Overview of Key Activities
Discussion/Forum on BSE Priorities
Future Direction/Steps

Patrick Huelman, John Straube, Theresa Weston, Bill Rose, Sam Taylor

December 6, 2016 – Clearwater, FL

Joint Committee on Building Science Education

& NIBS-BETEC Education Committee

http/www.BuildingScienceEducation.net

BUILDINGS XIII CONFERENCE

This Evening's Agenda

- Introductions
- Overview by Joint Committee & BETEC Education
  - Pat Huelman/John Straube; Georg Reichard/Theresa Weston
- DOE Overview: 2017 Race to Zero; BSE Solution Center
  - Sam Rashkin – Chief Architect, DOE Building Technologies Office
- Discussion/Forum: Input for Joint Task Group Priority Projects
  - Supporting *Building Science Fundamentals* (B.S. 101) for Schools
  - Developing a *"Hygrothermal Analysis Guide"* to support RTZ faculty & students
  - Encouraging *Infusion of B.S.* into traditional courses (need input – model syllabi, lecture modules, supplemental resources)
- Next Steps
  - Critical needs
  - Potential resources
- Adjourn to the Reception

This Week's (& Next Year's) Work

- Initiate Discussions/Inputs into Joint Task Group Priorities
  - Critical side meetings at this conference
  - Future inputs via email and web meetings
- With a Focus on Priority Products
  - Intro to Building Science Fundamentals
  - Hygrothermal Analysis Guide – initial focus is on RTZ
    - Technical approach
    - Levels of analysis
  - Infusion of BSE into Traditional Courses
    - Critical core competencies matching desired proficiency levels
    - Focused on key target courses and content/resources
- Address Next Steps/Schedule

Overarching Goal

- To improve building science education, in general
  - Quantity
  - Quality
- But in particular for the Joint Committee, a focus on degree programs for building professionals
  - Associate
  - Undergraduate
  - Professional
  - Graduate

Desired Outcome

- To ensure all students in building design, engineering, construction, and operations will graduate with:
  - a substantive “building science fundamentals” course (preferably early in their program),
  - solid “building science” concepts infused into their traditional coursework,
  - well-designed experiential learning opportunities,
  - access to specialized, in-depth building science coursework.

Mission of Joint Committee for Building Science Education

- Support a critical transformation of the education and training of the design and construction industry, such that its professionals:
  - Are educated, trained, and certified in building science and related advanced design and construction management practices;
  - Can routinely design, build (renovate or fix), and operate quality high-performance buildings that are safe, healthy, durable, comfortable and very energy efficient;
  - And will provide the highest value to their clients.

Progress Since "BUILDINGS XII"

Highlights of Outreach Activities

- BUILDINGS XXII – BSE Update -December 2013
- Building Science Education Workshops
  - Toronto BSE Workshop, April 2014 - Issues
  - Arlington BSE Workshop, Jan. 2016 - Solutions
  - Penn State Conference, March 2016 - BSE Session
- Ongoing Web Meetings – Both BETEC & Joint Task Group
- Support for DOE Race to Zero & BSE Solution Center
- Organize the Westford BSE Updates (2014, 2015, 2016)
- Special Briefings: ASHRAE, DOE, EEBA, etc.
- BUILDINGS XXIII – BSE Update – December 2016

Important Themes

- Using a broad definition for “building sciences”.
- Focus => Building science KSA’s needed to plan, design, analyze, construct/renovate, and commission quality, high-performance buildings.
- Prioritization => Health, Safety, Durability, IAQ
  - First: Ensure no harm, no foul, no lawsuits;
  - Second: Make it energy and resource efficient;
  - Everything else (daylighting, passive, green, sustainable) must fit within these two overarching priorities.

- Note: “Core Competencies for A/E Firm New Hires” and “DOE BSE Guidelines” are available.

Critical Pathways for Success

- 1. Focus early efforts on "baby steps"
  - Promote a dedicated building science fundamentals course,
  - Support infusion of building science into traditional coursework and teaching resources,
  - Encourage special higher level building science technical electives.
- 2. Provide easier access to building science resources
  - Promote excellence in building science teaching texts and support materials.

Critical Pathways for Success

- 3. Ensure best practices
  - Up-to-date access to research results
  - Connection to real world applications.
- 4. Support and expand building science experiential learning (RTZ) that is paired to academic learning
- 5. Support graduate building science programs to increase future teaching capacity.

