


Building for Energy Efficiency – Part 3


Design details and construction drawings for energy efficient homes

Alex Lukachko
Building Science Consulting LLC
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Building America




The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies – innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program uses a systems engineering approach to reduce energy use, utility bills, construction time, and construction waste.

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Objectives for this afternoon . . .

1. **“Show off” our house plans as examples of affordable, energy efficient, and durable construction**
2. **Explain applied building science principles through details and construction photos**

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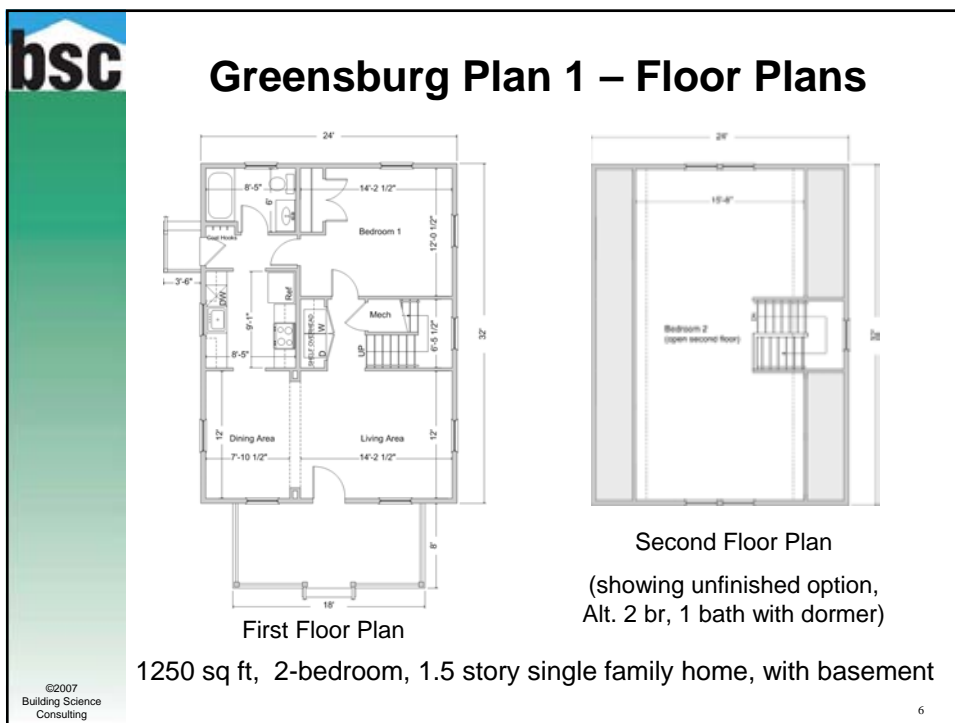
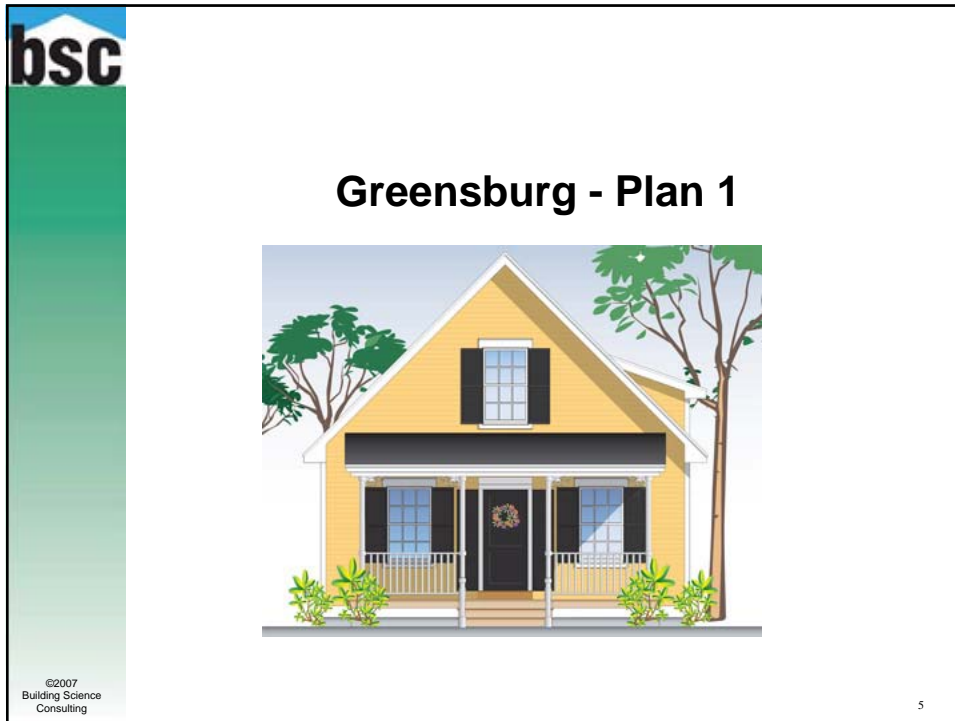
Overview of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

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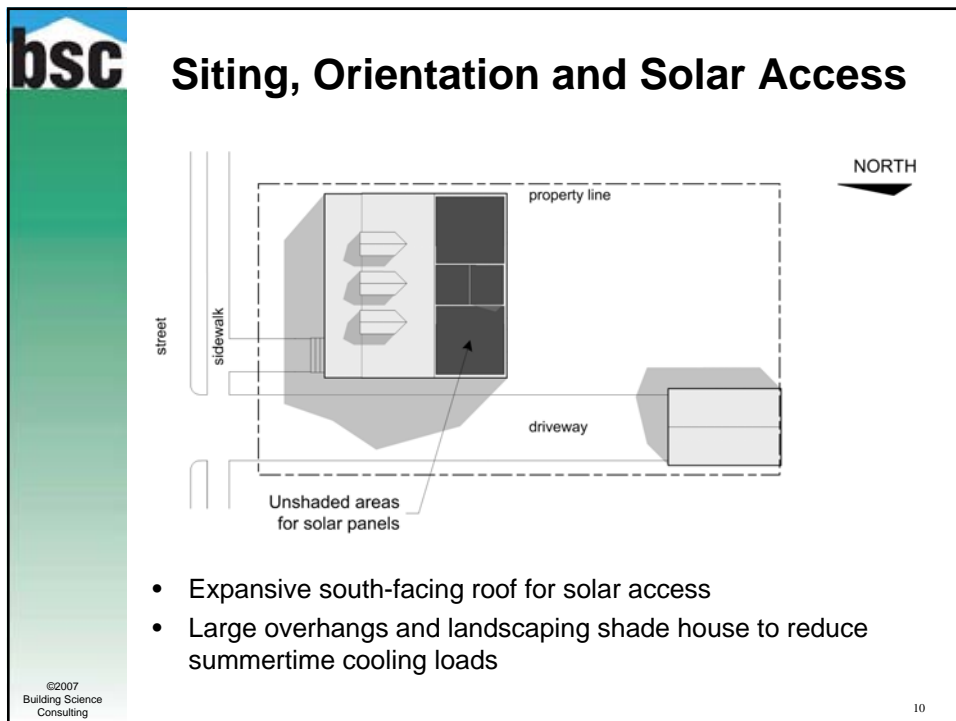
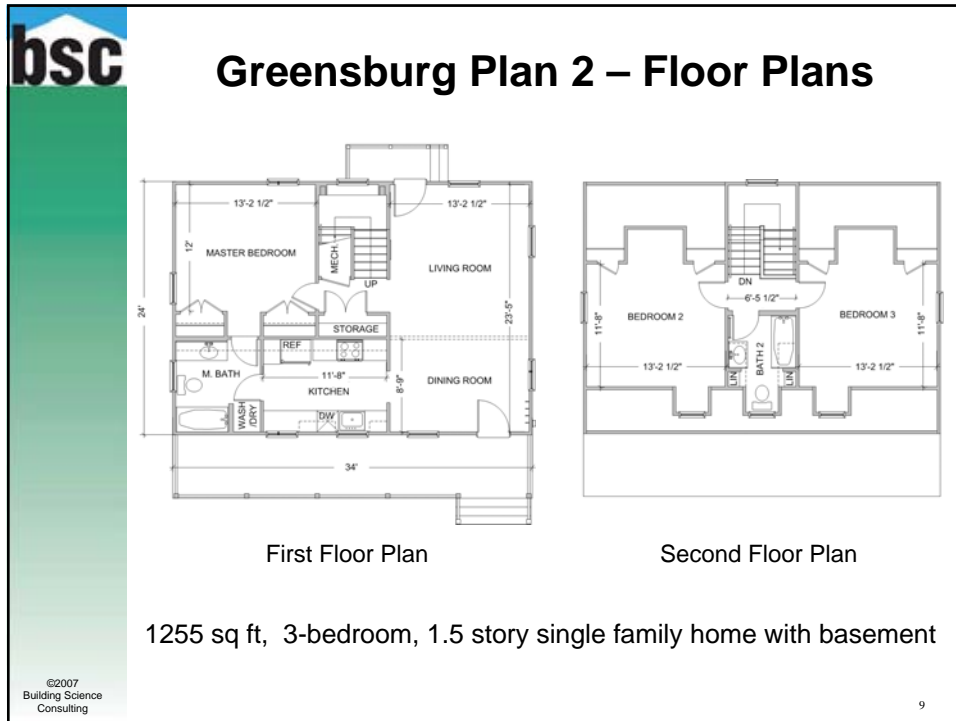
bsc **Siting, Orientation and Solar Access**


