

Environmentally-Friendly Construction

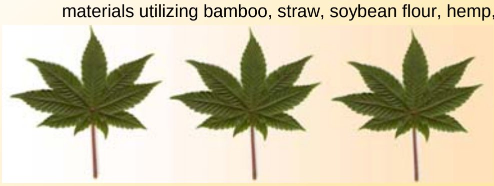
- Look to the past for answers as to how to build for the future


Environmentally-Friendly Materials

- Every building material in existence will claim it is a green building material for one reason or another
  - Even with good LCA information this in not surprising because of:
    1. The variety of different environmental impacts that exist and are tabulated (global warming, acidification, resource depletion, etc.)
    2. Individuals differ as to which environmental impacts are most critical
    3. Everything changes with time (e.g. as a resource becomes more scarce, protecting it becomes more critical)

Environmentally-Friendly Materials

- Considerations for choosing one material over another
  - Is it obtained from a renewable resource?
    - Wood is good (and thus post-frame is good). Some people favor *rapidly* renewable resources (i.e., those with a harvest rotation of 10 years or less). This may include materials utilizing bamboo, straw, soybean flour, hemp,



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Environmentally-Friendly Materials

- Considerations for choosing one material over another, cont.
  - What's its consumption of nonrenewable resources?
    - At some level, nonrenewable resources are used in the production of materials created from renewable resources (e.g. fossil fuels are burned in the conversion of trees to lumber). Is this expense of nonrenewable resources justified?
  - Is the material associated with measurable harmful emission and/or habitat destruction?
    - How does it stack up with other materials with respect to major environmental impact factors determined via an ***accurate*** LCA?

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Environmentally-Friendly Materials

- Considerations for choosing one material over another, cont.
  - Is a salvaged, remanufactured, or refurbished material available?
    - Common reused materials include bricks, millwork, framing lumber, plumbing fixtures, and period hardware
    - Salvage yourself, hire a deconstruction contractor or purchase from local or regional salvage yards
    - Make sure reused product will meet code (structural, energy, electrical, plumbing, etc.)
    - Evaluate salvaged products for contaminants (e.g., lead, asbestos, mold)
    - **Beware:** costs and embodied energy associated with removal, transportation, and preparation for reinstallation often make a comparable new material the better option

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Environmentally-Friendly Materials

- Considerations for choosing one material over another, cont.
  - Does the material have recycled content?
    - Making materials from items discarded by consumers (a.k.a., items with post-consumer recycled content) lessens the burden on landfills
      - Includes such materials as: plastic lumber, plastic-wood composite lumber, cellulose insulation, carpet, carpet backing, felts, ceiling tiles, rubber matting, steel framing, etc.
    - Weigh the pros and cons of a specific recycled product being considered
      - Is the proportion of recycled content significant in terms of the amount and type of resources used in the product as a whole?
      - Has the recycled content of the product been verified by an independent source?
      - Does this product create a market that encourages waste and inefficiency?

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Environmentally-Friendly Materials

- Considerations for choosing one material over another, cont.
  - Is the product produced locally?
    - Reducing overall transportation costs reduces embodied energy and many environmental impacts associated with harmful air emissions
    - Buying locally is generally good for the local economy
  - How much does the product cost?
    - Without LCA data, generally assume that the least cost product has the lowest embodied energy

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Environmentally-Friendly Materials

- Scientist continue to work on making materials more environmentally-friendly
  - Concrete takes a rap because of the high embodied energy of cement. New techniques for producing cements with power plant waste heat and gaseous emissions look promising

http://www.sciam.com/article.cfm?id=cement-from-carbon-dioxide

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Minimize Total Material Usage

1. Use a structurally efficient framing system
2. Use an efficient shape
3. Use products/systems that reduce material use
4. Use space efficiently

1/2 the materials = 1/2 the material environmental impact
1/2 the materials = 1/2 the total material cost

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Minimize Total Material Usage

1. Use a Structurally Efficient Framing System
   - The post-frame building system is often the most efficient system for:
     1. Buildings with numerous and/or relatively large wall openings
     2. Buildings without basements
     3. Buildings with tall exterior walls
     4. Bulk storage buildings
     5. Buildings with open walls
     6. Buildings requiring interior posts
     7. Buildings with large, clearspan wood trusses with on-center spacings 4 feet or greater

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Minimize Total Material Usage