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NIBS/ASTM/JCBSE BSE Workshop

Solutions for Building Science Education – Jan. 11, 2016

EXCELLENCE IN BUILDING SCIENCE EDUCATION
Transforming the Design/Construction Profession
Joint Committee on Building Science Education

Building Enclosure Technology and Environment Council
a council of the National Institute of Building Sciences

NIBS/ASTM/JCBSE WORKSHOP on Building Science Education

- Workshop Reflected Broad, High-Level Support
  - Keynote addresses from industry & academic leaders
  - Leadership of AIA, ASHRAE, ASC, SBSE, etc.
- Presentations Focused on Solutions
  - Sharing pedagogical approaches
    - Infusion of building science principles
    - Building science fundamentals and beyond
    - Pairing of academic & experiential learning
  - Current state of building science resources
    - Textbooks, supplemental materials
    - Need for best current science

Penn State Residential Conference
Building Science Education Session

Joint Committee Presentation:

"Not So Difficult" Approaches to Improve Building Science Education in Collegiate Design & Construction Programs

March 2016

EXCELLENCE IN BUILDING SCIENCE EDUCATION
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Joint Committee on Building Science Education

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Prioritization of Building Science Key Assumptions

- Priority building science requirements
  - Health & safety, building durability, IAQ, & energy
- Priority damage functions (buildings & people)
  - Fire, smoke, and structure
    - essential, but addressed by codes and established practice
  - Moisture Management (Water, Water, and Water)!
    - critical and currently under-represented
  - Indoor Environmental Quality
    - very important and must become integrated
- Effectively dealing with damage functions
  - risk tolerant designs and work procedures (e.g. QM)

Conveying Key Building Science Concepts
Heat-Mass Transfer/Moisture Transport/IAQ

- Can these critical concepts be fit into existing courses?
  - Heat transfer, 2nd Law of Thermodynamics (simplified)
  - Psychrometrics, relative humidity (RH), dew point
  - Prioritized moisture transport mechanisms
  - Requirements for air flow
  - Functions of the enclosure; esp. environmental separation
  - Continuity of control layers; verification with pen test
  - Understanding hygrothermal performance of enclosures, including performance consequences of material/placement
  - HVAC systems; esp. ventilation and make-up air
- Within one or two modules is a huge challenge?
  - Currently a “work in progress”, but it has been done!

Building Science Resources
(Partial Listing)

