



# **Green Building**

## **Workshop**

**March 28<sup>th</sup>**

**Town Hall**

**Marie Jones**

# Topics

## 1. Green Building Overview

- What makes a material or technique green?
- Environmental and health impacts of conventional building
- Market trends

## 2. Green Building Standards

- USGBC's LEED program
- Build It Green Program

## 3. Green Practices & Technologies

- Design
- Site selection & landscaping
- Construction
  - Foundation
  - Frame
  - Interior Finishes
  - Exterior Finishes
  - Waste Management

## • Water

- Plumbing, Electrical & Appliances
- Irrigation

## • Energy

- Appliances & Lighting
- Insulation & Windows
- Heating and Cooling

## • Indoor Air Quality

- Finishes
- Mold
- Household Cleaners

## 4. Natural Building Techniques

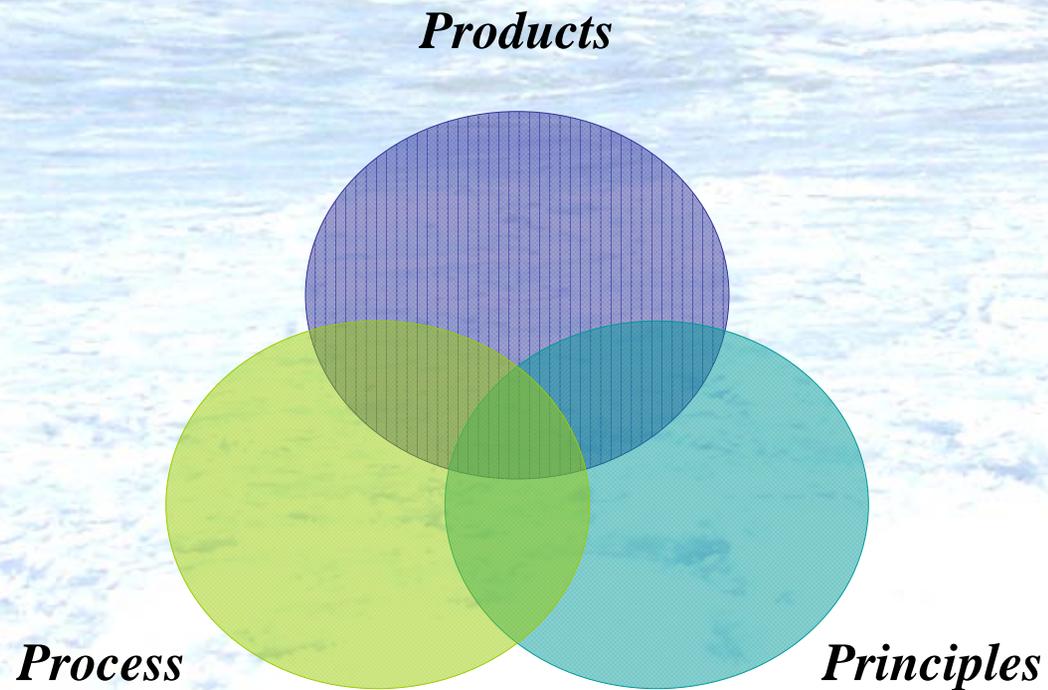
- Straw Bale
- Rammed Earth
- Earth Bag

# I. What is Green Building?

Design & construction practices that reduce the negative impacts of buildings on the [environment](#) and [occupants](#)

- **Site** - urban infill, erosion control, storm water management, parking, transit access, etc.
- **Water** - low flow faucets & toilets, waterless urinals, drip irrigation, native landscaping, rainwater capture & reuse, grey water systems....the lawn!
- **Energy** – whole building design, passive solar, insulation, lighting, windows, effective operation, tree plantings, appliances, etc.
- **Materials and Resources** - engineered wood, FSC certified wood, blown cellulose insulation, bamboo flooring, fiber cement siding, smart framing, linoleum.
- **Indoor Environmental Quality** - source control (carpets, paints), ventilation, filtration, day-lighting, etc.

# What is Green Building?



# Green Products & Process

- **Use recycled content:** post-consumer content, post-industrial content, agricultural waste, salvaged material
- **Conserve natural resources:** products that reduce materials waste, exceptional durability, low maintenance, sustainably harvested, rapidly renewable resource.
- **Avoid toxic emissions:** alternatives to “bad” products (such as CCA treated wood, vinyl, ozone depleting HCFC, PVCs) products that reduce pesticide treatments, products that reduce/eliminate waste/pollution from operations, products that are manufactured in a sustainable manner.
- **Reduce environmental impacts during construction, demolition, renovation:** erosion-control products, building to lumber dimension lengths.
- **Save energy or water:** energy modeling, SIPs, ICFs, high performance windows, energy efficient appliances & equipment, PV.
- **Improve indoor environmental quality:** day lighting, solar access, views, reduce indoor contaminants removing contaminants, monitoring indoor pollutants

# Green Design Principle

- An integrated, whole building design approach
  - Design, construction techniques, materials choices and systems selection.
- Based on overall green design objective for project
  - Energy & Water Efficiency
  - Indoor Environmental Quality
  - Environmental Footprint
  - Demonstration & Education
- Big impact on the overall cost, savings, and green benefits of the project

# Why Green Building? Big Environmental Impacts

## Buildings Use Resources

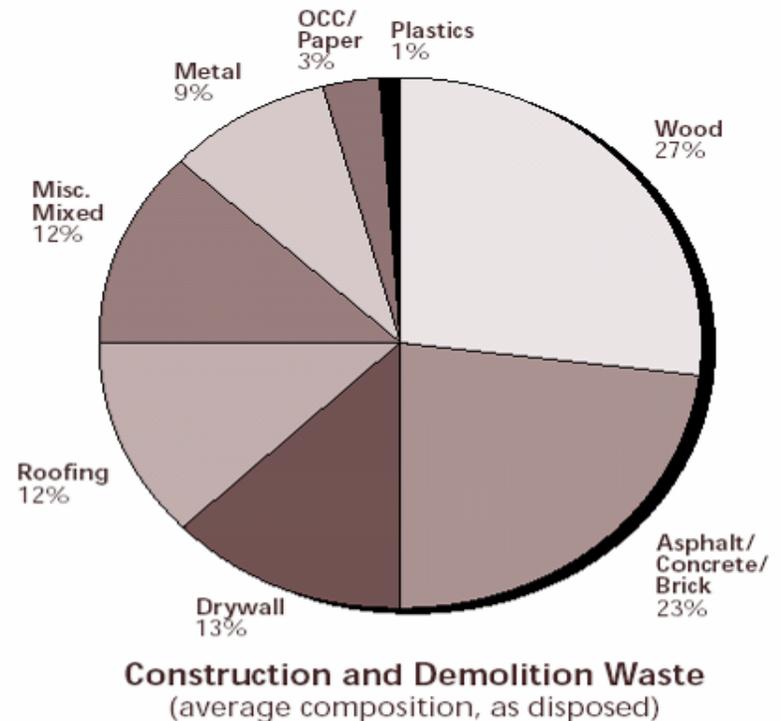
- Use 65.2% of U.S. electricity consumed
- U.S. Buildings consume twice as much energy as all our cars and emit twice the amount of carbon dioxide (calculation includes total embodied and operating cost energy)
- Use 12% of potable water
- Use 40% (3 billion tons annually) of raw materials
- Use 25% of wood resources
- Consume 2 million acres of forests and farmland each year.



