BUILDING SCIENCE FOR BUILDING ENCLOSURES

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Excellence in Building Science Education Workshop
Orlando, FL - January 13, 2011

Building Science Corporation
Boston, MA

University of Waterloo
Waterloo, Ontario

WHY DO WE NEED TO LEARN BUILDING SCIENCE?

WHAT DO WE NEED TO LEARN?

WHAT RESOURCES CAN THE UNIVERSITY OF WATERLOO PROVIDE?

BECAUSE BUILDINGS ARE CHANGING.

BECAUSE (ENVIRONMENTAL) PERFORMANCE MATTERS.

1. INCREASING THERMAL RESISTANCE

- Old buildings used energy leakage to dry materials and assemblies
- Increased airtightness
  - Reduces drying, interior RH increases
- Increased insulation = less drying
  - Colder exterior, colder interior
  - Wider swings
- White roofs, efficient lights, etc

2. CHANGE PERMEABILITY OF LININGS

- Low permeance exterior layers
  - Metal panels, precast concrete
  - OSB and foam vs skip wood sheathing
- Low permeance interior layers
  - Polyethylene, vinyl wall paper
  - Vinyl sheet flooring

3. WATER SENSITIVITY OF MATERIALS

- Moisture= mold growth
- Wood products
  - New growth vs old
  - Processing: plywood, OSB, particle board
  - Paper, Veneers
- Finishes
  - Drywall, ceiling tile

4. MOISTURE STORAGE CAPACITY

- Changing moisture storage
  - Concrete block / terra cotta
  - Rough cut wood / skip sheathing
  - Steel stud with exterior gypsum
- Orders of magnitude!
- Lightweight often low-impact

5. THREE-D AIRFLOW NETWORKS

- Hollow walls
- Taller buildings

FIVE FUNDAMENTAL CHANGES

1. Increasing Thermal Resistance
2. Changing Permeance of Enclosure Linings
3. Water/Mold Sensitivity of Materials
4. Moisture Storage Capacity
5. 3-D Airflow Networks

Building America Special Research Project: High-R Walls Case Study Analysis

Research Report - 0903

March 11, 2009 (rev. 8/7/09)

John Straube and Jonathan Smegal

Abstract:

Many concerns, including the rising cost of energy, climate change concerns, and demands for increased comfort, have lead to the desire for increased insulation levels in many new and existing buildings. More building codes are being modified to require higher levels of thermal control than ever before. This report considers a number of promising wall systems that can meet the requirement for better thermal control. Unlike previous studies, this one considers performance in a more realistic matter, including some true three-dimensional heat flow and the relative risk of moisture damage.

Whole wall R-values for all of the assemblies were calculated using Therm and the summary is shown in Table 16 below. In some of the analyzed cases, different types or thicknesses of insulation may be used depending on climate zone and local building practice. An attempt was made to choose the most common strategies and list all assumptions made for wall construction.

Table 16 : Summary of all calculated R-values

Case	Description	Whole Wall R-value	Rim Joist	Clear Wall R-value	Top Plate
1bii	2x4, 16"oc, R13FG + OSB (25%ff)	**10.0**	9.8	10.1	9.8
1b	2x4 AF, 24"oc, R13FG + OSB	**11.1**	9.8	11.5	9.8
1aii	2x6, 16"oc, R19FG + OSB (25%ff)	**13.7**	12.3	14.1	12.5
6a	SIPs (3.5" EPS)	**14.1**	12.3	14.5	10.6
1a	2x6 AF, 24"oc, R19FG + OSB	**15.2**	12.3	16.1	12.5
7a	ICF - 8" foam ICF (4" EPS)	**16.4**		16.4	
8b	2x6 AF, 24" o.c., 5.5" R21 0.5 pcf SPF, OSB	**16.5**	13.1	17.2	16.6
7c	ICF - 14" cement woodfiber ICF with Rockwool	**17.4**		17.4	
9	2x6 AF, 24"oc, 2" SPF and 3.5" cellulose	**17.5**	13.2	18.4	17.7
8a	2x6 AF, 24" o.c., 5" 2 pcf R29 SPF, OSB	**19.1**	13.6	20.3	19.5
2a	2x6 AF, 24"oc R19FG + 1" R5 XPS	**20.2**	18.5	20.6	20.3
7b	ICF - 15" foam ICF (5" EPS)	**20.6**		20.6	
3	2x6 AF, 24"oc, 2x3 R19+R8 FG	**21.5**	13.4	23.5	18.4
4	Double stud wall 9.5" R34 cellulose	**30.1**	14.4	33.5	28.8
12	2x6 AF, 24"oc, EIFS - 4" EPS	**30.1**	23.8	31.4	31.1
10	Double stud with 2" 2.0 pcf foam, 7.5" cell.	**32.4**	15.9	36.2	28.5
2b	2x6 AF, 24"oc R19FG + 4" R20 XPS	**34.5**	29.0	35.6	35.4
6b	SIPs (11.25" EPS)	**36.2**	14	41.6	28.2
5	Truss wall 12" R43 cellulose	**36.5**	18.6	40.5	34.4
11	Offset frame wall with ext. spray foam	**37.1**	18.8	40.6	41.9