- Expansive south-facing roof for solar access
- Large overhangs and landscaping shade house to reduce summertime cooling loads

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bsc **Greensburg - Plan 2**

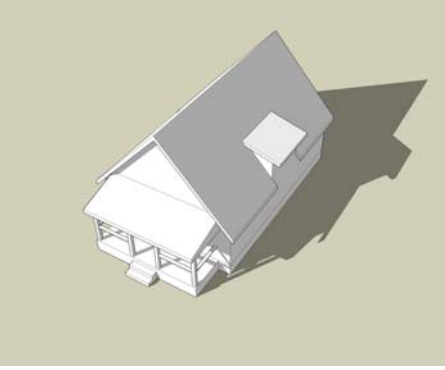
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Adding to the Basic Plan

House Plan	Greensburg Standard	
Description	Two-bedroom house with living area on the main floor. Second floor can be divided into two bedrooms and bath.	
Living Area	Ground Floor	750 sq ft
	Second Floor	500 sq ft
	Total	1250 sq ft
Bedrooms	Ground Floor	1
	Second Floor	1
	Total	2
Number of Bathrooms	1	



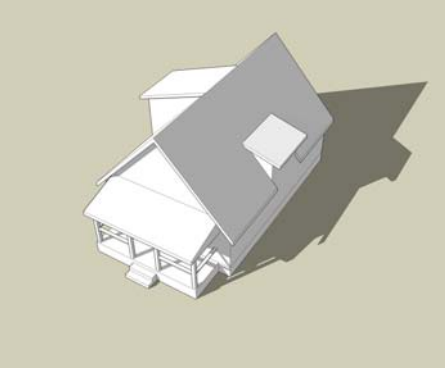
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Adding to the Basic Plan

House Plan	Greensburg Plus	
Description	Three-bedroom version of the Standard with a second bathroom under a new dormer.	
Living Area	Ground Floor	750 sq ft
	Second Floor	500 sq ft
	Total	1250 sq ft
Bedrooms	Ground Floor	1
	Second Floor	2
	Total	3
Number of Bathrooms	2	

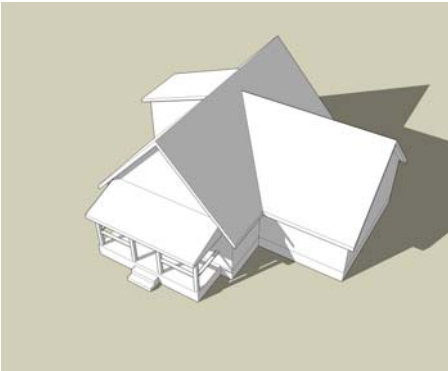


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bsc **Adding to the Basic Plan**

House Plan	Greensburg "L"	
Description	Three-bedroom house with "Great Room" and study on the ground floor, 3 bedrooms and second bath on the second floor.	
Living Area	Ground Floor	1050 sq ft
	Second Floor	800 sq ft
	Total	1850 sq ft
Bedrooms	Ground Floor	0
	Second Floor	3
	Total	3
Number of Bathrooms	2	



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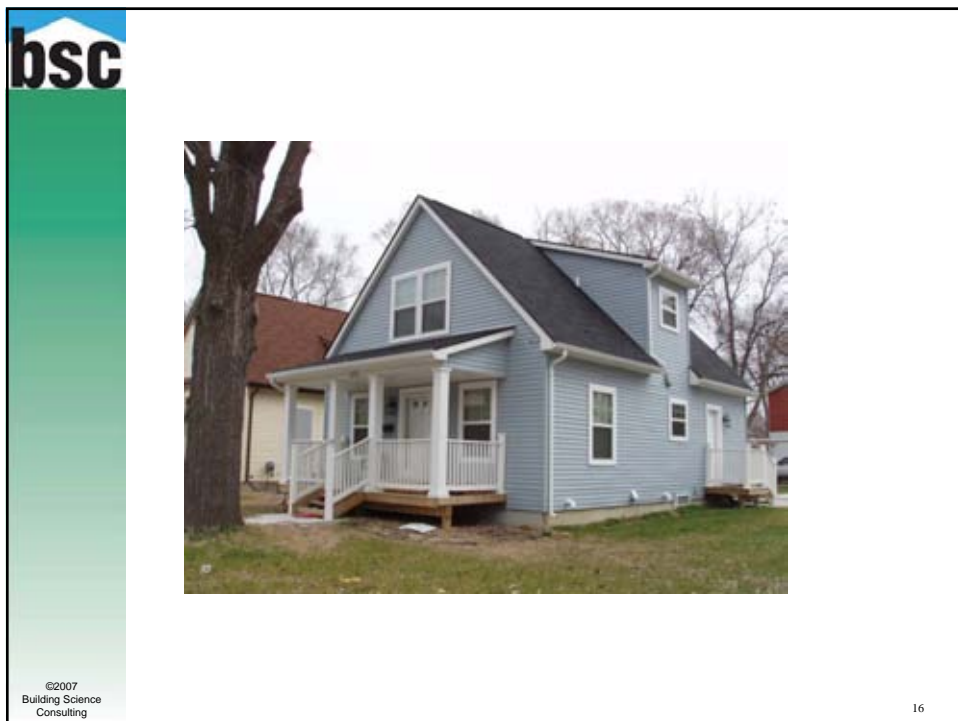
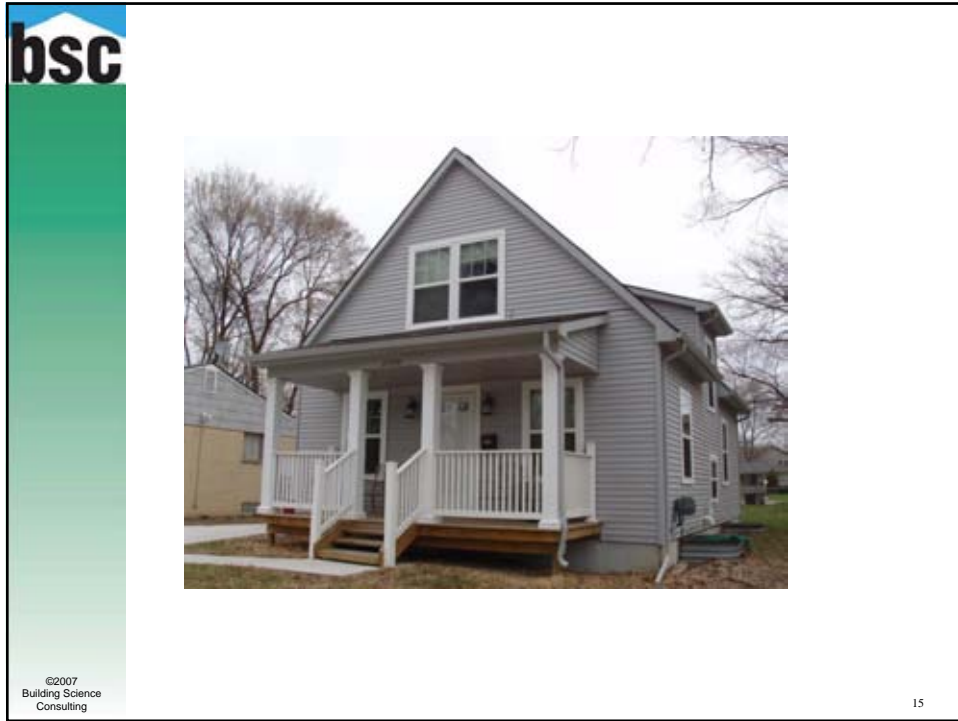
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bsc **Examples: Royal Township, Michigan**




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Examples: Carbondale, Colorado