# Why Green Building? Big Environmental Impacts

## Buildings Generate Waste

- Construction & demolition debris make up 25% of municipal waste, 136 million tons/year.
- 30 tons of waste to construct a 20,000 sq ft office building
- 20 tons/ major home home remodel = 60 years of curbside recycling
- 30% of total U.S. greenhouse gas emissions



# Green Building Saves Money, Improves Productivity

**Cost:** Initial design and construction costs typically **1 to 5%** higher

## Benefits

- Projects “pay for themselves” 3-5 years
- A 2% initial investment results in a 20% reduction in operations and maintenance costs
- Improve productivity
  - Increase sales & productivity 40% improvement for retail sales, 2-16% for office worker
  - Reduce absenteeism and turnover
- Reduce liability & improve risk management
  - Fewer sick buildings, disposal of hazardous materials, etc.

**Table 1: Cost Data for 33 LEED Projects<sup>6</sup>**

Level of LEED Rating	Average Cost Premium
Certified	0.66%
Silver	2.11
Gold	1.82
Platinum	6.50
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Average of 33 LEED Buildings	1.84%

Average Savings of Green Buildings

ENERGY SAVINGS  
30%

CARBON SAVINGS  
35%

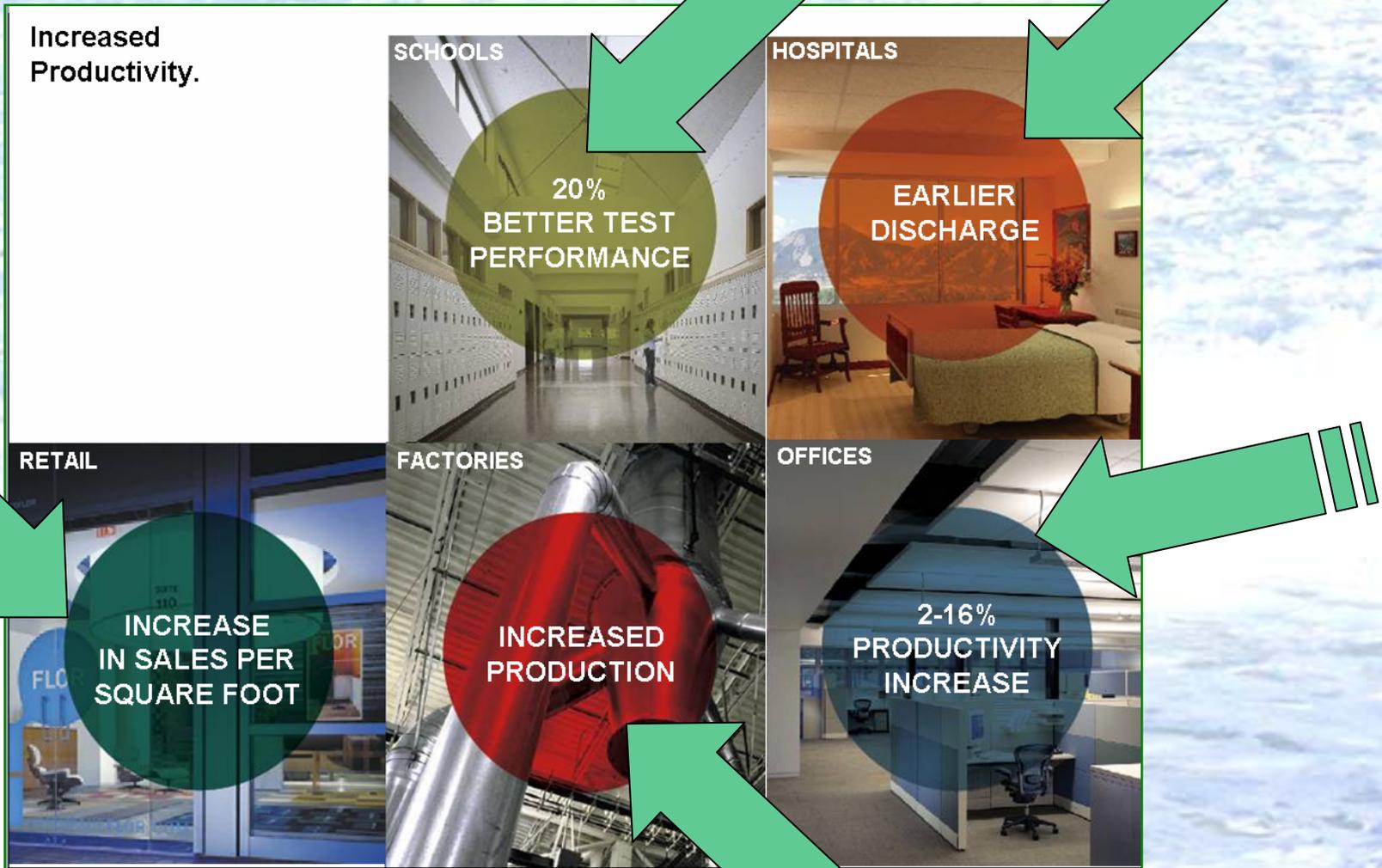
WATER USE SAVINGS  
30-50%

WASTE COST SAVINGS  
50-90%



Source:  
Capital E

# Enhanced Productivity



Source: U.S. Green Building Council



# Key Points to Minimize Costs and Maximize Benefits

- Green building goals should be established early in the project
- Set clear, desired outcomes
- Use an integrated, whole-building approach to design
  - Site planning, design, construction, operation and maintenance
- Involve the whole project team
  - From preliminary to final stages
  - Collaborative process – allows synergies among design elements
  - Owner, architect, landscape architect, civil/structural/mechanical engineers, interior designer, contractor

# Market Transformation

## Residential Market

- **30%** jump in two years in home builders focused on environmentally responsible construction.
- **50%** of all builders will produce at least some homes using green methods by 2010.
- **10%** of new homes will be green by 2010 (2% in 2006)
- By 2010, **\$38 billion** a year market (up from \$7 billion in 2006).

Source: McGraw Hill Construction & National Association of Home Builders (NAHB)

## Commercial Market

- Today, 500 buildings are USGBC's LEED certified or higher
- 4,000+ buildings under construction *will* qualify soon.

## Regulatory Requirement

- 11 federal agencies, 17 states and 53 municipalities require buildings to meet either local green standards or those set by the U.S. Green Building Council

# Market Concern = Cost

- Perception of green building as more costly
  - Some owners/developers not convinced that first costs are competitive, even if they understand the savings in the operating costs
- Perceived as new, uncertain, unproven = financial risk
- Lack full understanding of the benefits

*Source: Environmental Design & Construction,  
“Green Building: What We Have Learned About  
Costs, Savings and Value”, November 1, 2006*



# Green Building Market

Most desired overall home features include:

63% want lower operating and maintenance

50% are motivated by environmental concerns and their family's health.