*AF - Advanced Framing

Figure 15 : Installation of high density spray foam in an Offset Framed Wall in a cold climate

In the case of new construction, wood sheathing may not be necessary on the exterior of the structural wall framing to support the spray foam. Removing the sheathing would decrease the cost and work considerably. Other membranes, such as housewraps may be used to support the foam during installation, but more analysis and research may be required before installing spray foam directly on housewraps.

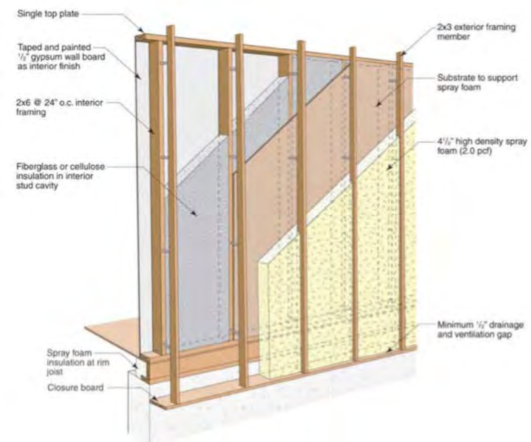


Figure 50 : Offset frame wall construction with exterior spray foam

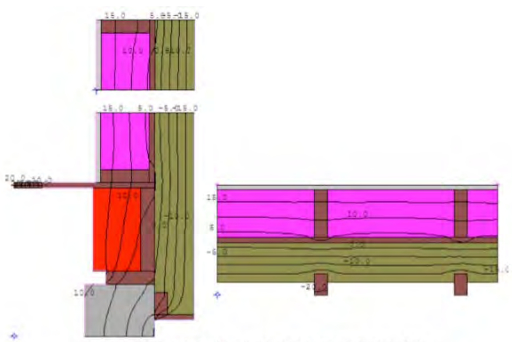


Figure 51 : Therm analysis of an offset truss wall with exterior spray foam

Table 14 : Calculated whole wall R-value for an offset framed wall with exterior spray foam

Case	Description	Whole Wall R value	Rim Joist	Clear Wall R value	Top Plate
11	Offset frame wall with ext. spray foam	**37.1**	18.8	40.6	41.9

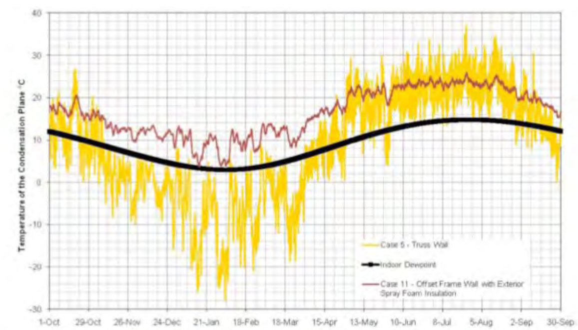


Figure 16 : Winter time air leakage condensation potential for Case 5 and Case 11

There are other advantages to an offset frame wall with exterior foam besides the decreased risk for condensation potential in the enclosure. A house can be dried in very quickly with exterior spray foam insulation, which means that the house is weather proof against rain and snow. This is very important in arctic regions with a very short construction season. Once the foam is installed on the exterior, interior work such as insulation, drywall and finishes can be finished as desired.

There were complaints from the remote areas of Northern Canada (according to the NRC) that when foam board was shipped to be used as exterior insulation, it always arrived broken, which is why they preferred not to use it. High density spray foam is shipped as two liquid components that are combined during the foam installation process. Many more board feet of spray foam can be shipped on the same truck than the