1. Use a Structurally Efficient Framing System
   - The post-frame building system is often the most efficient system for:
     8. Buildings requiring a more open structural frame to accommodate non-structural “infill” panels/materials
     9. Stilt buildings
     10. Towers and buildings with towers
     11. Buildings with post-supported porches, roof overhangs and arcades
     12. Buildings with bracket-supported overhangs

From: Bohnhoff, D.R. *Twelve Structural Applications Ideal for Post-Frame*, Frame Building News, June 2008

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Minimize Total Material Usage

1. Use a Structurally Efficient Framing System
   - Wood not used very efficiently in classical timber-frame buildings
     - Clearspan capabilities low relative to amount of timber used
     - Connections??


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Minimize Total Material Usage

1. Use a Structurally Efficient Framing System
   - How green is a structure built with full logs?
     - Tremendous amount of wood but functions as exterior and interior wall finish and insulation
     - Historically very low embodied energy as logs harvested, debarked and shaped on site all with manual labor (seldom does this apply today)

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Minimize Total Material Usage

2. Use an efficient shape
   - Use dimensions that reduce cut-off waste
   - Use building shapes that minimize total exterior wall length relative to floor area (in addition to saving materials, this also lowers HVAC costs)
   - Adding jags in walls drives up building costs
     - jags = more total wall = more material + more labor
     - jags = more total wall = more area for heat loss
     - jags = short walls = more cut-off waste

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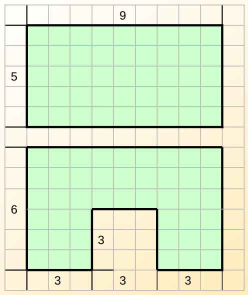
Minimize Total Material Usage

2. Use an efficient shape



Floor Area = 45 sq units
Wall Length = 28 units
Floor Area/Wall Length = 1.61 units

Floor Area = 45 sq units
Wall Length = 36 units
Floor Area/Wall Length = 1.25 units

Minimize Total Material Usage

2. Use an efficient shape
- ❖ Complex wall shapes give rise to complex roof shapes
  - ❖ Complex roof geometries = more material + more labor
  - ❖ Complex roof geometries = greater probability of roof failure (i.e., roof leaks)

Minimize Total Material Usage

- ❖ **A Roofers Dream or Nightmare?**

A house with 20 different roof planes

Minimize Total Material Usage

- ❖ Why these odd shapes?

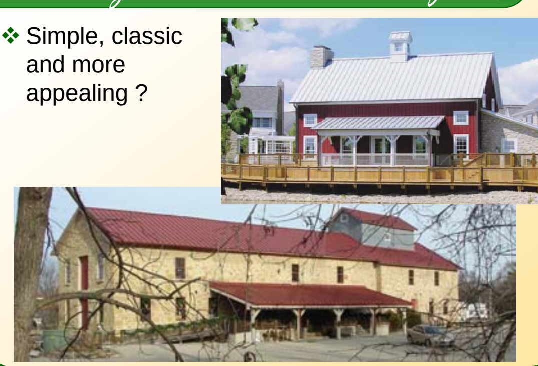
Two post-frame buildings

Minimize Total Material Usage

- ❖ Simple, classic and more appealing ?

Minimize Total Material Usage

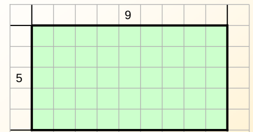
- ❖ Simple, classic and more appealing ?



Minimize Total Material Usage

Minimize Total Material Usage

2. Use an efficient shape



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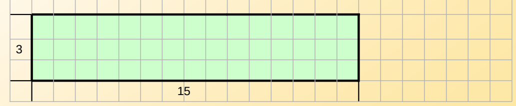
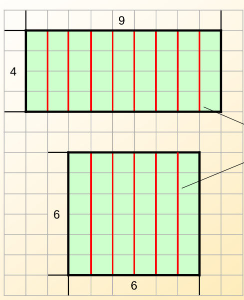


Minimize Total Material Usage

2. Use an efficient shape



Floor Area = 36 sq units
Wall Length = 26 units
Floor Area/Wall Length = 1.385 units

Red lines represent main floor and roof framing members

Floor Area = 36 sq units
Wall Length = 24 units
Floor Area/Wall Length = 1.5 units