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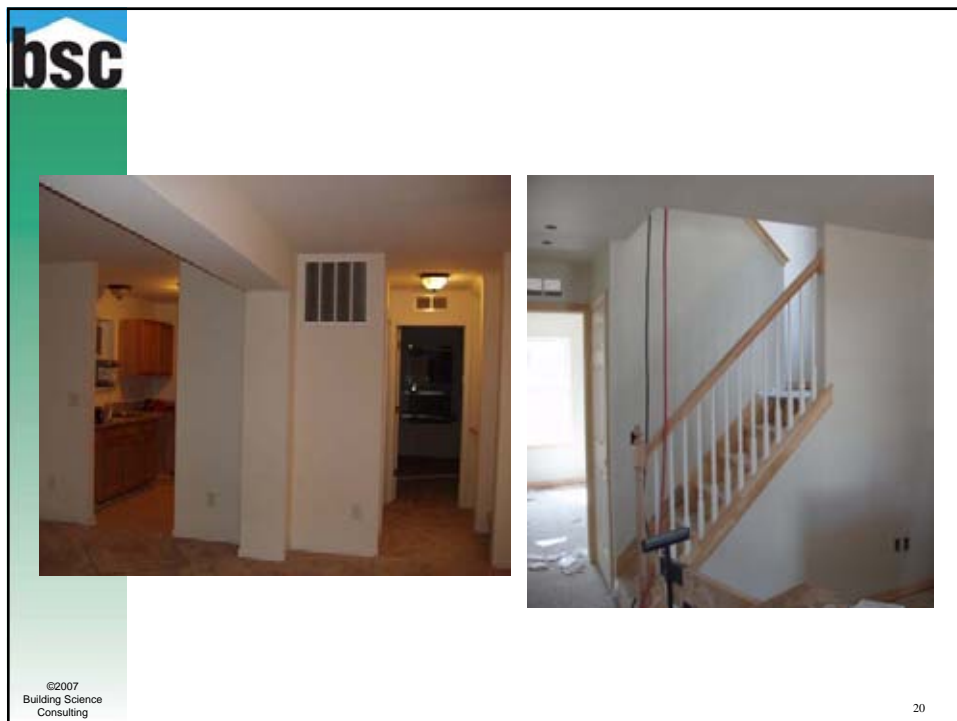
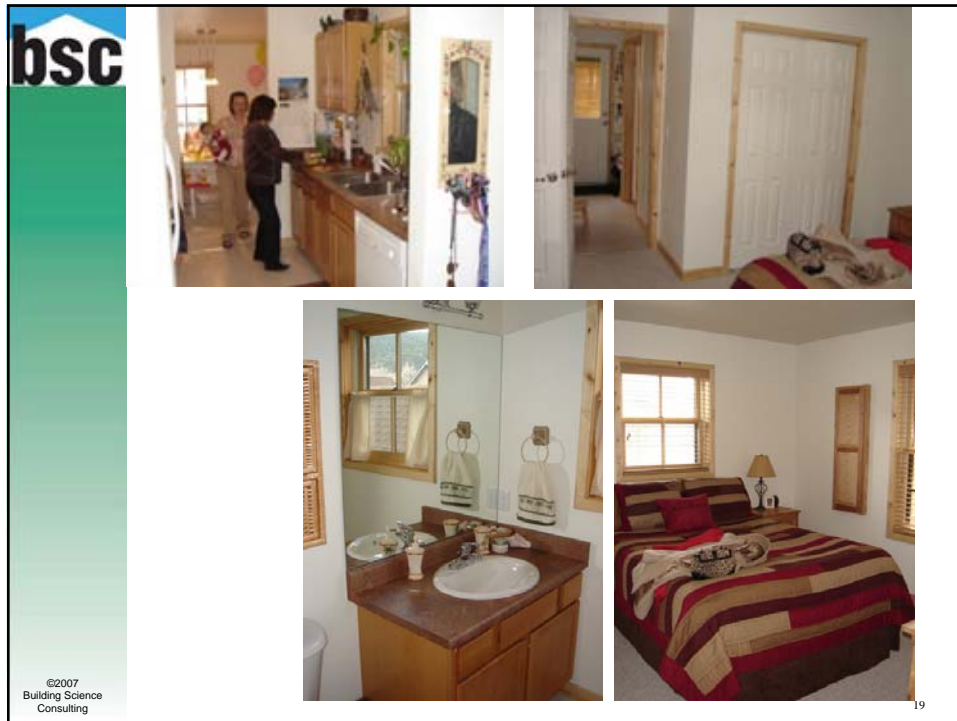
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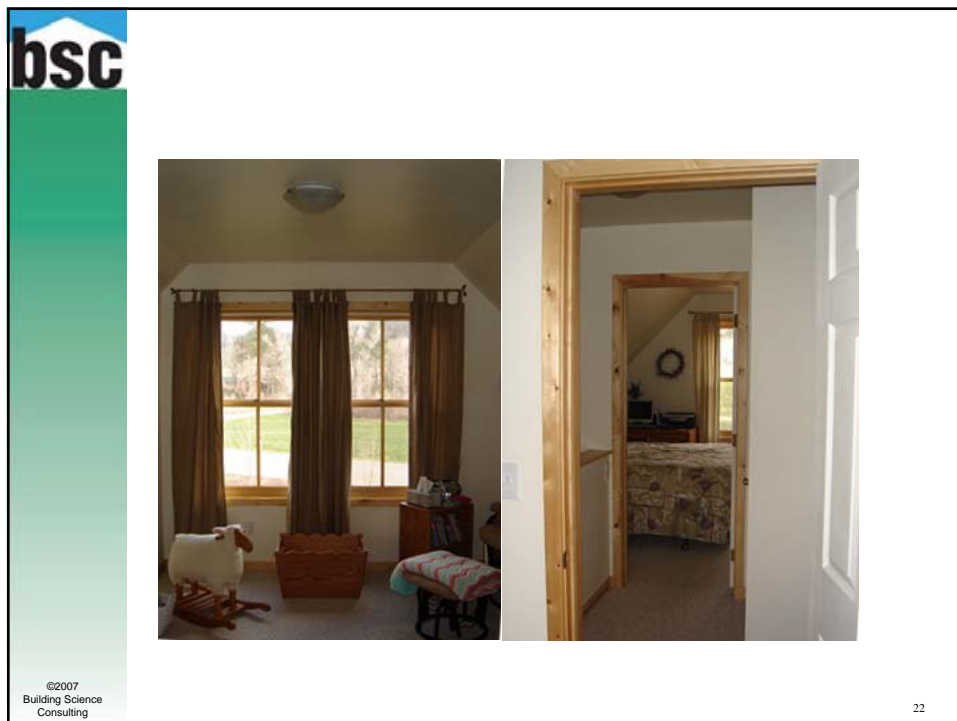
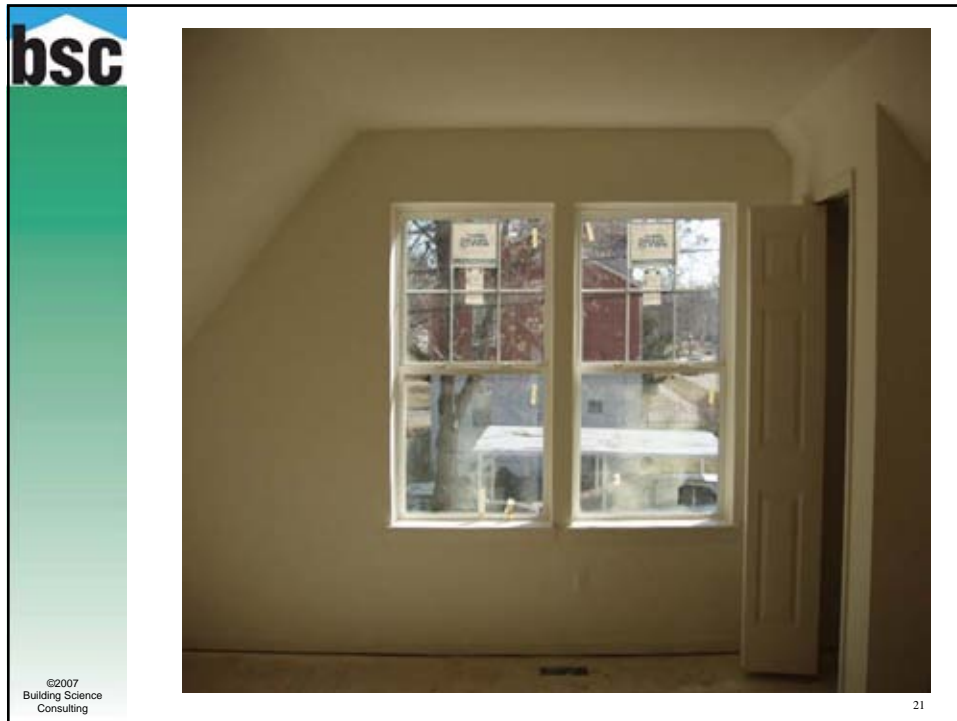
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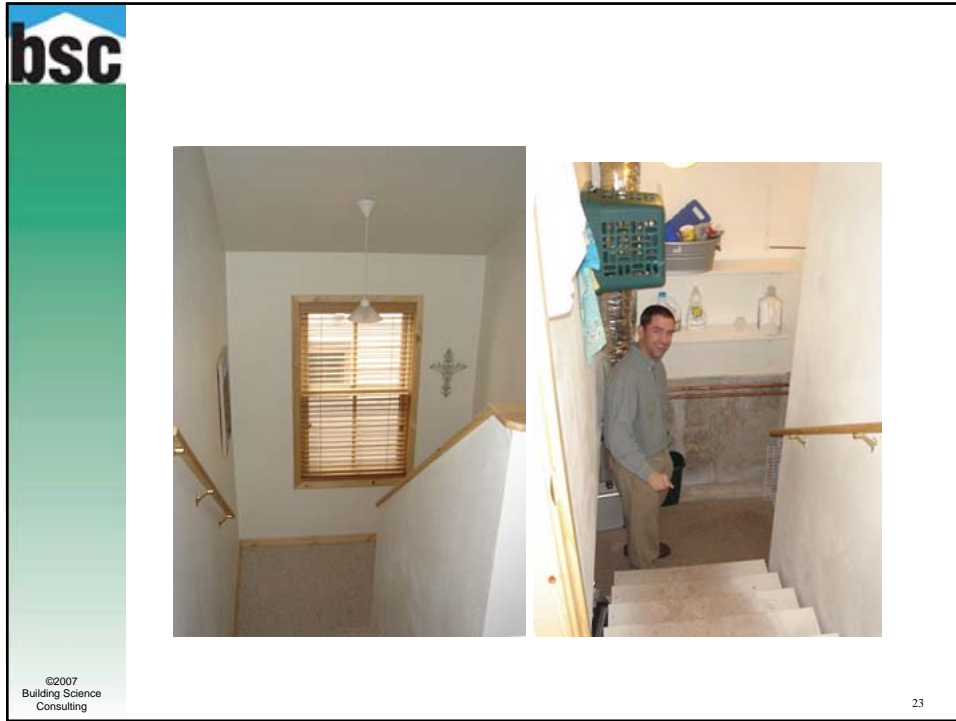


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REBUILDING GREENSBURG HOUSING FAIR Greensburg, KS PLAN 1 - THREE BEDROOM - BASEMENT

PROJECT DESCRIPTION
 These plans describe an affordable, energy-efficient, and durable 1250 sq ft single-family home. The drawing set and specifications were developed by Building Science Corporation through the Department of Energy's Building America Program for the "Rebuilding Greensburg" Housing Resource Fair on July 19-21, 2007. The plans provide an example of how homes in Greensburg could be rebuilt as part of a healthy, energy-efficient and affordable town. During project planning and construction, all efforts should be made to meet the goals of this project.