- 85% of new green home buyers are more satisfied with their green homes than their previous, traditionally built homes.
- 40% of homeowners who have recently completed home remodeling/renovation work used green products or materials
- The typical green homeowner is affluent, well educated, in the mid- forties, married, and from a Western state.

## **II. Green Building Standards**

- USGBC LEED Standards
- Built It Green's GreenPoint Rated



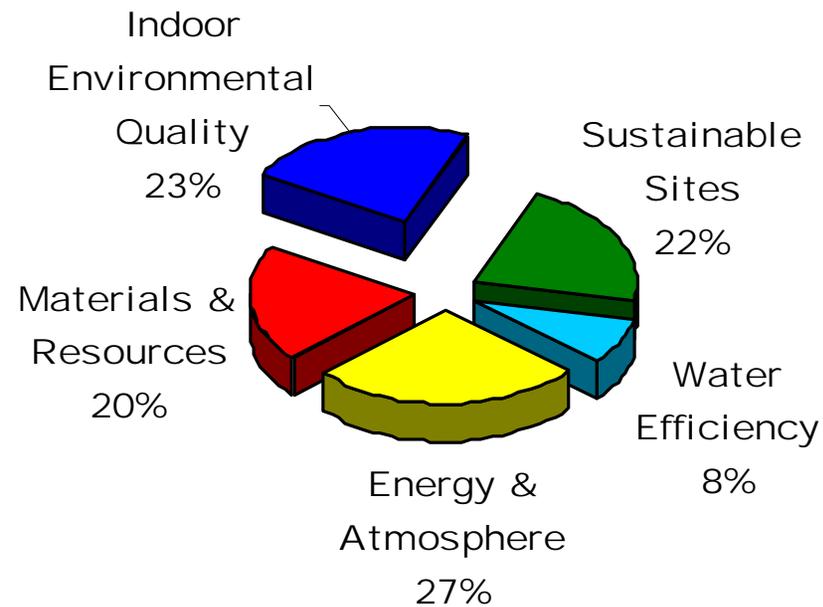
**Leadership in Energy and Environmental Design (LEED)** is a program of the US Green Building Council a national nonprofit based in Washington, DC.

- The LEED standard was developed by architects, builders, contractors, manufacturers, environmentalists, building owners. Pilot tested, revised, now on version 2.2
- LEED is:
  - Comprehensive and performance-based, not proscriptive
  - Credits are earned for satisfying performance-based criteria in five categories:
    1. Site
    2. Water Efficiency
    3. Energy Efficiency
    4. Materials, Resources
    5. Indoor Environmental Quality
  - Different levels of green building certification are awarded based on the total credits earned: certified, silver, gold & platinum

# Technical Overview of LEED

- **LEED-NC:** LEED for NEW Construction: commercial, institutional, and high-rise residential
- **LEED-EB:** LEED for Existing Buildings
- **LEED-CI:** LEED for Commercial Interiors
- **LEED-CS:** LEED for Core and Shell
- **LEED-H:** LEED for Homes (forthcoming)
  - Existing, proven technologies
  - Flexible, performance-based
  - Whole-building approach
  - Optimizes environmental and economic factors
- Four levels of certification
  - LEED Certified      26 - 32 points
  - LEED Silver        33 - 38 points
  - LEED Gold         39 - 51 points
  - LEED Platinum    52+ points (69 possible)
- Certification is performance-based and largely self-audited

# LEED™ Point Distribution



Five LEED credit categories

# Residential Standards

- National Standards
  - ENERGY STAR for Homes
  - U.S. Green Building Council's LEED for Homes Program
  - National Association of Home Builders' guidelines
- California Standards
  - Built It Green: GreenPoint Rated
  - California Green Builder (a program developed by the building industry for production builders).

# GreenPoint Rated Made in-and for-California



Built It Green: professional non-profit membership organization, technical expertise, database of green building products, education, certification, and referrals for building professionals.

## GreenPoint Rated

- Five Categories
  - Energy Efficiency
  - Resource Conservation
  - Indoor Air Quality
  - Water Conservation
  - Community
- Minimum points in each category
- At least 50 points = GreenPoint Rated label.

# Residential Green Building Programs

- **Voluntary Local Programs**

- Austin, TX
- Seattle, WA
- Portland, OR
- Alameda County, CA
- Santa Barbara County, CA
- Chula Vista, CA

- **Mandatory Local programs**

- Marine County
- San Francisco, CA
- Santa Cruz, CA
- Santa Monica, CA
- Cotati, CA
- Pasadena, CA
- Dublin, CA
- Emeryville, CA
- Novato, CA

- **State Programs**

- California
- New York
- North Carolina
- Pennsylvania
- New Jersey
- Vermont

- **Federal Programs**

- Building America Partner Program
- Energy Star Homes



# III. Green Building Practices & Materials

- Design & construction practices that benefit the environment & occupants
- Whole building approach
- Build for the long term
- Conserve natural resources, increase energy efficiency, & improve indoor air quality

# 1. Design

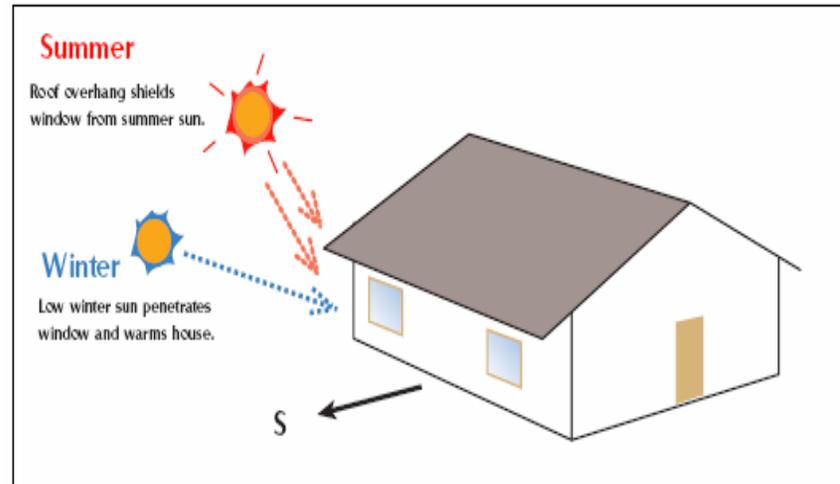
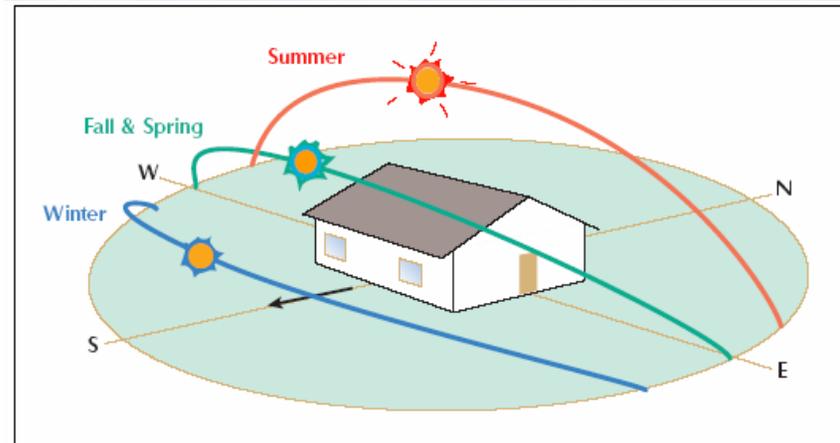
## Design Considerations