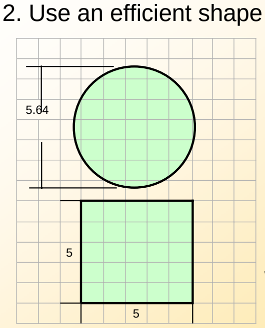
Minimize Total Material Usage

2. Use an efficient shape

- The more square the shape, the more floor area per unit length of wall, however:
  - Additional support or larger members may be needed for roof and floor framing members
  - Harder to get natural lighting into center of room

Minimize Total Material Usage

2. Use an efficient shape



Floor Area = 25 sq units
Wall Length = 17.72 units
Floor Area/Wall Length = 1.41 units

Floor Area = 25 sq units
Wall Length = 20 units
Floor Area/Wall Length = 1.25 units

Minimize Total Material Usage

2. Use an efficient shape

- Round is more efficient than square
  - Rounds are generally difficult to frame, thus hexagons, octagons, etc. more common than rounds
  - Use a more square/circular shape when walls are expensive to construct

Minimize Total Material Usage

Virtually all cordwood homes are near round which (for a given floor area) reduces fabrication and maintenance costs associated with exterior walls

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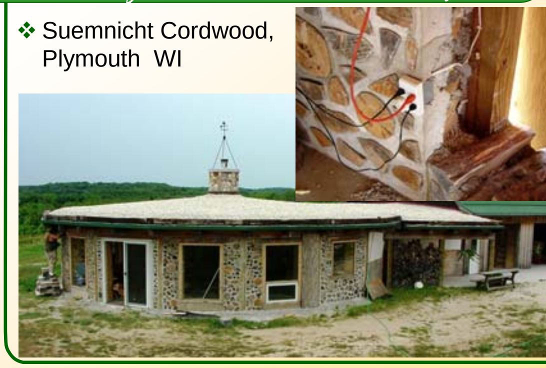
Minimize Total Material Usage

- Suemnicht Cordwood, Plymouth WI



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Minimize Total Material Usage

2. Use an efficient shape
   - THE GOOD: The majority of post-frame buildings are constructed with a very **sustainable** shape (i.e. they have rectangular floor plan)
   - THE BAD: In general, post-frame building designers have an extremely poor knowledge of classical architecture
     - Training in this area would go a long way toward the development of simple, ***attractive***, functional, low-cost, environmentally-friendly structures

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Minimize Total Material Usage

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Minimize Total Material Usage

2. Use an efficient shape
   - All architects/building designers need to work harder to develop designs for rectangular plan views – designs that turn the rectangular layout into efficient, functional, well-connected interior spaces

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Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - **Use post/pier or slab-on-grade foundation systems in-place of continuous frost walls**

(ITS HARD TO BEAT POST FRAME HERE)

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Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - ❖ Give concrete slab a special finish (color, stamping) instead of covering it with another flooring system

Minimize Total Material Usage

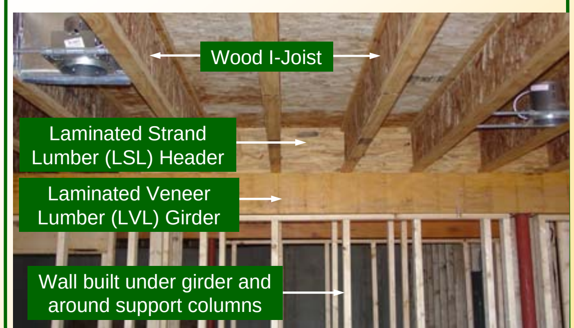
3. Use products/systems/construction methods that reduce material use
   - ❖ **NOTE!! More and more residential builders are going to stamped concrete floors with in-floor radiant heating**
     - ❖ **They are warm, durable, low maintenance, and have good thermal mass (important for passive heating)**
     - ❖ **Post-frame buildings and concrete floors are a match made in heaven. Elaborate concrete floors can be installed in a protected environment (no wind, rain, snow, cold, heat, bright drying sun, etc.)**

Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - ❖ Replace interior columns with load bearing walls

This portion of a new single-family home basement contains thirteen steel columns. Wings off to the left and right contain additional columns

Minimize Total Material Usage



Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - ❖ Replace interior columns with load bearing walls, cont.
     - ❖ Cost of lumber to frame a continuous wall almost always less than the row of steel columns it replaces
     - ❖ Girder cost per foot generally exceeds total material cost per foot to frame, cover with wallboard, and paint both sides of an interior wall
     - ❖ Girders and steel columns negate many plumbing, mechanical, and electrical installation options

Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - ❖ Replace interior columns with load bearing walls, cont.
     - ❖ Column footings must be replaced with continuous footings
     - ❖ Short "stub" wall can be placed on the footing and wall installed on this stub wall before basement slab is placed
     - ❖ Stub can be fabricated to hold interior-framed wall above finished basement floor, leaving framed wall less susceptible to water damage should minor flooding occur

Minimize Total Material Usage

Short "stub" wall on top of continuous footing will support interior basement wall

Minimize Total Material Usage

3. Use products/systems/construction methods that reduce material use
   - ❖ Utilize cut-offs to the greatest extent possible
     - ❖ Always look to utilize the smallest cut-offs first
     - ❖ Keep cut-offs organized on site
   - ❖ Make stair stringers from engineered lumber to reduce use of wide dimension lumber
   - ❖ Clad only one side of partition walls that do not contain electrical, plumbing or mechanical runs (generally clad one side with T&G boards)

Minimize Total Material Usage

4. Use space efficiently
   - ❖ Build smaller by utilizing space more efficiently.
     - ❖ In addition to saving materials, this lowers HVAC costs
     - ❖ Put the money you save on materials into craftsmanship that will increase the value of what you build (i.e., that will turn your project into an attractive work of art) without increasing environmental impact and embodied energy
     - ❖ A smaller building means lower initial costs which means lowers real estate taxes and insurances
   - ❖ Do not use conditioned space for seasonal storage of materials
     - ❖ Increase the size of an unheated garage or **post-frame** outbuilding and store your stuff there

Conserve Energy

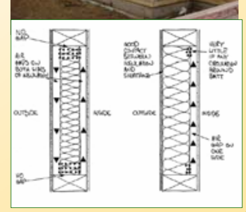
- ❖ Each new building constructed increases our country's dependency on foreign oil
  - ❖ Every cost effective measure should be taken to reduce the amount of energy consumed during building operation
- ❖ The most cost effective way to reduce energy consumption is to lower space heating and cooling loads via proper construction of the exterior thermal envelope

Conserve Energy

- ❖ Minimize Windows
  - ❖ No if, ands, or buts about it, virtually all heat loss in well-insulated and sealed facilities is via the windows
  - ❖ Ideally, any windows that exist in a structure should be part of a well planned passive solar system

Conserve Energy

- ❖ Air cannot be allowed to bypass, move through, or circulate in insulation
  - ❖ Air barriers, caulk, tape are all used to limit air movement around and through insulation but will not stop air from circulating in insulation
  - ❖ Air can circulate in porous insulations via thermal buoyancy
    - ❖ Foam-in-place insulations by far the best option

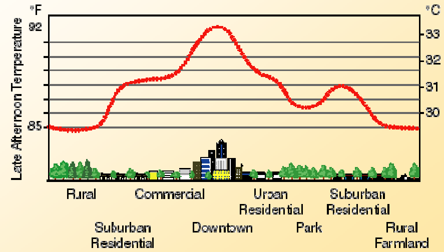


Conserve Energy

- Install thermal insulation at levels that exceed energy code minimums
- Use energy saving lighting and appliances
- Minimize hot water use
- Use energy sources that utilize less total energy (e.g., geothermal)

Conserve Energy

- In urban areas, use vegetated roofing systems or roofing materials that reduce heat island effects



Provide for Healthy Living

- **Install an air-to-air heat exchanger**
  - This is a no-brainer in any climate with a high heating and/or cooling load during a portion of the year
    - Removes dangerous emissions, humidity, odors while simultaneously recovering energy
  - IRC minimum continuous ventilation rate are 25 cfm for kitchens and 20 cfm for bathrooms. Generally most homes should be at a minimum 100 cfm continuous.
  - IMC minimum continuous ventilation rates are 15 cfm/person for most occupancies, 75 cfm per water closet and urinal (see IMC Table 403.3)

Provide for Healthy Living

- **Install an air-to-air heat exchanger**
  - At $0.10 kW-h and 100 cfm, a typical air-to-air exchanger saves about $0.70/day for each 10 F difference in indoor and outdoor temperatures ($3.50/day for 50F difference)
  - In residences without air-to-air heat exchangers, the amount and uniformity of air exchange are generally both very poor
    - Air exchange only occurs when a bathroom fan, kitchen exhaust fan, or dryer are operating or a door/window is opened
      - To save energy, some individuals limit use of bathroom exhaust fans during cold weather, which is generally the time when people are spending more time indoors and good air quality is most important