SQUARE FOOTAGES	
BASEMENT	816 SQ FT
FIRST FLOOR	816 SQ FT
SECOND FLOOR	444 SQ FT

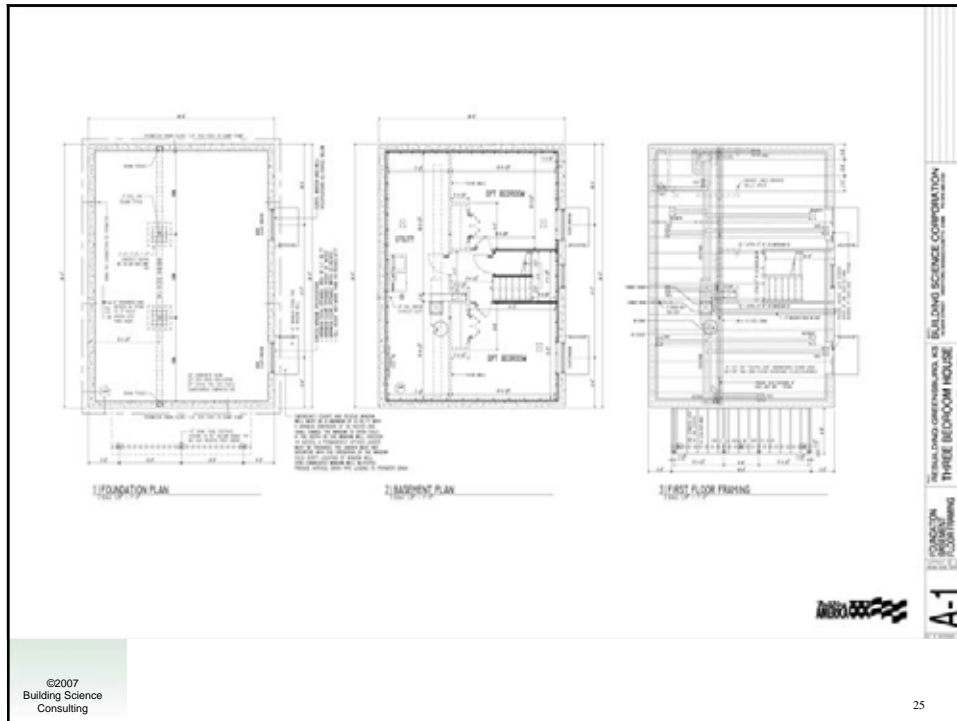
LIST OF DRAWINGS
 A-1 FOUNDATION / BASEMENT / FIRST FLOOR FRAMING PLANS
 A-2 FIRST AND SECOND FLOOR PLANS / WALL FRAMING ELEVATIONS
 A-3 SECOND FLOOR FRAMING / ROOF FRAMING / ROOF PLANS
 A-4 BUILDING SECTION AA / WALL SECTION
 A-5 BUILDING SECTION BB / WALL SECTION
 A-6 BUILDING ELEVATIONS
 A-6 DETAILS
 M-1 MECHANICAL PLANS
 E-1 ELECTRICAL PLANS