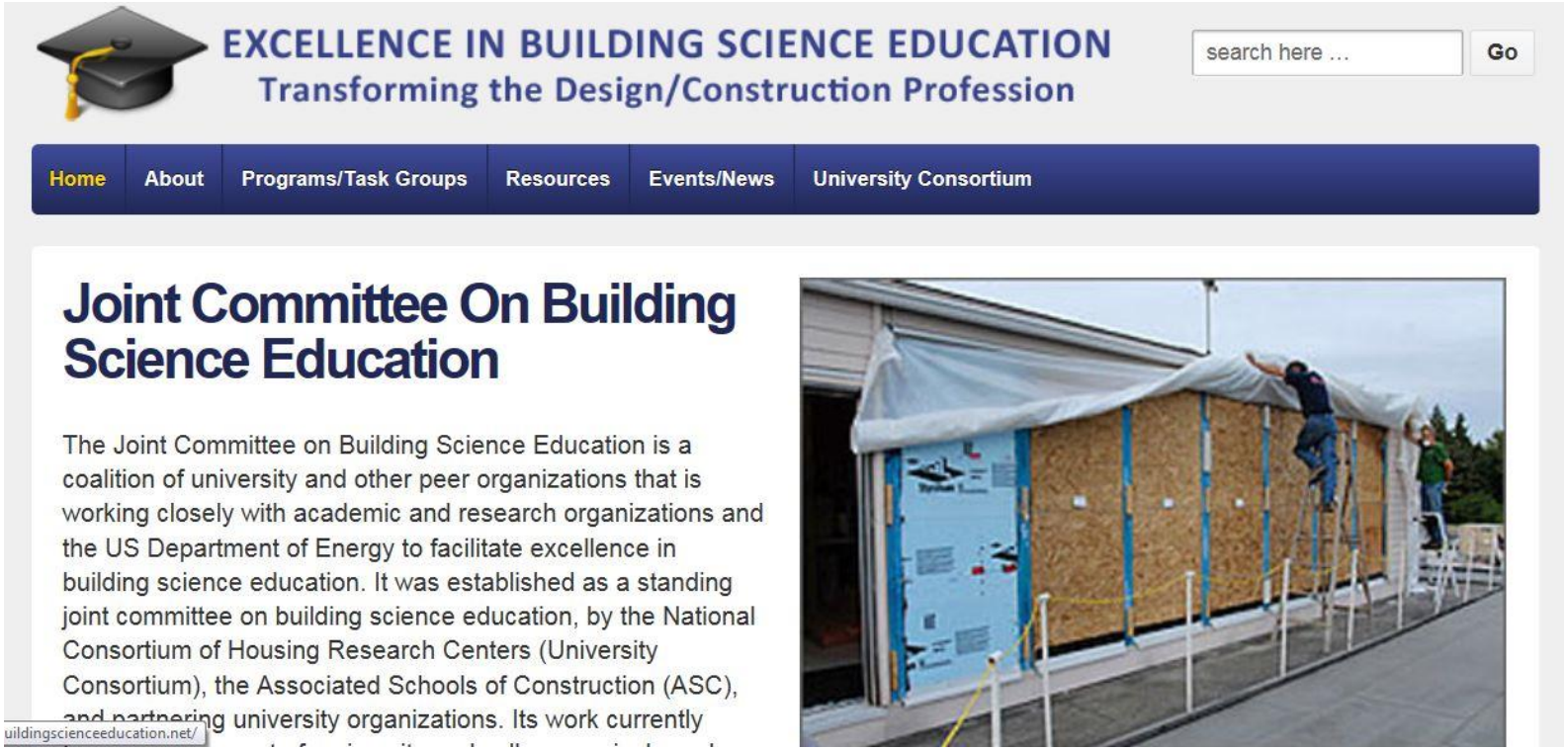
- Key Textbooks/References
  - ASHRAE Handbook of Fundamentals
  - High Performance Enclosures: Straube, J.
  - Understanding Psychrometrics: Gatley, D.
  - Water in Buildings: Rose, W.
  - Other resources under development
    - DOE/PNNL BSE Solution Center
    - Building Science Fundamentals: Lstiburek, J.
    - Building Science for Building Enclosures: Straube, J. & Burnett, E. 2nd Edition

Building Science Online Resources
(Partial Listing)

- DOE Building America Solution Center
  - https://basc.pnnl.gov/
- Building Science Corporation
  - www.BuildingScience.com/Information
- Building Science Labs
  - www.buildingsciencelabs.com/the-library/
- SBSE Website
  - www.sbse.org/resources/

Building Science Online Resources
(Partial Listing)

- Joint Committee Website
  - www.BuildingScienceEducation.net



Recognizing Great Progress

- Quality resources for teaching building science
  - Currently available or under development
- Improved access to building science research & best practices
  - DOE Building America BSE Solution Center
  - Other: ASHRAE, NIBS, BSC, BSL, Joint Committee
- Affirming opportunities for "infusion"
  - Traditional courses; associated teaching resources
- Excellent experiential learning opportunities
  - Race to Zero, etc.

Theresa Weston (for Georg Reichard)
NIBS-BETEC Education Committee

- Overview/Update/Announcements from BETEC

Sam Rashkin

Chief Architect – DOE Building Technologies Office

- Race to Zero Student Design Competition

- DOE/PNNL BSE Solution Center

Building Science Fundamentals

B.S. 101 - Dedicated Stand-Alone Course

- Strong desire for a required (or technical elective) course
- Provide adequate coverage of key concepts & principles
  - Heat & mass transfer
  - Hygrothermal performance of enclosures
  - HVAC, IAQ, etc.
- Variations have been taught at:
  - Waterloo, Penn State, Leuven, U-IL, U-MN, etc.
- Popular textbooks & resources
  - B.S. for Building Enclosures/High Performance Enclosures/B.S for Building Enclosures
  - Building Physics/Applied Building Physics
  - ASHRAE Handbook of Fundamentals
  - Online Articles: BSC, BSL, BA Solution Center, etc.

Building Science Fundamentals

B.S. 101 - Dedicated Stand-Alone Course

- Open Discussion
  - How?
  - Where?
  - When?
  - What?