- Design for local conditions: earthquake, wind patterns, rainfall, humidity, high & low temperatures, pests (termites)
- Design for community: orient living rooms and porches to streets and public spaces, avoid snout garage/driveways
- Design for diverse family types, with attention to universal design
- Size: is a 3,500 or 7,000 sq. ft green house an oxymoron?
- Design to stock lengths
  - Design rooms so that sawn lumber and other products (drywall, OSB, Plywood, Carpet, tile) require minimal cutting and produce minimal waste.
  - Rooms that come in 16' 12' & 8' dimensions are better than rooms of 9', 11' and 15' dimensions.
  - Lower material and labor costs per square foot
- Integrated design: better window choices can allow for a smaller heating/cooling system

# Design For Local Environment

## Passive Solar

- Orient long edge of home on an east/west axis for solar gain during winter months
- Balance thermal mass
  - For solar glazing of less than 7% of total heated floor space, drywall and framing lumber will provide enough thermal mass.
  - When glazing is between 7 to 12% of sq ft, additional mass is required. Tile, bricks, and concrete should be evenly distributed throughout a house. The more mass in direct contact with sunlight the better.
  - Don't over glaze, don't oversize heating and cooling systems

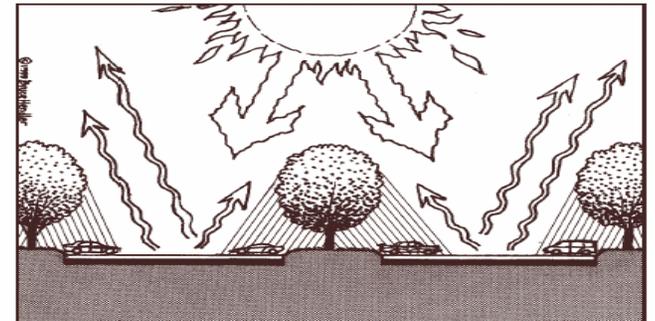


*Notice how the overhang of this house will shade the windows on the south side in summer, but not in winter, when the sun's heat is needed.*

# 2. Site Selection

## Urban Design & Site Selection

- Urban Infill
  - Higher density, minimize parking
- Livable Communities
  - Develop mixed-use, residential/commercial, walkable communities
  - Provide for “granny flats” above garages
  - Minimize street widths
- Do not build on
  - prime farmland
  - within 100 year flood
  - on habitat of threatened or endangered species
  - within 100 feet of a wetlands
  - on former public park land.
- Site Practices
  - Erosion & Sedimentation Control
  - Increase on-site infiltration of storm water runoff
- Heat Island Management
  - Non-roof: shade, light-colored, open grid pavement, underground parking, open grid paving system for parking
  - High emissivity roofing
- Light pollution reduction



Mitigation of Urban Heat Island Effect  
Illustration: Bruce Hendler



# Site Landscaping

## Reduce water use

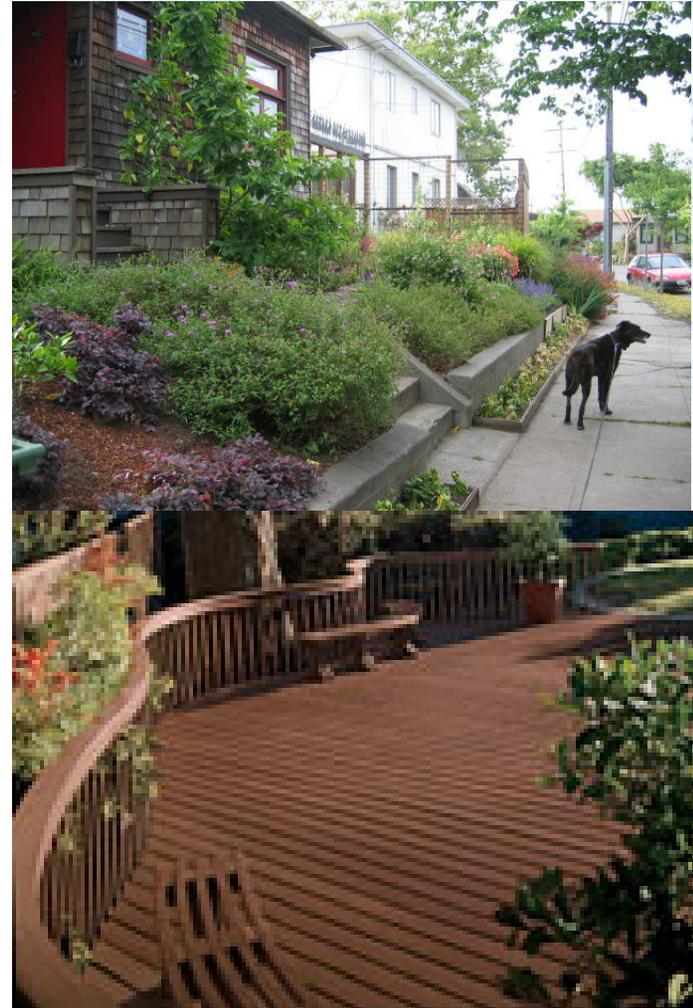
- Use native, low-water use, bio-diverse, non-allergy landscaping
- Install drip irrigation, mulch plant beds
- Consider using rain water cistern for irrigation.

## Reduce materials use

- Conserve & reuse site soil & mature trees
- Use recycled plastic content decking -- does not require staining or maintenance, long life span, no splinters, non-toxic

## Use non- chromium/arsenic treated wood for decking, fencing, sill plates

- Alkaline Copper Quaternary (ACQ) and Wolman Natural Select do not contain chromium – a heavy metal – and arsenic.



# Site Landscaping

## Stormwater Management

- Use permeable pavers/surfacing for sidewalks, patios and driveway.

## Manage heat/cold absorption

- Landscape with evergreen trees on north-facing walls
- Landscaping with deciduous trees on south-facing walls
- Use light color roofing



Permeable Pavers



*One large shade tree can provide cooling equal to a four-ton air conditioner.*

# Sustainable Site Materials

- **Pervious paver block systems:** allows stormwater to pass to the sub-base and infiltrate into underlying soils.
- **Pervious concrete mixes:** Concrete mixes that exclude fine particles, usually sand size and smaller. Small voids allow stormwater to pass through the pavement and infiltrate into the underlying soils.
- **Pervious asphalt mixes:** Asphalt mixes that exclude a percentage of the fine particles.