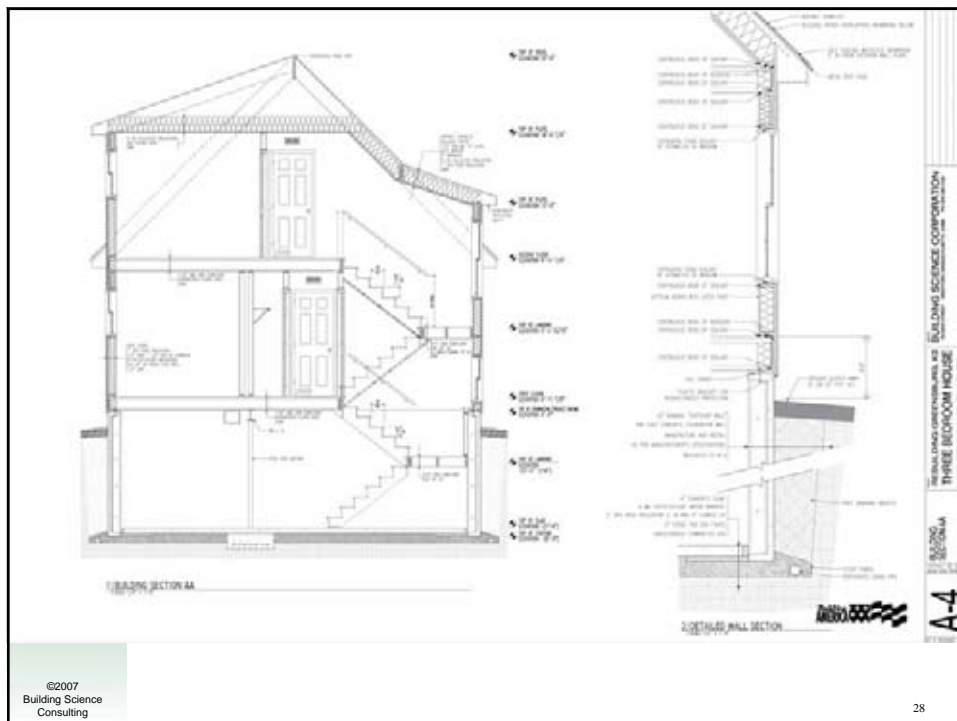
DATE: 19 JULY 2007

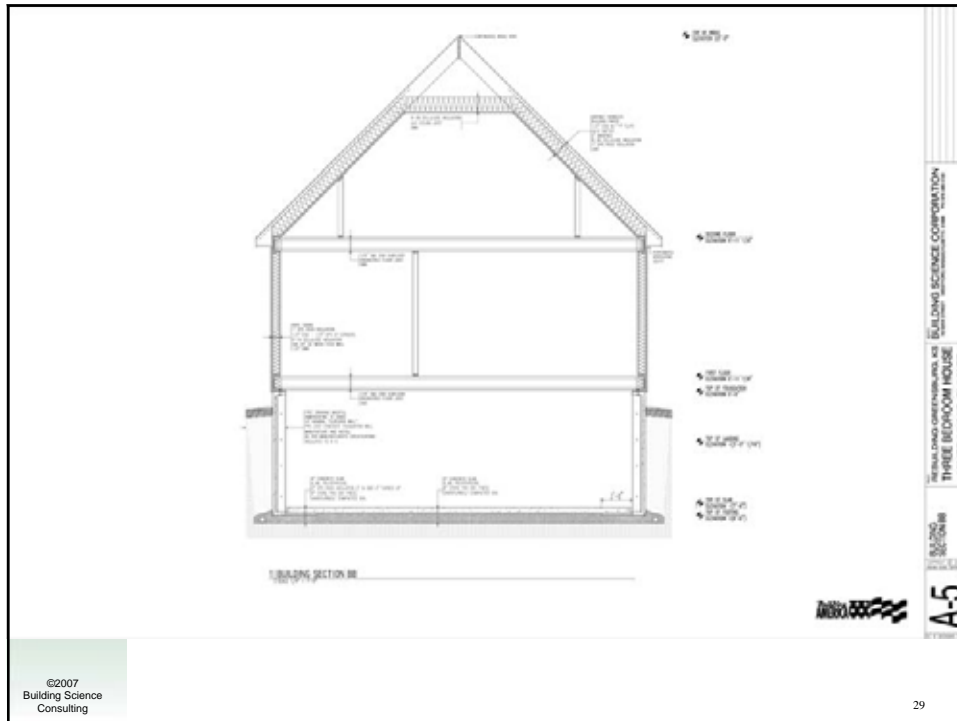
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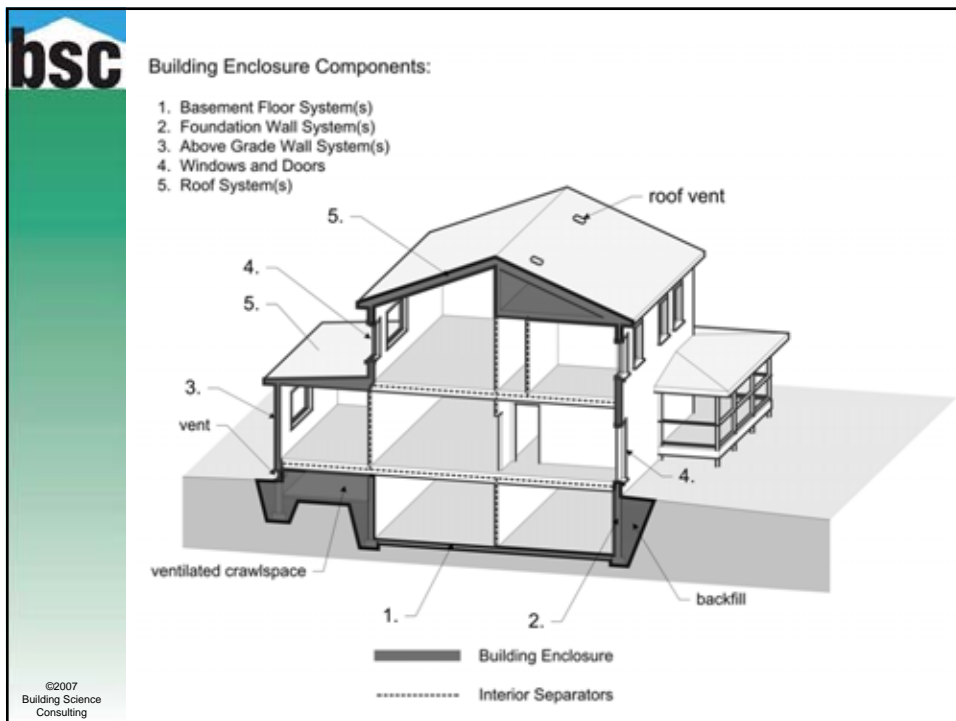
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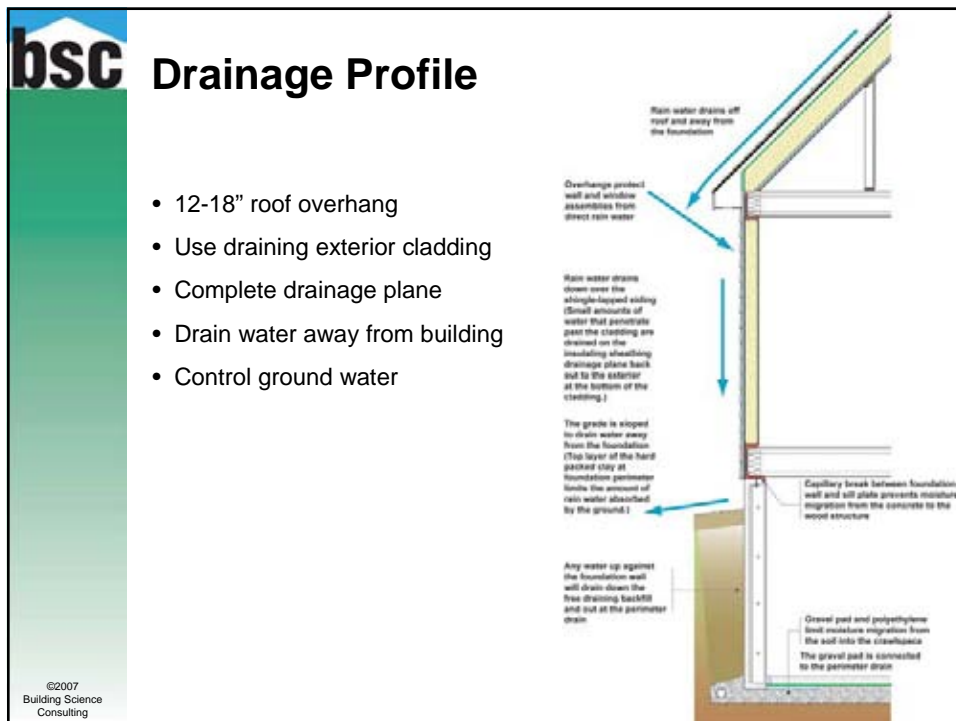
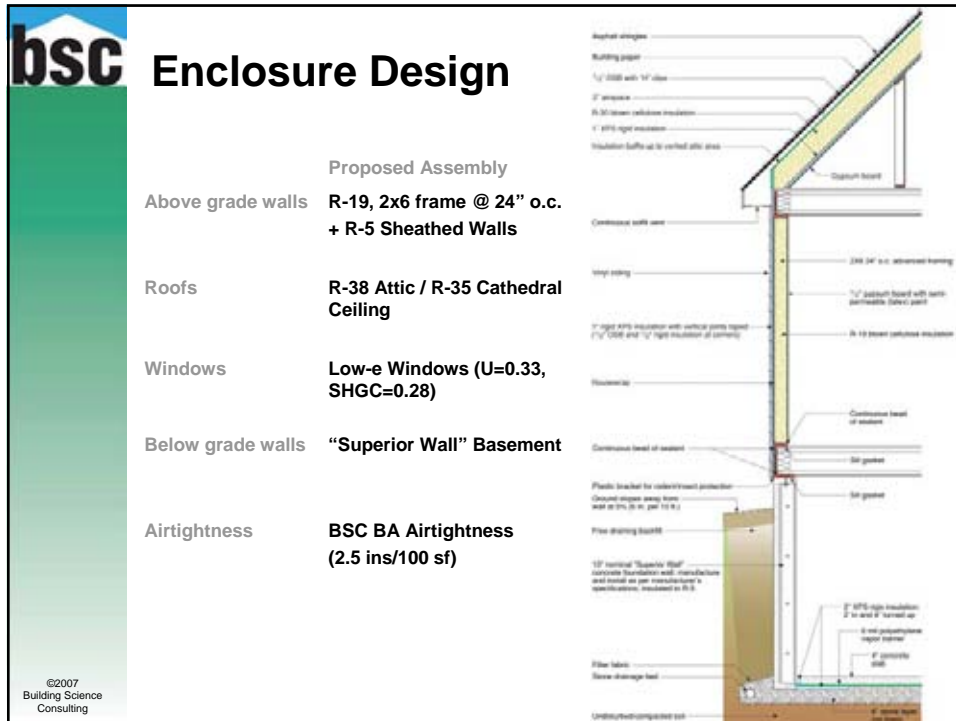
Building Science Details

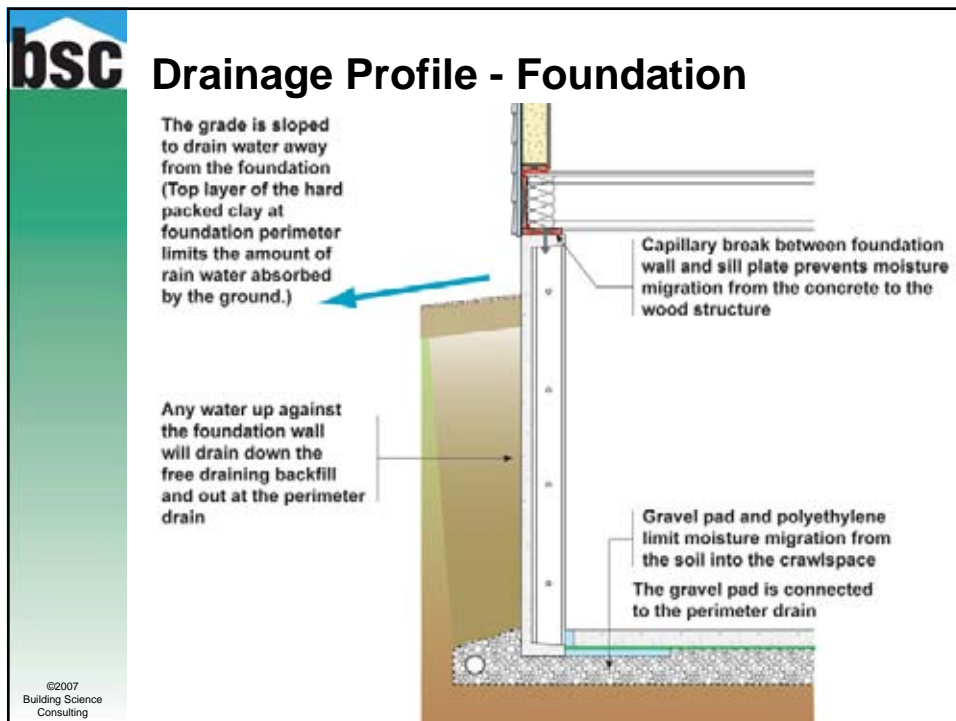
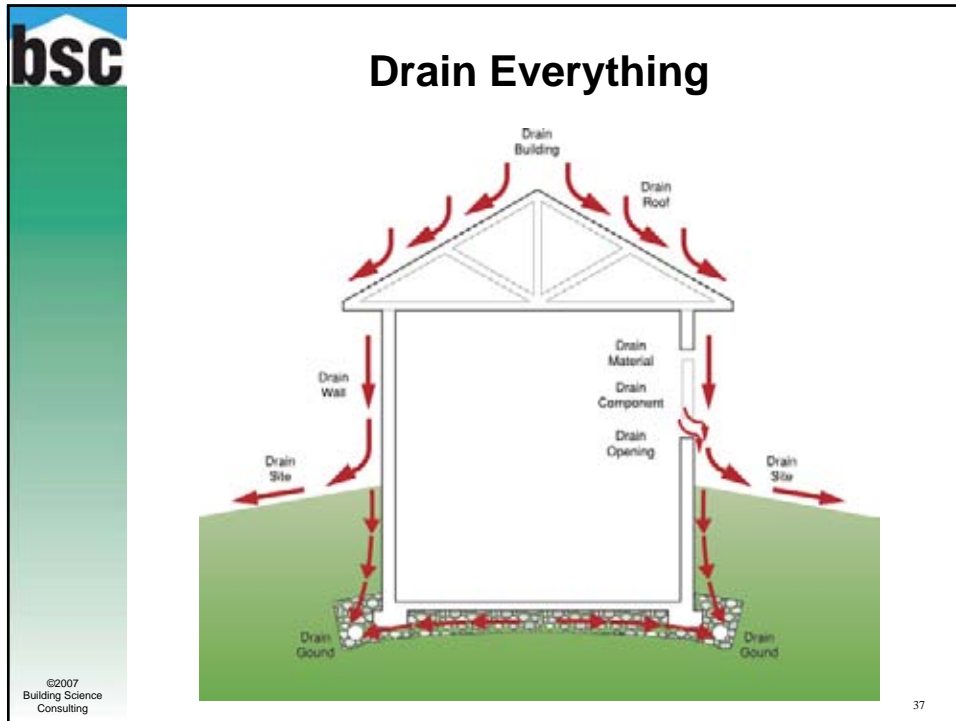
- The Building Enclosure
- Rainwater Control
- Airflow Control
- Water Vapor Control
- Thermal Control