Development of a "Hygrothermal Guide"

- Many faculty have expressed some hesitation or concerns about "best practices" to teach hygrothermal design, analysis, and evaluation.

- Determined to be especially important/desirable to support faculty and students in the Race to Zero.

- Is it possible (and useful) to create a "Schaum's Outline" type guide to assist faculty in teaching hygrothermal analysis?

Building Science Fundamentals

U-MN "Hygrothermal" Experience – "5 Steps"

- Establish Context, Principles, and Perspective
- Heat Transfer & Thermal Profiles
- Psychrometrics, Moisture Transport & Vapor Profiles
- Material Storage & Modeling
- Analysis, Interpretation & Synthesis

Note: This approach has been part of our senior capstone course for many years and successfully applied by our U of MN RTZ teams. A summary handout is available.

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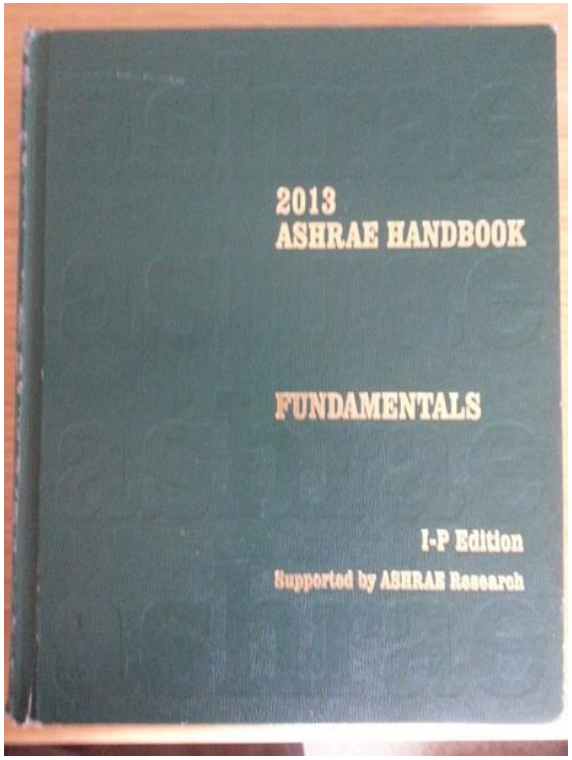
It Takes A Bookshelf

Building Science Fundamentals

U-MN "Hygrothermal" Experience

- Establish Context, Principles, and Perspective
  - Lstiburek: "The 5 Fundamental Changes"
    - Increased thermal resistance
    - Change in permeability of linings
    - Mold susceptibility of materials
    - Storage/redistribution of moisture
    - Uncontrolled 3-D airflow
  - Intro to …
    - Building science
    - Heat/Air/Moisture
    - Control layers