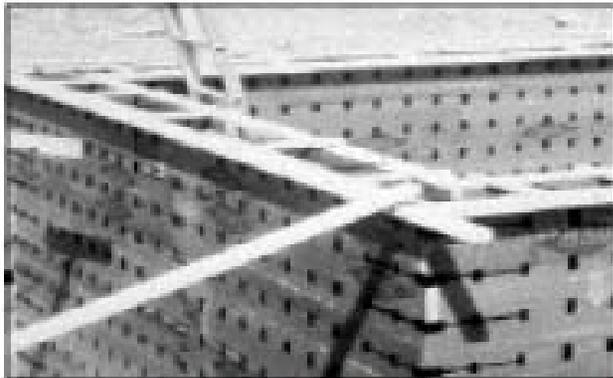
# 3. Foundation

Reuse form boards or use Aluminum forms

- Aluminum forms can be reused many times for a smoother finish

Use ICFs – rigid foam insulated concrete forms

- Rigid foam forming systems hold concrete in place during curing and provide long-term thermal insulation for concrete walls.



Insulated Concrete Forms (ICFs)

Use recycled aggregate and incorporate flyash into concrete. 15%-50% of cement can be replaced with flyash.

## Benefits

- Higher compressive strength over time
- More durable & less permeable
- Less shrinkage & creep
- Lower heat of hydration
- Better pump-ability
- Costs less
- Saves energy required for making cement and reduces the emission of global warming gasses.
- Usefully employs a waste product

## Drawbacks

- Slower rate of compressive strength gain
- It is one more product to control at the point of batching
- Consumer acceptability

# 4. Structural Frame



## Use engineered lumber

- Made of fast growing farm trees and only 50% wood fiber
- Typically stronger, straighter and lighter than sawn lumber
  - Floors & Ceiling: wood I-joists which can span longer distances
  - Substitute smaller dimension lumber for non-load bearing headers: a 4x6 can be replaced with two 2x6s
  - Use engineered studs for vertical applications
  - Use finger-jointed studs for non-structural applications
  - Use steel studs for non-insulated interior walls. Steel is 75%+ recycled content.



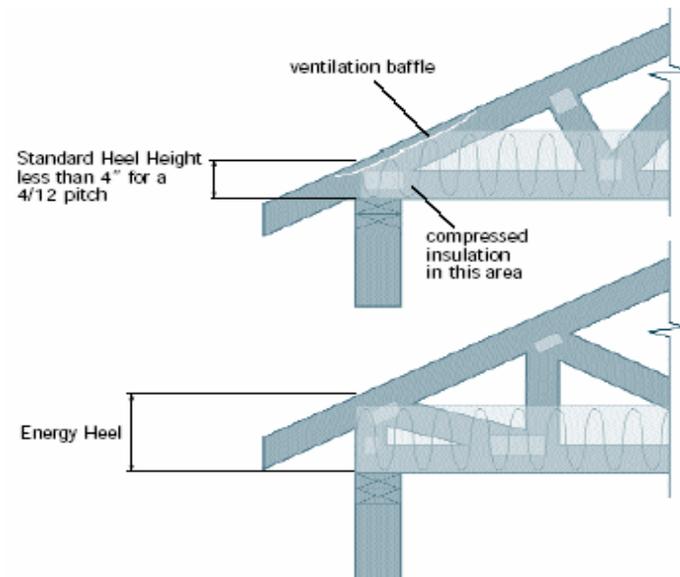
I-Joists use 50% less wood fiber than solid sawn lumber.

## Apply advanced framing techniques

- Replace 16" on center framing with 24" on-center. Reduces wood use and increase insulation value of walls

## Use energy heels on trusses

- Increase insulation in roof and reduces energy costs



# Structural Frame

- Subflooring and sheathing
  - Use zero-formaldehyde OSB as it does not require old growth trees
- Use Structural Insulated Panels (SIPs) for floors, walls and/or roof
  - Twice as strong as a 2x4 wall, SIPs offer R-values up to 25 in a standard 4½" wall thickness.
  - SIPs are rigid enough to span up to 8' in roof applications, saving the cost of additional support members, and allowing for more open, aesthetically pleasing spaces.
  - Labor saving
  - Stronger than traditional stud framing
  - Some insect and rodent boring concerns
- Recycled and/or recovered content gypsum wallboard
- Reclaimed lumber from old buildings reduces landfill deposits and is often of higher quality than new lumber.

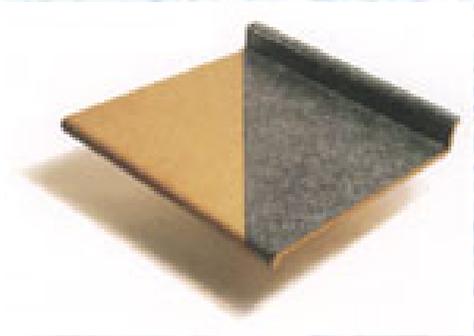


# 5. Interior & Exterior Finishes

## Sustainably Harvested Materials

Specify rapidly renewable building materials

- Floor coverings: bamboo, cork, linoleum flooring, wool carpet, recycled-content carpet, carpet tiles
- Cabinetry: straw board, sunflower seed board, wheat board



Use sustainably harvested wood

- Forest Stewardship Council certified, reclaimed wood flooring (e.g. from salvaged barns, etc.)

## Materials Reuse

Use salvaged, refurbished, reused materials

- Flooring, doors, windows, cabinetry, decorative architectural items

Use building materials with recycled content

- Carpet, metals, concrete, masonry, acoustic tile, carpet, ceramic tile, decking and insulation.



## Local Materials

Use locally manufactured materials to reduce transportation costs & environmental impacts

# Use Rapidly Renewable Resources



## Linoleum

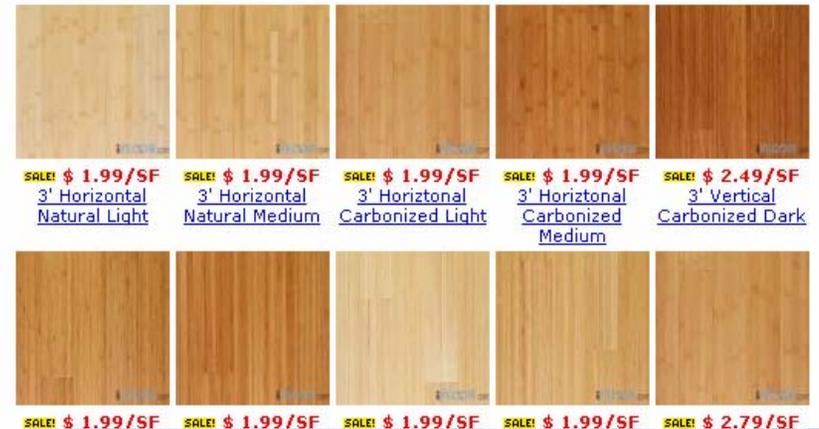
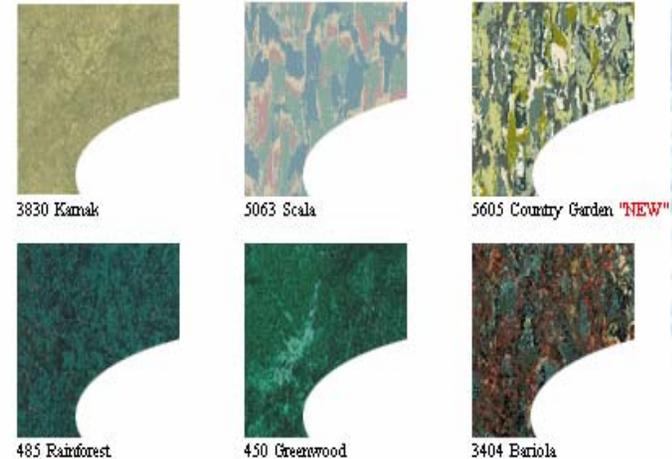
Has been around for 100 years