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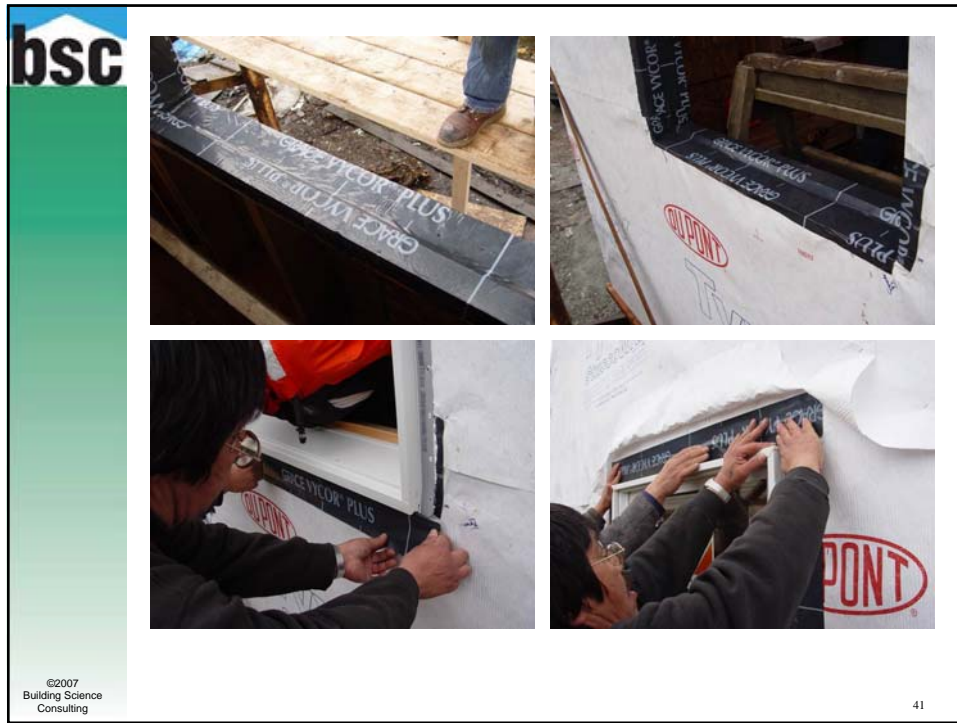
bsc Drainage Profile - Walls

Rain water drains down over the shingle-lapped siding (Small amounts of water that penetrate past the cladding are drained on the insulating sheathing drainage plane back out to the exterior at the bottom of the cladding.)

Windows and other penetrations must be integrated with drainage plane

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1. WINDOW INSTALLATION SEQUENCE

2. ILLUSTRATIVE WALL SECTION AT WOOD LAP SIDING

3. ILLUSTRATION FLASHING DETAILS

THREE BEDROOM HOUSE
 VERY COLD CLIMATE

DETAILS
A-7

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bsc Drainage Profile - Roofs

Rain water drains off roof and away from the foundation

Overhangs protect wall and window assemblies from direct rain water

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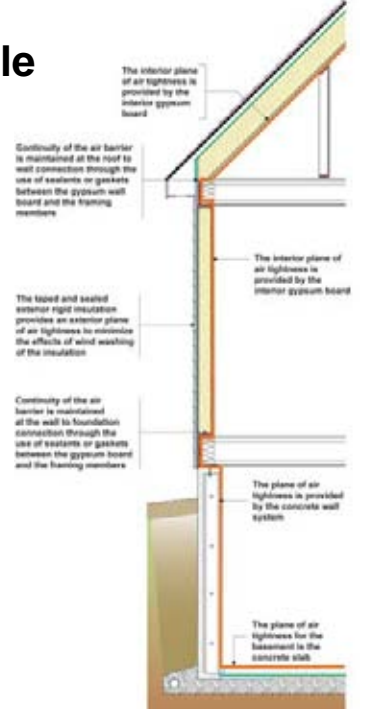
44




Airflow Control Profile

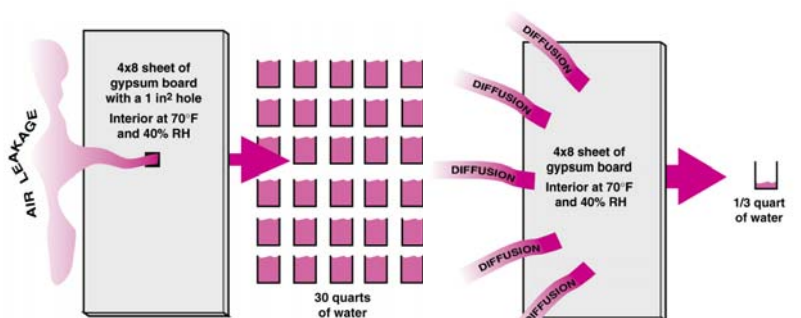
- Continuous interior air barrier with Airtight Drywall Approach
- Additional resistance to airflow - housewrap and exterior sheathing
- Soil gas control
- Airsealing of windows and other penetrations

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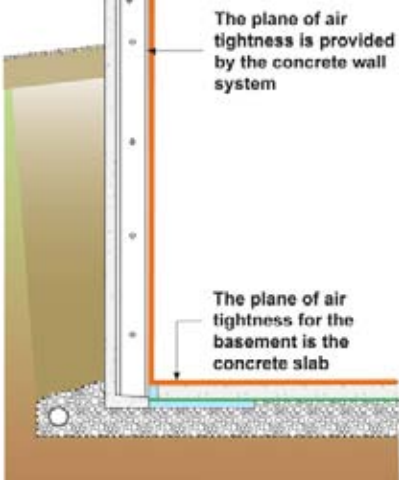


Air Leakage vs Vapor Diffusion



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bsc **Airflow Control - Foundation**



The diagram shows a cross-section of a foundation wall. The wall is made of concrete and is shown with a vertical section. The interior of the wall is filled with insulation. The exterior of the wall is also insulated. The diagram highlights two planes of air tightness: one provided by the concrete wall system and another provided by the concrete slab at the base of the wall.

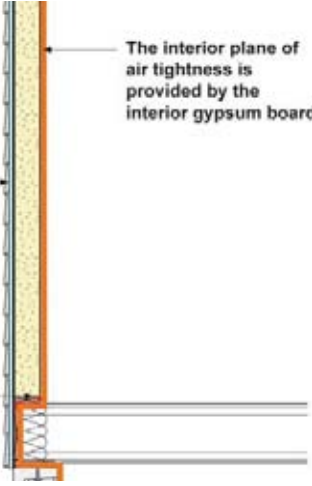
The plane of air tightness is provided by the concrete wall system

The plane of air tightness for the basement is the concrete slab

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bsc **Airflow Control - Walls**



The diagram shows a cross-section of a wall. The wall is made of wood framing with insulation. The interior of the wall is finished with gypsum board. The exterior of the wall is finished with rigid insulation. The diagram highlights three key features for air tightness: the interior gypsum board, the exterior rigid insulation, and the continuity of the air barrier at the wall to foundation connection.

The interior plane of air tightness is provided by the interior gypsum board

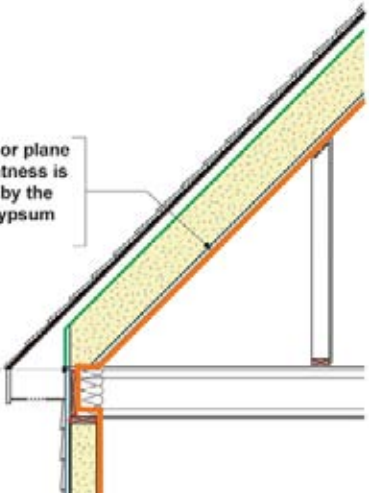
The taped and sealed exterior rigid insulation provides an exterior plane of air tightness to minimize the effects of wind washing of the insulation

Continuity of the air barrier is maintained at the wall to foundation connection through the use of sealants or gaskets between the gypsum board and the framing members

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bsc **Airflow Control - Roofs**



The interior plane of air tightness is provided by the interior gypsum board

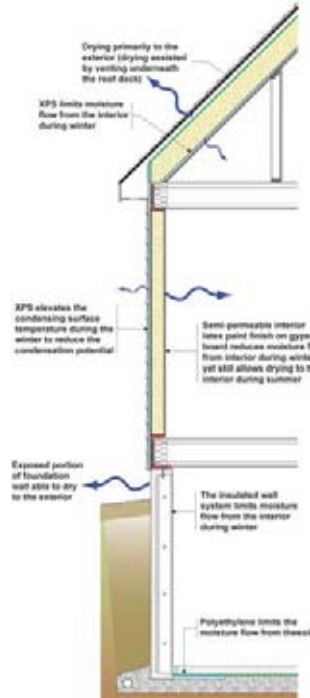
Continuity of the air barrier is maintained at the roof to wall connection through the use of sealants or gaskets between the gypsum wall board and the framing members.