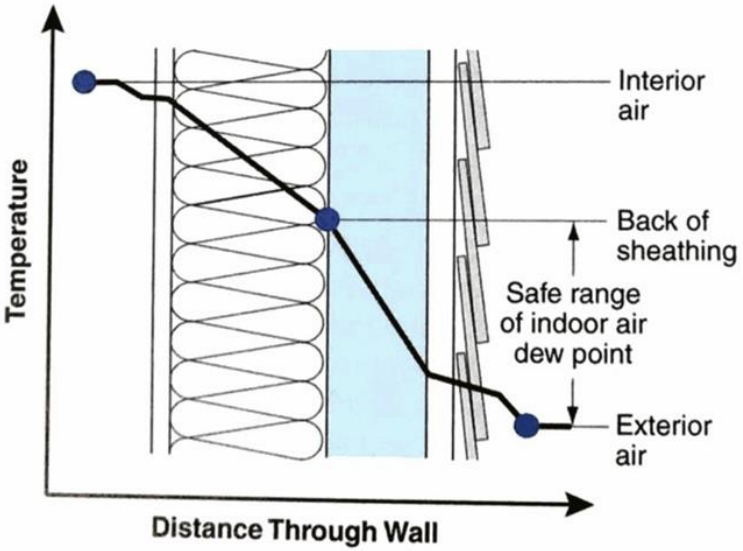


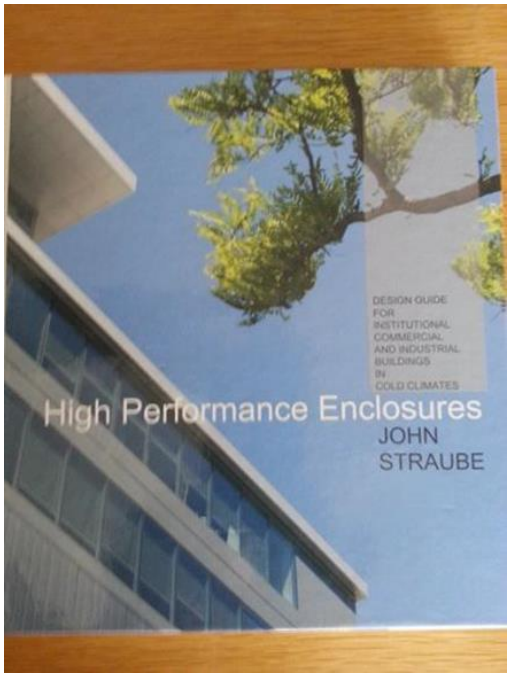
Building Science Fundamentals

U-MN "Hygrothermal" Experience

- Heat Transfer & Thermal Profiles
  - Temperature profile (hand calculations/spreadsheet)
  - Simplified (single surface) to detailed (each interface)

$$T_{back\ of\ sheathing} = T_{interior} - (T_{interior} - T_{exterior}) \frac{R_{batt}}{R_{total}}$$

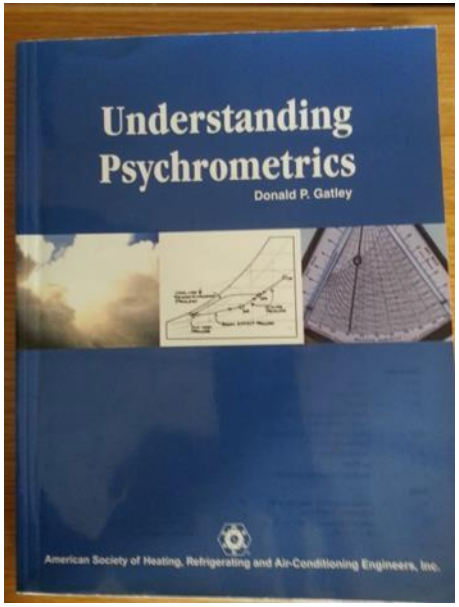




Building Science Fundamentals

U-MN "Hygrothermal" Experience

- Psychrometrics, Moisture Transport, Vapor Profiles
  - Enhanced Glaser (Dew Point) Method (spreadsheet)
  - WIB for context, BSBE for structure, ASHRAE for units



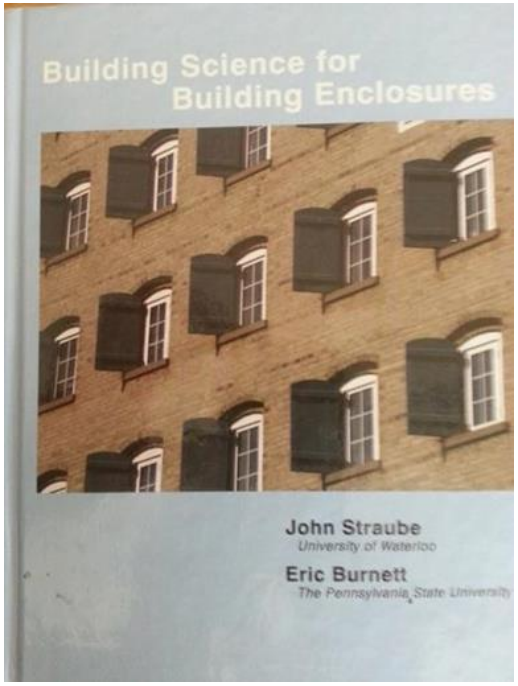
Component name	*R*-Value (hr-ft²-°F/Btu)	Permeance (gr/hr-ft²-in.Hg)	*r* perm (hr-ft²-in.Hg/gr)	Temperature (°F)	Saturation vapor pressure (in.Hg)	RH	Vapor pressure (in.Hg)
				T_i (=input)	svp_i (=f(T_i))*	rh_i (=input)	vp_i (=svp_i * rh_i)
				T_1			vp_1
	R_1 (from reference)	p_1 (from reference)	rp_1 (= 1/p_1)				
	R_2 (from reference)	p_2 (from reference)	rp_2 (= 1/p_2)	T_m =(T_1 R_2 + T_2R_1)/(R_1+R_2)	svp (=f(T_m))*		vp_m =(vp_1 rp_2 + vp_2 rp_1)/(rp_1+rp_2))
				T_2			vp_2
				T_o (=input)	svp_o (=f(T_o))*	rh_o (=input)	vp_o (=svp_o * rh_o)