- Made from linseed oil, rosins, and wood flour, on a natural jute backing.
- Tough, visually striking, highly resistant to heavy rolling loads and foot traffic.
- Performance enhanced by time, as exposure to air hardens and increases durability.
- Low VOC
- Rapidly renewable resource

## Bamboo Flooring

30 year finish

- Rapidly renewable resource
- Low VOC
- Variety of colors



# Exterior Finish & Roofing

## Exterior Finishes

- Fiber-cement siding and trim (Hardiplank)
  - Looks, paints, and nails like wood
  - More durable, termite resistant, noncombustible
  - Requires carbide blade and dust protection
- Indigenous stone or locally produced brick – durable local materials
- Wood siding from 3<sup>rd</sup> party certified sustainably harvested sources
- Recycled or recovered-content siding



## Roofing

- Minimum 30 year roofing material:
  - clay: \$19/psf
  - standing seam metal \$14/psf
  - slate \$18/psf
  - cement tile \$10.50psf
  - (asphalt shingle = \$10/psf)
- Recycled-content roofing material
- Self-adhering roof under layment on eaves, valleys and roof penetrations



# 6. Waste Management

## Construction Waste Management

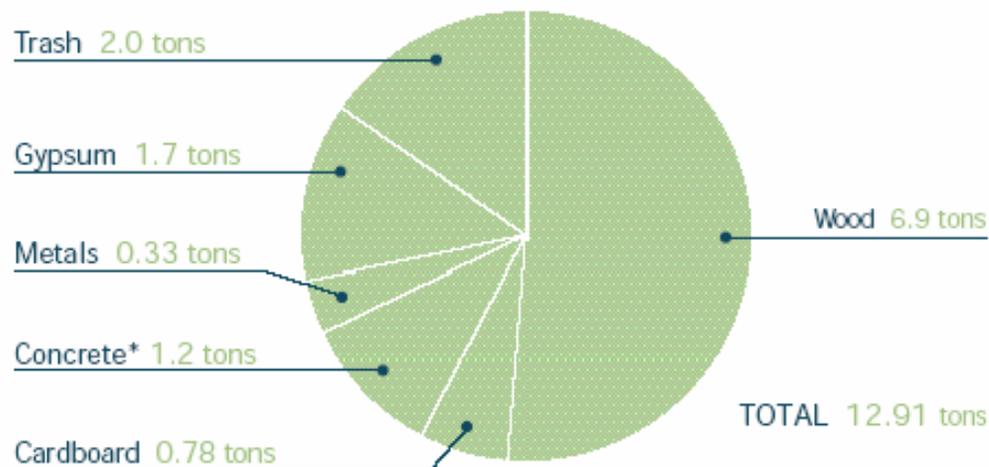
- City of Fort Bragg requires the diversion of 50% construction and demolition waste from landfill
- Payment of a refundable deposit (.35 to .50 cents/square foot) at the time you submit building permits.

## Encourage Recycling

- Built in kitchen recycling center for easy segregation of waste streams



Construction Waste Generated from a 2,000 Square Foot New Home



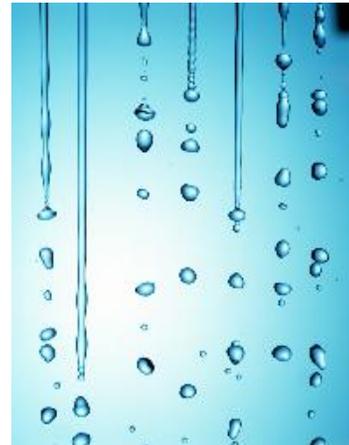
*A built-in kitchen recycling center is a feature of Neil Kelly Company's "Naturals Collection," a semi-custom cabinet line made with FSC-certified or recycled wood and environmentally friendly finishes and case materials. Photo courtesy of the Environmental Home Center.*



# 7. Water Efficiency

## THE PROBLEM

- Only 0.007% of all water on the earth is available for human consumption.
- California residences use 5.6 million acre-feet of water annually.
- Daily *indoor* water use/capita is 69.3 gallons, and 153 gallons/house. Overall use falls into the following categories:
  - **Toilets:** 26.7%
  - Baths: 1.7%
  - Showers: 16.8%
  - **Clothes Washer:** 21.7%
  - Dishwashers: 1.4%
  - **Faucets:** 15.7%
  - **Leaks:** 12.7%
  - Other Domestic Uses: 2.2%



# Water Conserving Technologies

## Specify/Install water conserving plumbing fixtures and fittings

- Flow reducers cut water use of faucets and showers by 40%
- Ultra low flush/dual flush toilets reduce water use by 30-50%
- Composting toilet
- Insulate hot-water pipes

## Specify/install water conservation appliances

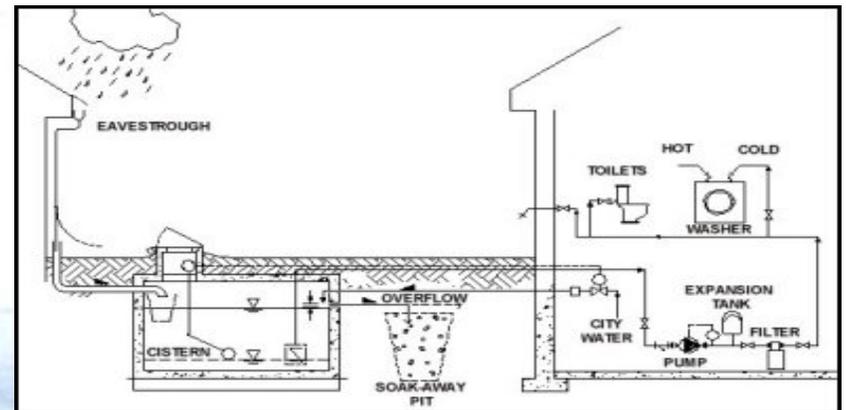
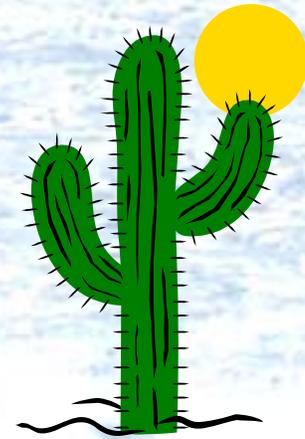
- High efficiency dishwashers save at least 25% over the federal minimum standards.
- Energy Star clothes washing machines use 45% less energy and 50% less water
- Tankless hot water heater saves 15% on heating costs, unlimited hot water, smaller footprint.
- Point of use hot water for fixtures further than 25 feet from hot water heater. Eliminates hot water line.