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bsc **Vapor Control Profile**

- Mixed-Humid Climate - assemblies need to dry to interior and exterior
- Rigid insulation (XPS) limits moisture flow
- Works with insulation to control surface temperature and reduce condensation potential



Drying primarily to the exterior (driving moisture by venting underneath the roof deck)

XPS limits moisture flow from the interior during winter

XPS elevates the condensing surface temperature during the winter to reduce the condensation potential

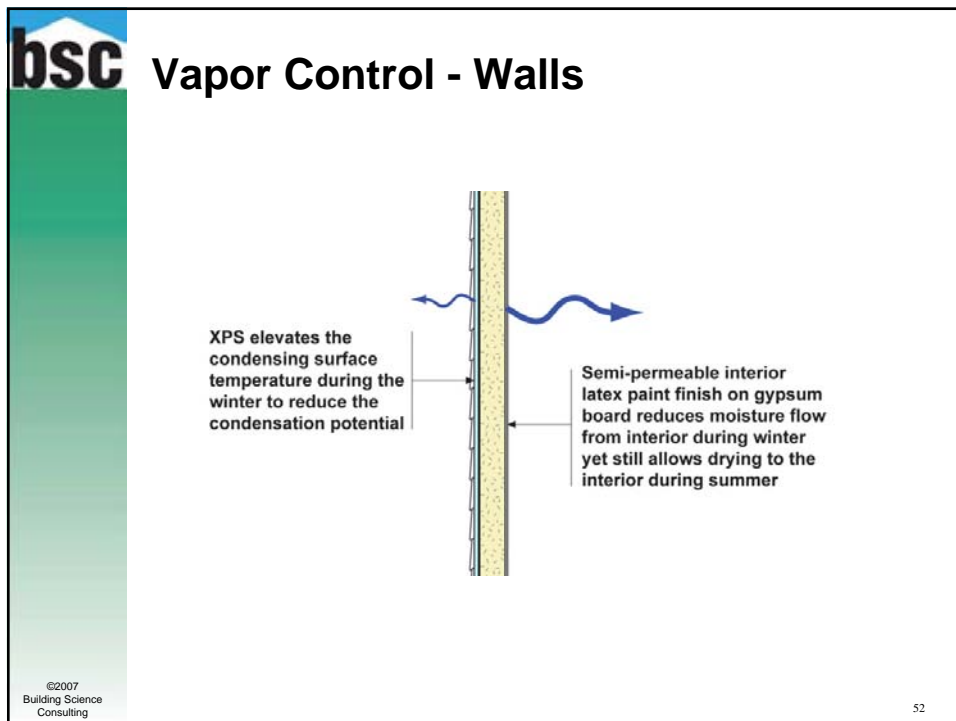
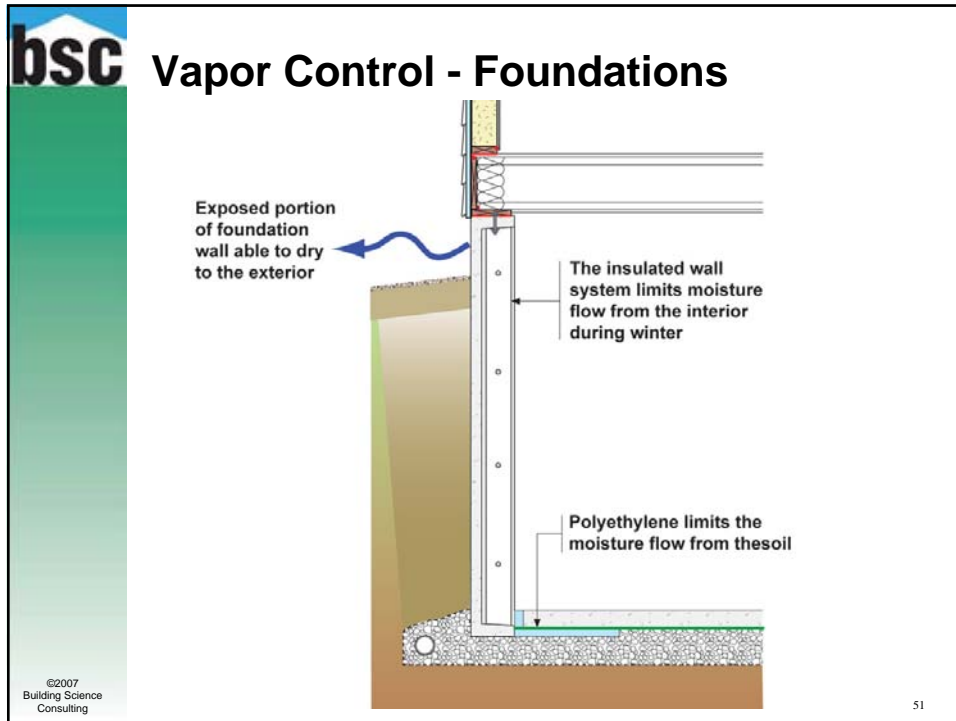
Semi-permeable interior latex paint finish on gypsum board reduces moisture flow from interior during winter yet still allows drying to the interior during summer

The insulated wall system limits moisture flow from the interior during winter

Polyethylene limits the moisture flow from the exterior

Exposed portion of foundation wall able to dry to the exterior

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bsc Vapor Control - Roofs

Drying primarily to the exterior (drying assisted by venting underneath the roof deck)

XPS limits moisture flow from the interior during winter

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Detailed description: This diagram shows a cross-section of a roof assembly. From top to bottom, it consists of a roof deck, a layer of XPS insulation, and a structural member. Blue arrows indicate the path of moisture vapor: one arrow points from the interior through the XPS to the exterior, and another arrow points from the interior through the XPS to a vented space underneath the roof deck, where it is then exhausted to the exterior. The text 'Drying primarily to the exterior (drying assisted by venting underneath the roof deck)' points to the vented space. The text 'XPS limits moisture flow from the interior during winter' points to the XPS layer.

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1/2" OSB

2" AIRSPACE

24" ATTIC RAFTER VENTS SUCH AS TUFTVENT OR RAFTER MATE

2X12 RAFTERS

1" XPS

6 | RAFTER BAFFLE DETAIL

SCALE 1/2" = 1'-0"

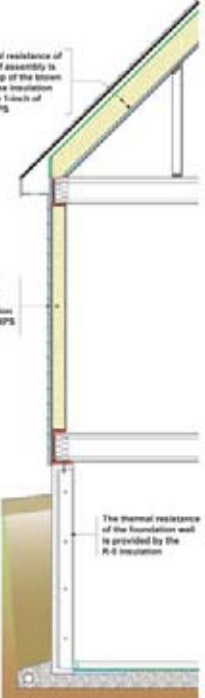
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Detailed description: The top part of the slide is a photograph showing a construction worker in a white shirt using a hammer to install a white rafter baffle between wooden rafters in an attic. The baffle is being placed over a layer of yellow insulation. The bottom part is a technical cross-section diagram of the rafter baffle detail. It shows a 1/2" OSB sheathing on top, followed by a 2" airspace containing 24" attic rafter vents. Below the vents are 2x12 rafters, and at the bottom is a 1" XPS insulation layer. The diagram is labeled '6 | RAFTER BAFFLE DETAIL' and 'SCALE 1/2" = 1'-0"'. The BSC logo is in the top left, and the copyright information and page number are at the bottom.

bsc Thermal Control Profile

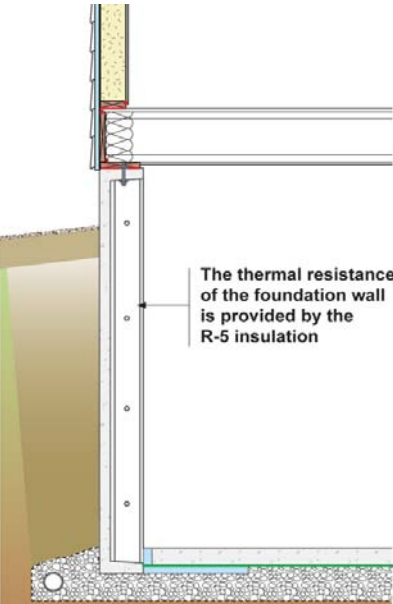
- Rigid insulation used to control thermal bridging
- Advanced framing techniques used to maximize overall thermal resistance
- Air barrier system and full cavity fill insulation to minimize airflow thermal bypass