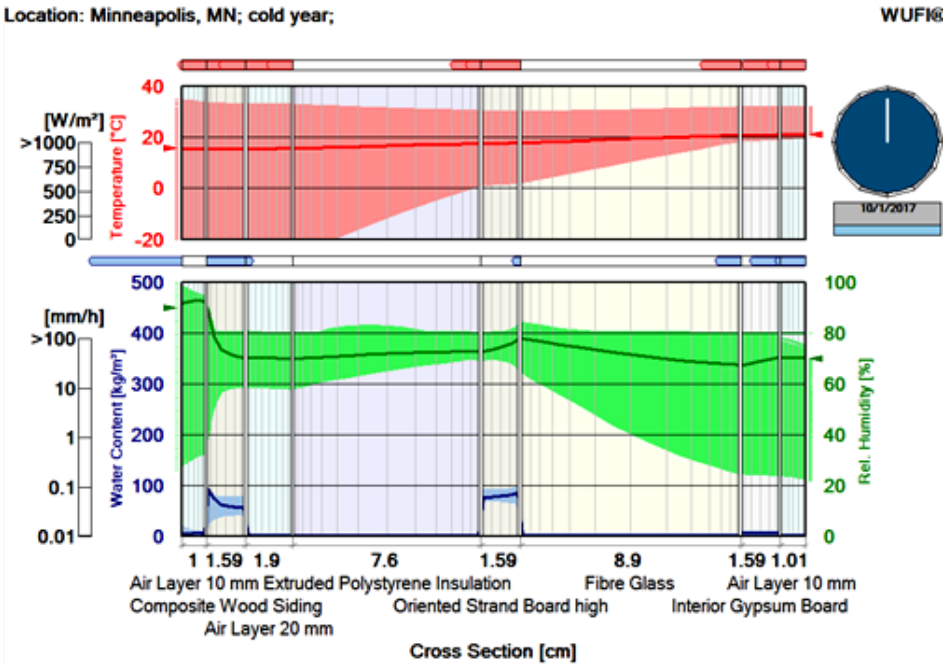
*See Appendix B for the function converting temperature F to saturation vapor pressure.

Building Science Fundamentals

U-MN "Hygrothermal" Experience

- Material Storage & Modeling
  - BSBE: Chapter 8 (materials); Chapter 6 (examples)
  - 1-D coupled heat/moisture analysis (WUFI software)

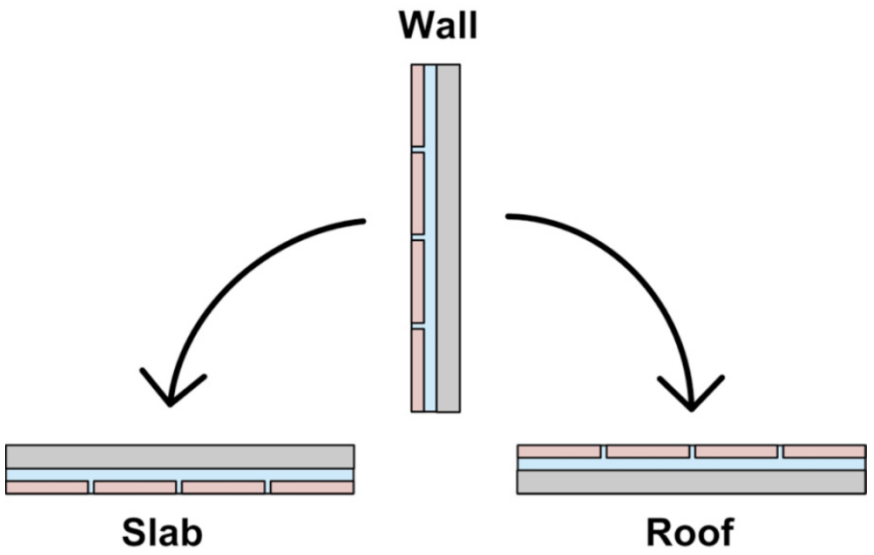




Building Science Fundamentals

U-MN "Hygrothermal" Experience

- Analysis, Interpretation, & Synthesis
  - Review limitations of each approach
  - Compare and contrast results
  - Step away from the edge!
    - The Perfect Enclosure