GREEN BUILDING

WE ARE AT THE BEGINNING OF THE END OF THE BEGINNING

Architecture Students

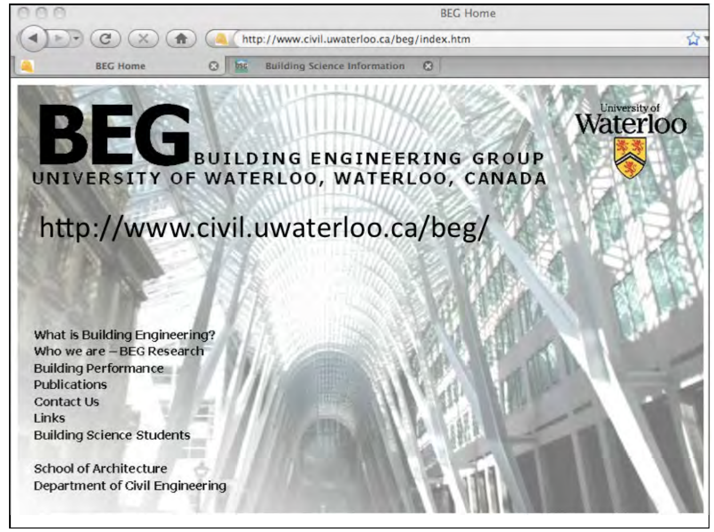
- Undergraduate
  - Core courses: Construction technology (2), HVAC course, Building Science
  - Design Studio
    - we are trying! (students want this and there is a willingness on the part of the faculty)
    - 4th year Comprehensive Building Design course
- Graduate
  - Building Enclosures and Mechanical Systems
  - Special Topics in Sustainable Design

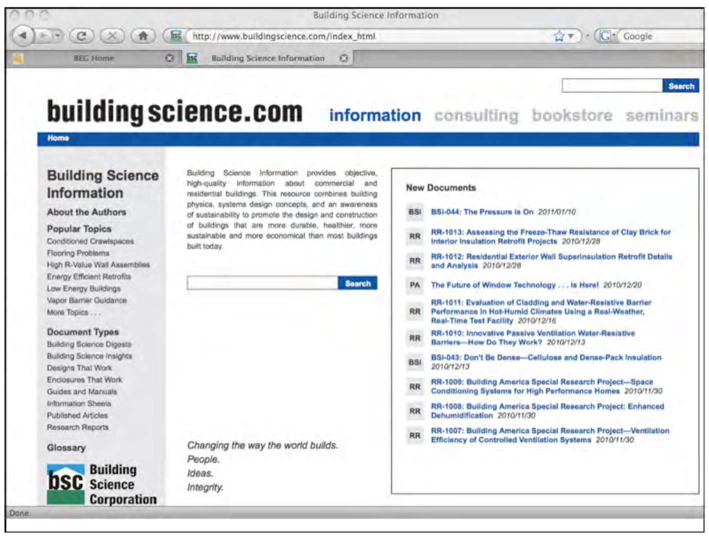
Engineering Students

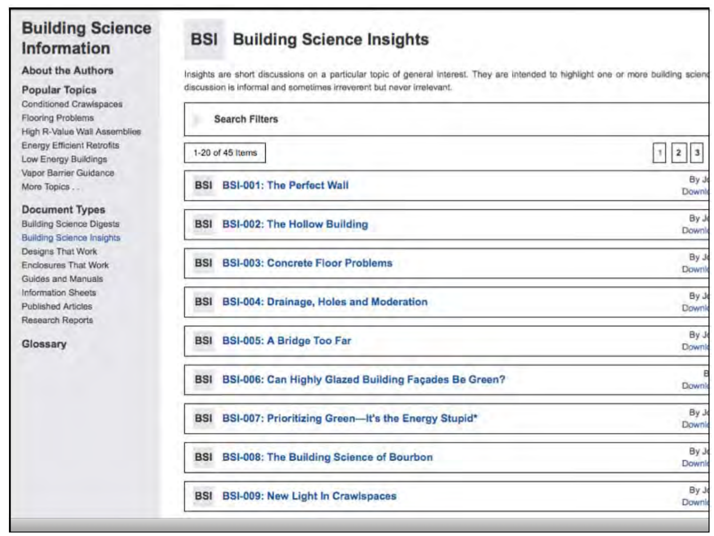
- Undergraduate
  - Learn about heat and gas and fluid dynamics (builds on other standard engineering courses) Calculate dew point, air leakage condensation, air flow through holes, 1 and 2 D heat flow. Background to computer calculations. Demonstration WUFI – but spreadsheet calculation only unless fundamentals are well understood
  - Other engineering courses: Mechanical Engineering – energy transfer in buildings (process, equipment), new course on low energy building mechanical systems, new course on modeling for sustainable energy technology
- Graduate
  - Building Physics
  - Computer modeling
  - Renewable energy systems courses

U of T – Building Science Case Studies course
McMaster – Masonry course

WHAT RESOURCES CAN THE UNIVERSITY OF WATERLOO PROVIDE?







BSD Building Science Digests

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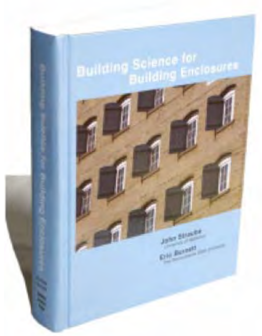

Building Science for Building Enclosures

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