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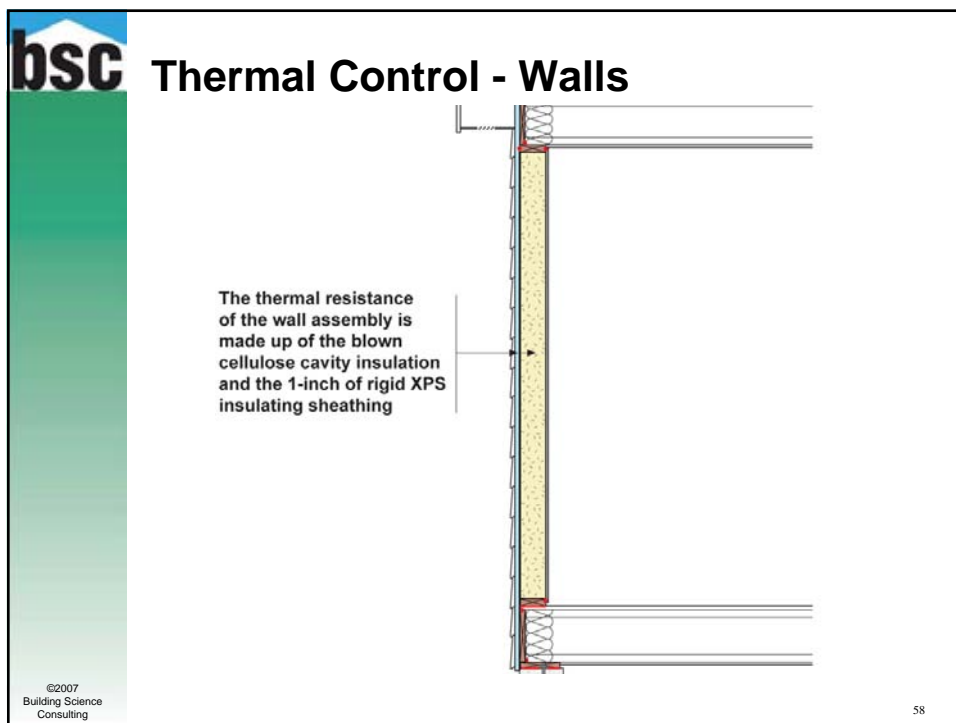
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bsc Thermal Control - Foundation



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The Future of Framing

Smarter strategies can save money, speed construction, improve energy efficiency, and cut down on job-site waste

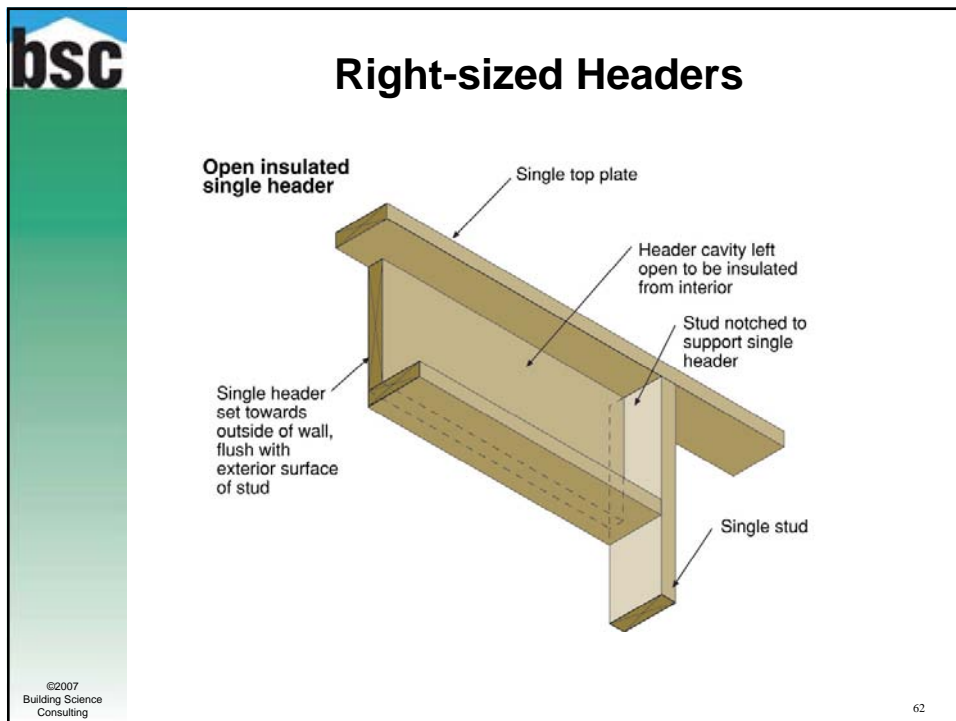
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bsc **Reduce framing in non-bearing walls**



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bsc **Two-stud corners and Drywall clips**

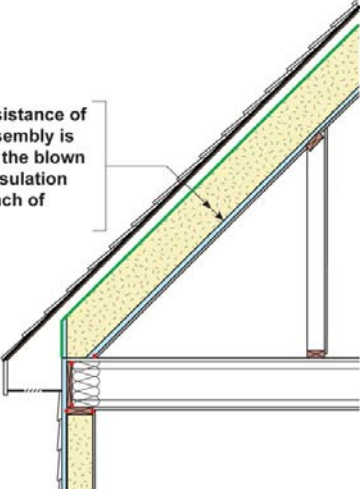


- Clips save wood, labor and call-backs
- NAHB: \$100/1000 sq ft in material
- Further savings in energy . . .

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bsc Thermal Control - Roofs




Thermal resistance of the roof assembly is made up of the blown cellulose insulation and the 1-inch of rigid XPS

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The diagram illustrates a cross-section of a roof assembly. It shows a sloped roof structure supported by a vertical post. The roof assembly consists of several layers: a top layer of roofing material, a layer of blown cellulose insulation (indicated by a dotted pattern), and a 1-inch layer of rigid XPS insulation (indicated by a solid yellow pattern). Below the insulation, there is a layer of sheathing and a structural member. A callout box with a line pointing to the insulation layers contains the text: 'Thermal resistance of the roof assembly is made up of the blown cellulose insulation and the 1-inch of rigid XPS'.

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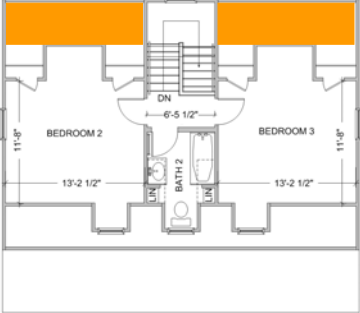
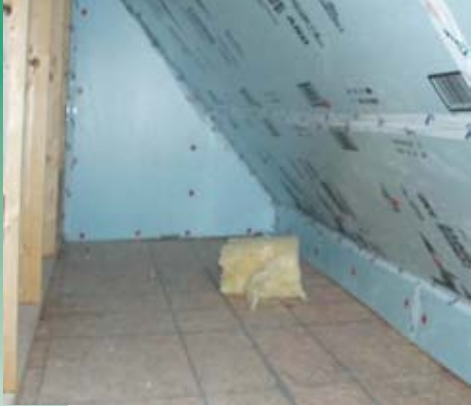


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The photograph shows a construction worker in a white t-shirt and safety glasses installing insulation on a roof. The worker is using a utility knife to cut a piece of white Styrofoam insulation. The insulation is being installed over a wooden roof structure. The worker is standing on a wooden frame. The background shows a yellowish insulation material already installed. A digital timestamp '6:29:00' is visible in the bottom right corner of the photo.

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Pushing the Envelope . . .



Second Floor Plan

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Resources


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Resources

Building Science Corporation
Designs that Work – Mixed-Humid Climate Case Study
find this at:
www.buildingscience.com/dtw



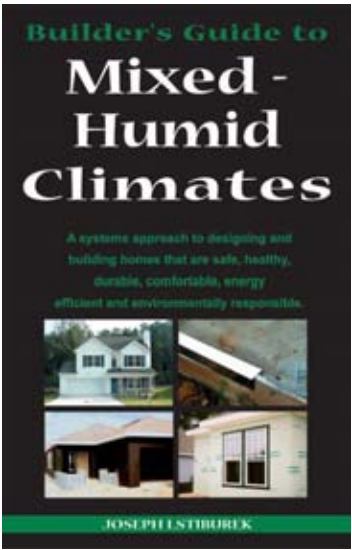
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Resources

Building Science Corporation
Builder's Guide to Mixed-Humid Climates
find this at:
www.buildingsciencepress.com




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Resources

Building America
Mixed-Humid Climate Best Practices Guide
find this at:
www.buildingamerica.gov
(look for "publications")




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Rebuilding Greensburg A Seminar Series on Affordable, Energy Efficient Construction Techniques



Part 1: House Design and Foundation Systems
Date: September 8, 2007

- An overview of energy efficient and affordable house design
- Foundations and rainwater management

Part 2: Framing

- Advanced framing techniques
- Choosing the right windows and doors

Part 3: Mechanical Systems and Airtightness

- Build tight, ventilate right
- Mechanical system design and selection

Part 4: Enclosure


- Insulation – theory and installation practices
- Exterior cladding systems

Part 5: Finishes, Testing and Commissioning

- Measuring building performance
- Whole house commissioning and homeowner training

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Questions?

Before you go . . .

- **Sign up sheet for builders**

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