Fixture Type	[GPF]
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

# Water Conserving Technologies

- Reduce water use in landscaping
  - install drip irrigation, water moisture sensors, timers
  - Use native, low-water use, bio-diverse, non-allergy landscaping
- Don't use potable water for irrigation
  - Use captured rain water & Cistern system or don't irrigate



# 8. Energy Reduction

- Buildings use **70%** of U.S. electricity consumed
- U.S Buildings consume twice as much energy as all our cars and emit twice the amount of carbon dioxide
- According to DOE if current buildings were green-improved, they would use **\$20 billion less** in energy/year.
- Homeowners who complete a green remodel lower energy consumption by **30-50%**.
- In the typical U.S. home:
  - 44 % of every use for heating and cooling.
  - 14 % goes to water heating,
  - 9 % is used for refrigerators and freezers.
  - 33% is used for appliances, electronics, and lighting.

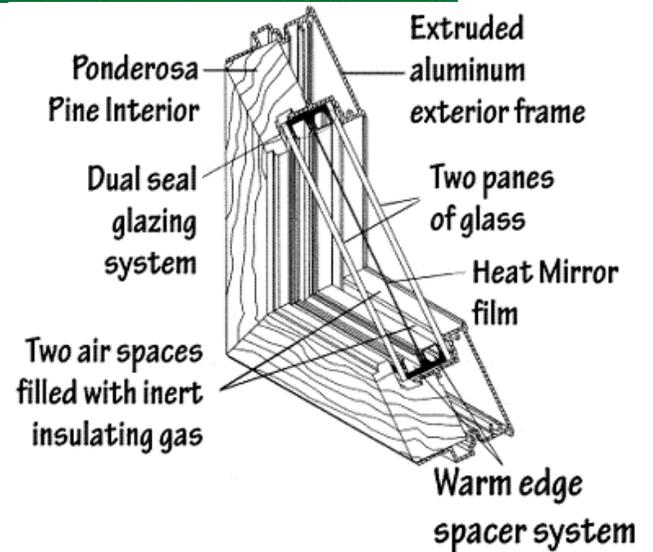


# Heating: 40%

- Design for Passive Solar (free energy!)
- Right-size your furnace (or wood stove)
  - most are oversized, which reduces efficiency and increases cost
  - Install furnace in central location and conditioned space.
  - Consider zoning with 2+ thermostats, programmable thermostats
  - All ductwork sized & installed in room-by-room load calculations, joints insulated and sealed with low toxic mastic
  - High efficiency furnace with sealed combustion air gets oxygen for combustion from outside the house instead of robbing it from the air you breathe.
- In-floor (radiant floor) heating system
  - Solar hot water with back-up gas powered instant hot water

# Heating: Insulation & Windows

- Advanced sealing and caulking to reduce drafts
- 2x6 wall framing with increased insulation
- Blown Cellulose Insulation
  - Increased fire resistance (25-50% over fiberglass) improved safety from smoke
  - Higher insulation value & coverage
  - Recycled material, no VOCs
  - Higher cost
- Cotton batt insulation
- Double glazed/ low-E windows
  - Windows can account for as much as 25% of heat loss in winter
  - Low-E windows reflect heat, making the home more comfortable on cold and hot days. Purchase climate specific shading coefficient and Insulating value.
  - Comparable cost to conventional mid-range windows
- Curtains



# Appliances & Lighting: 30%

- Upgrade to Energy Star
  - Refrigerators reduce electric bill by 15%.
  - Front loading washing machine use 40% less water and 50% less energy
  - Dishwashers use internal water heater to boost temperatures and save \$\$
- Use day lighting techniques
  - Light-colored interior walls, ceilings & soffits, carpets and floors
  - Skylights & sun tunnels for north facing rooms
    - Heat loss is 2-3X higher in horizontally installed glazing. Use skylights with an R-value of 5 to 10.
    - Sun Tunnel is 95% efficient in transferring daylight; great for hallways, kitchens, bathrooms
- Use fluorescent light bulbs



Horizontal Axis Washing Machines



# 9. Indoor Environmental Quality

Americans spend 90% of their time indoors

- Indoor air quality is 6-10 times more polluted than outdoor air

Children are particularly vulnerable

- 40% of children will develop respiratory disease, in part due to the chemicals in their homes (New England Journal of Medicine)
- Poor indoor air quality contributes to asthma (15 million) and hay fever/other allergies (28 million).
- One of the top five environmental risks to public health

# Indoor Environmental Quality

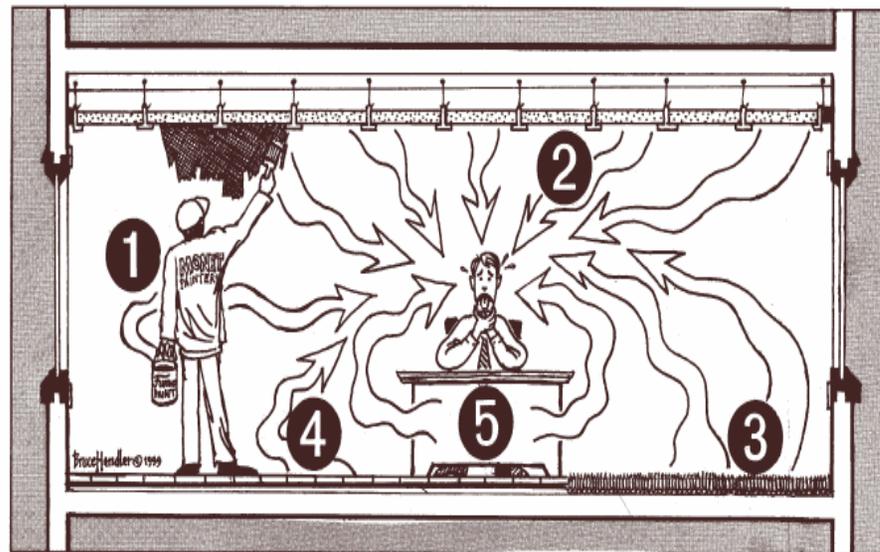
## Sources of Pollution

- Materials purchased off-gas toxic chemicals
  - particle-board, medium-density fiberboard (MDF) and other pressed-wood products found in shelving, furniture, countertops, cabinets.
- Finishing products off-gas toxic chemicals
  - Paints, adhesives, sealants, floor finishes
- Household ventilation, design and maintenance
  - Carbon monoxide, radon, mold
- House-hold cleaning products off-gas toxic chemicals
- Tracked-in contaminants
  - Dust, dirt, other biological contaminants



# Techniques to Improve IEQ

- Exhaust fan in garage, detached garage
- Zero formaldehyde
  - particle board/MDF for cabinets, shelving, counter top
  - OSB for sheathing
  - insulation
- No or Low-VOC
  - paints (green seal)
  - wood finishes
  - adhesives
- Natural linoleum instead of vinyl flooring
- FSC-certified wood or bamboo flooring instead of carpet



Sources of offgassing in building materials typically include:  
① paints, ② ceiling tiles, ③ carpeting, ④ VCT floor tiles, and ⑤ manufactured wood products.