Provide for Healthy Living

- Limit potential for mold/mildew growth by ensuring that building materials stay dry, and can dry should they get wet
  - Well insulated and airtight envelopes have a difficult time drying if they get wet since heat transfer through envelope is minimal and considerable energy is required to evaporate water

Change temperature of 1.0 lbm liquid water 1F	= 1.0 Btu
Change temperature of 1.0 lbm water vapor 1F	= 0.5 Btu
Change temperature of 1.0 lbm ice 1F	= 0.5 Btu
Vaporize/Condense 1.0 lbm water at 50F	= 1065 Btu
Freeze/Thaw 1.0 lbm water at 32F	= 143 Btu

Provide for Healthy Living

- Limit potential for mold/mildew growth, cont.
  - Above-grade in cold climates, the vapor retarder is placed inside the insulation and thus the thermal envelope must be designed to dry to the outside should it get wet
  - Regardless of climate, do not install a vapor retarder on the inside of a basement wall or floor since walls and floors below grade can only dry to the inside
- Use throw rugs instead of carpets as carpets are very difficult to clean/sanitize and thus are a haven for many ugly things

Design for Durability

- Durability could fall under the category of "minimize material usage" because we build durable to avoid prematurely replacing material
  - When you have to replace a component, you effectively double the embodied energy and environmental impact of construction as far as that component is concerned
- With the move to environmentally-friendly construction, a greater emphasis is being placed on durability (although it still suffers badly in some circles)

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Design for Durability

- Use materials with a long service life – materials that are not readily destroyed by solar radiation, decay fungi, freezing and thawing, large temperature swings, etc.
  - Examples of long service life materials include fiber-cement siding, fiberglass windows, slate shingles, masonry veneers, highly-corrosion resistant metal alloys
  - Long service life materials tend to be more costly
- Do not use untreated lumber in applications where it can not rapidly dry should it get wet

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Design for Durability

- Extend life by protecting building components from adverse conditions to the greatest extent possible
  - Use adequately sized overhangs to protect siding, windows and doors
  - Control condensation/excess humidity that results in mold growth and decay and hence premature component failure
  - Keep trees and shrubs from close contact with building exteriors where such vegetation will hinder exterior from properly drying after rains

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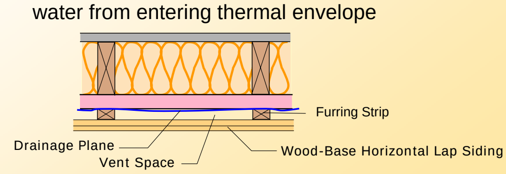
Design for Durability

- Vent the backside of all exterior surfaces (roof and wall)
  - Essential for materials that absorb water such as brick veneers; stuccos; wood siding, shingles and trim; and fiber cement cladding
  - Back the air space with a drainage plane to keep water from entering thermal envelope



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Design for Durability

- Vent the backside of all exterior surface (roof and wall), cont.
  - Temperature and relative humidity in the vented space should be near identical to outdoor conditions
  - Screen vents to keep out insects/rodents
  - Vents reduce exterior surface temperatures during sunny days, and this almost always prolongs material life
    - Exterior surfaces need all the help they can get. They are the barriers that block precipitation and radiation and they must be strong enough to withstand wind and other externally applied forces

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Design with Eventual Reuse in Mind

- Use materials that can be recycled/reused
  - Examples of recoverable materials: virtually all framing components, masonry brick and block, ceramic tile, marble and granite, quality hardware, slate or tile shingles
  - Be cautious about using preservative-treated lumber as what is sold today may be ban tomorrow

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Design with Eventual Reuse in Mind

- Design systems so that materials can be easily salvaged for recycling/reuse
  - Use mechanical fasteners instead of glue adhesives
  - **Use screw fasteners instead of nails**
  - Use ceiling tile in-place of drywall (good thing to do in basement area for accessibility)
  - **Use wood post and precast concrete pier foundations instead of other foundation systems that can not be easily removed and reused**

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Design with Eventual Reuse in Mind

- Green Frame
  - Is an environmentally-friendly post-frame building system currently under development at UW-Madison
  - Why? Because functional life of agricultural post-frame buildings is relatively short, so current buildings should be designed for reuse/reconfiguration
  - Green-Frame Features:
    - Standard, deep-end notched purlins and girts
    - I-Posts
    - Precast concrete piers
    - No nails used in on-site assembly

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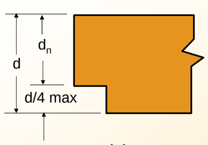
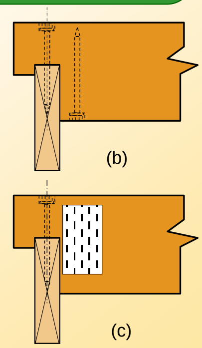
Design with Eventual Reuse in Mind



(a)



(b)

(c)

(a) Maximum code allowed unreinforced depth for an end notch,
(b) Deep-end notch member, screw reinforced and screw attached to support,
(c) Deep-end notch member, MPC reinforced and screw attached to support.

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Design with Eventual Reuse in Mind

- Advantages of Deep-Notched Purlins and Girts
  - Faster installation
  - More accurate construction
  - Better transfer of chord forces relative to hangers
  - Facilitates on-ground assembly of a roof bay
  - Deeper notches = less roll for top-running purlin
  - Deeper notch = shorter (less expensive) fastener
  - Standardization of post-frame building components means mass production (could be done by same companies that mass produce columns or trusses)

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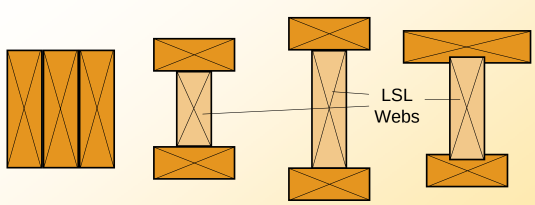
Design with Eventual Reuse in Mind



(a) (b) (c) (d)

Post configurations (a) vertical lamination of three identical-sized members, (b) I-post of three identical-sized members, (c) I-post with flanges and webs that differ in size, (d) I-post in which all three members vary in size and flanges are notched to accept web

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Design with Eventual Reuse in Mind

- Advantages of I-Posts
  - Uses lumber more efficiently, and thus has better bending strength in both weak and strong axis direction than the same 3 members vertically, mechanically-laminated
  - Better thermal properties
    - Less wood (and more insulation) bridging the inside to the outside of the building
    - No path for air to travel directly into building between post plies
  - More options for inexpensive attachment of "bookshelf" girts

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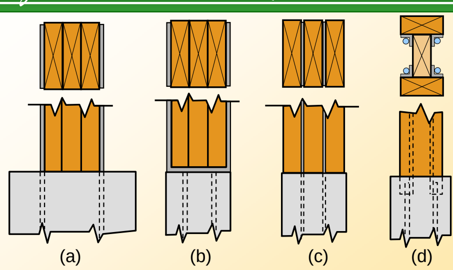
Design with Eventual Reuse in Mind



Top and front views of pier-to-post connections; (a) Outer plates extend into a cast-in-place pier, (b) U-bracket welded to rebars embedded in precast pier, (c) Plates between wood plies extend into precast pier, (d) Angles welded to rebars embedded in precast pier

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Design with Eventual Reuse in Mind

- Advantages of I-Post-to-Pier Connection
  - Load transferred directly from wood flanges into concrete piers
  - Thermal bridging reduced as angles fastened to the outside wood flange do not touch angles fastened to the inside wood flange
  - Metal fabrication very simple
  - Self-drilling fasteners can be used to attach wood to steel (no predrilling of metal required)
  - Easy to size angles and fasteners to meet bending capacity needs

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Design with Eventual Reuse in Mind

- Status of Green Frame Research
  - Notched member testing on-going. Plan to draft ASABE standard on notched members in 2009
  - Materials for I-post tests ascertained and conditioned. Begin assembly and test late this spring
  - Post-to-pier connection tests to follow I-post tests
  - Experimental building in 2010?

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Environmentally-Friendly Construction

- Two final points
  - Leave the country to the farmers
    - Some of the worst hypocrites are people who triumph the environmentally friendly building they just erected in a previously undeveloped area of the country
  - Live by the golden rule
    - Conserve resources so they can be enjoyed by future generations just as you have enjoyed them during your stay on this earth

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