# IV. Unconventional Green Techniques

Straw Bale \* Rammed Earth \* Dirt Bag \*  
Adobe \* Cob \* Log and cordwood \*  
Papercrete

- Lower materials costs
- Requires less skilled labor, but more of it
- Most techniques are suitable for building off the grid
- More suitable to some climates and locations
- Techniques have been around for 1000s of years, some of the oldest buildings on earth are rammed earth structures

# Straw Bale Construction



Dry baled straw from rice, wheat, oats covered by stucco. Straw is highly stable, does not attract termites, has an R- value of 30 to 45.



Bales can be structural and support the roof (inexpensive) or as infill with timber frame construction (expensive and legal in California).



Bales are anchored to each other by stakes of wood (1x2x36), rebar (#3 or #4) or bamboo that penetrate at least two bales. Or 4" wide circular columns of concrete bored through the entire height of the wall.



Windows and doors are towards the exterior creating a deep well. Avoid water entering or collecting in these areas.

# Straw Bale Construction

People have built homes using straw throughout history.

- European houses built of straw over 200 years old.
- In the US the invention of the hay/straw baler (1890) resulted in many 2-3 story straw bale homes in the plains which are still standing
- California UBC allows straw bale

## Benefits

Simple construction, low costs

- Houses have been constructed for as low as \$10/SF to \$300/SF for high end homes.
- Sweat equity and barn-raising can lower costs.

Converts of an agricultural waste into a building material.

- U.S. Department of Agriculture estimates that farmers annually harvest enough straw to build about four million, 2,000 square-foot homes each year, 4 times the number of new houses constructed each year
- Two hundred million tons of straw are burned annually in the US.

# Rammed Earth



Rammed earth walls are built in forms similar to those for foundations.



A skid loader is used to dump soil in lifts of 7"- 8" into forms.



The soil (65% sand, 25% clay, 3% Portland cement, 6-10% moisture) is tamped down to 4"- 5" with pneumatic tampers.



Forms are stripped away immediately upon wall completion for rapid curing.



# Rammed Earth Construction

## Construction technique

- Electrical conduits, steel ladder reinforcement, window block outs, plumbing vents, anchors and steel reinforcing are rammed into wall during construction.
- All wiring in conduit and fixtures must be rated for integration in masonry assemblies.
- Exterior walls are protected from moisture by hard plaster or stucco finishes.
- Most codes for earthen wall construction are designed for adobe not rammed earth.

## Advantages

- Energy efficiency lies in the massive structure's ability to reduce interior temperature swings. Insulation value is R-4.5 for a typical 18-inch wall.
- Uses local sustainable materials.

## Cost

- About \$60/linear foot for a 9' wall. Cost depends on the ratio of wall area to floor area and finishes. Stabilized rammed earth does not require interior or exterior finishes. Cost is similar to conventional construction.

# Dirt Bag or Earth Bag Construction

- Uses "reject sand" from gravel yards. The reject material has the best ratio of clay to sand (25% clay to 75% sand) for earth construction.
- Uses woven polypropylene "misprint" bags
- Dirt bags are stabilized with rows of barbed wire interwoven between bags and rebar.
- Utilities are laid between bag layers
- Exterior and interior finishes: natural adobe, stabilized earth, lime/cement stucco.

## Benefits

- Earthen walls have absorbent mass that stores warmth (or cold) and returns it to the living space. Known as the thermal flywheel effect (K-value).
- Cost \$6 to \$50 /sf
- Flexible form, round walls are easy





# V. City of Fort Bragg Next Steps

- Consider a Green Building program/policy for City of Fort Bragg
  - Near term: Incentives for Green projects
  - Mid-Term: Minimum requirements
- Two green projects in the pre-application phase
  - LEED Certified Credit union
  - 8-unit residential project on West Street

# VI. Resources

USGBC: [www.usgbc.org](http://www.usgbc.org)

Build It Green: [www.builditgreen.org](http://www.builditgreen.org)

Environmental Building News & GreenSpec  
[www.buildinggreen.com](http://www.buildinggreen.com)

Alameda County: [www.stopwate.org](http://www.stopwate.org)

# Resources

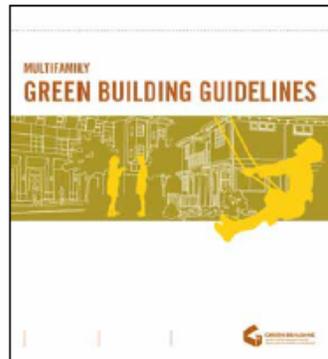
## Green Building in Alameda County Standards & Guidelines

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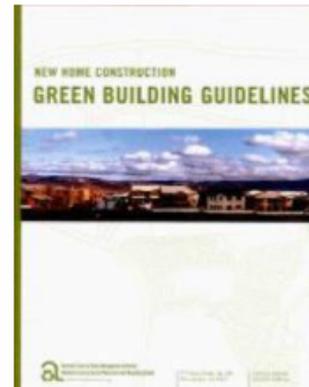
**Commercial &  
Civic Buildings**



**Multifamily**



**New  
Construction**



**Single Family**

**Remodeling**



# Books Resources

- **A Primer on Sustainable Building**  
Dianna Lopez & William D. Browning  
[www.rmi.org/catalog/gds/htm](http://www.rmi.org/catalog/gds/htm)  
Brief, comprehensive and readable  
introduction to green building
- **The Not So Big House**  
*A Blueprint for the Way We Really Live*  
Sarah Susanka, Kira Obolensky  
The Taunton Press
- **Before You Build**  
A Preconstruction Guide  
Robert Roskind, Owner Builder Center  
Ten Speed Press  
[www.tenspeed.com](http://www.tenspeed.com)
- **The Natural House**  
Daniel D. Chiras  
Chelsea Green Publishing
- **A Pattern Language: Towns, Buildings, Construction**  
Oxford University Press 1977
- **Buildings or Earth & Straw**  
Bruce King  
Ecological design Press, 1996
- **Regional Guidelines for Passive Energy Conserving Homes**  
AIA Research Corp. for US Department of Housing and Urban Development  
July 1980 HUD-PDR-355(2)
- **Heating, Cooling, Lighting**  
Design Methods for Architects  
Norbert Lechner  
John Wiley & Sons  
ISBN 0-471-62887-5
- **The Healthy House**  
*Healthy House Building*  
John Bower  
The Healthy House Institute  
7471 N. Shiloh Road  
Unionville, IN 47468
- **The Natural House Book**  
*The Natural House Catalog*  
David Pearson  
Simon & Schuster/Fireside  
Rockefeller Center  
1230 Avenue of the Americas  
New York, NY 10020