Development of a "Hygrothermal Guide"

- The Progression???
  - Establish Context, Principles, and Perspective
  - Heat Transfer & Thermal Profiles
  - Psychrometrics, Moisture Transport & Vapor Profiles
  - Material Storage & Modeling
  - Analysis, Interpretation & Synthesis

Development of a "Hygrothermal Guide"

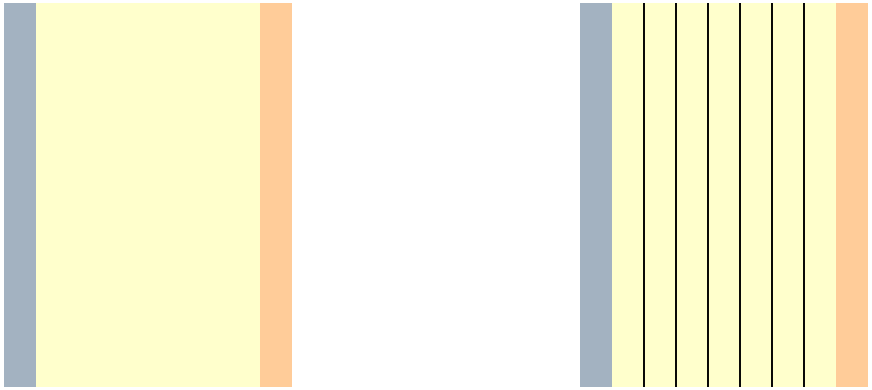
- Levels and/or Depth???
  - Qualitative Approaches
  - Quantitative Approaches
    - Simple hand calculation
    - Extended spreadsheet calculations
    - Modeling & simulation
  - Precedence/Prior Experience/Intuition

Development of a "Hygrothermal Guide"

- Other Approaches
  - Georg Reichard
  - John Straube
  - Bill Rose
- Open Discussion

Hygrothermal Profile

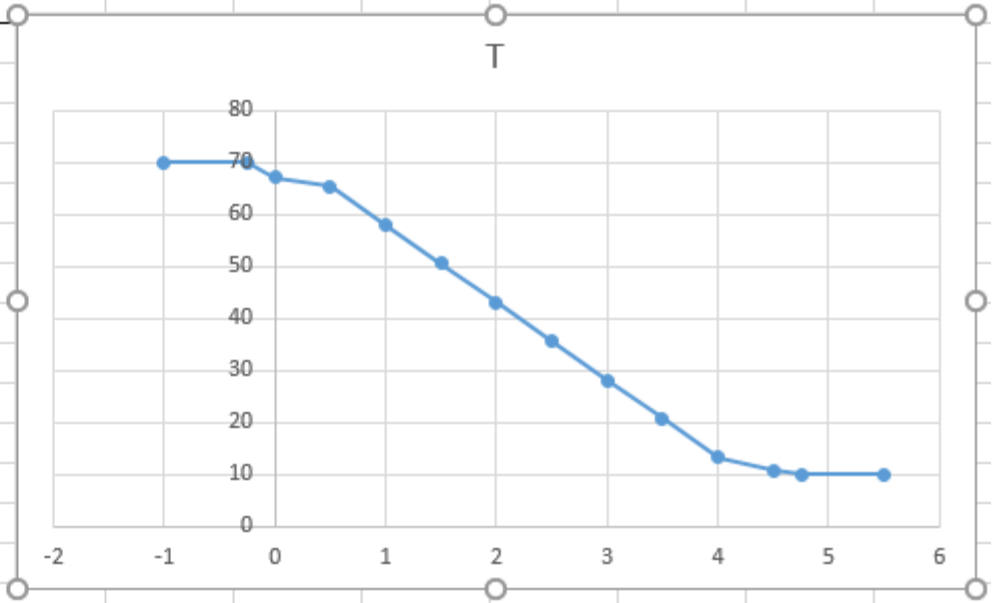
- For this exercise building component with the following layer composition is given (from inside to outside):
  - ½" Gypsum board (drywall)
  - 3½" Fiberglass batt insulation
  - ½" Plywood sheathing



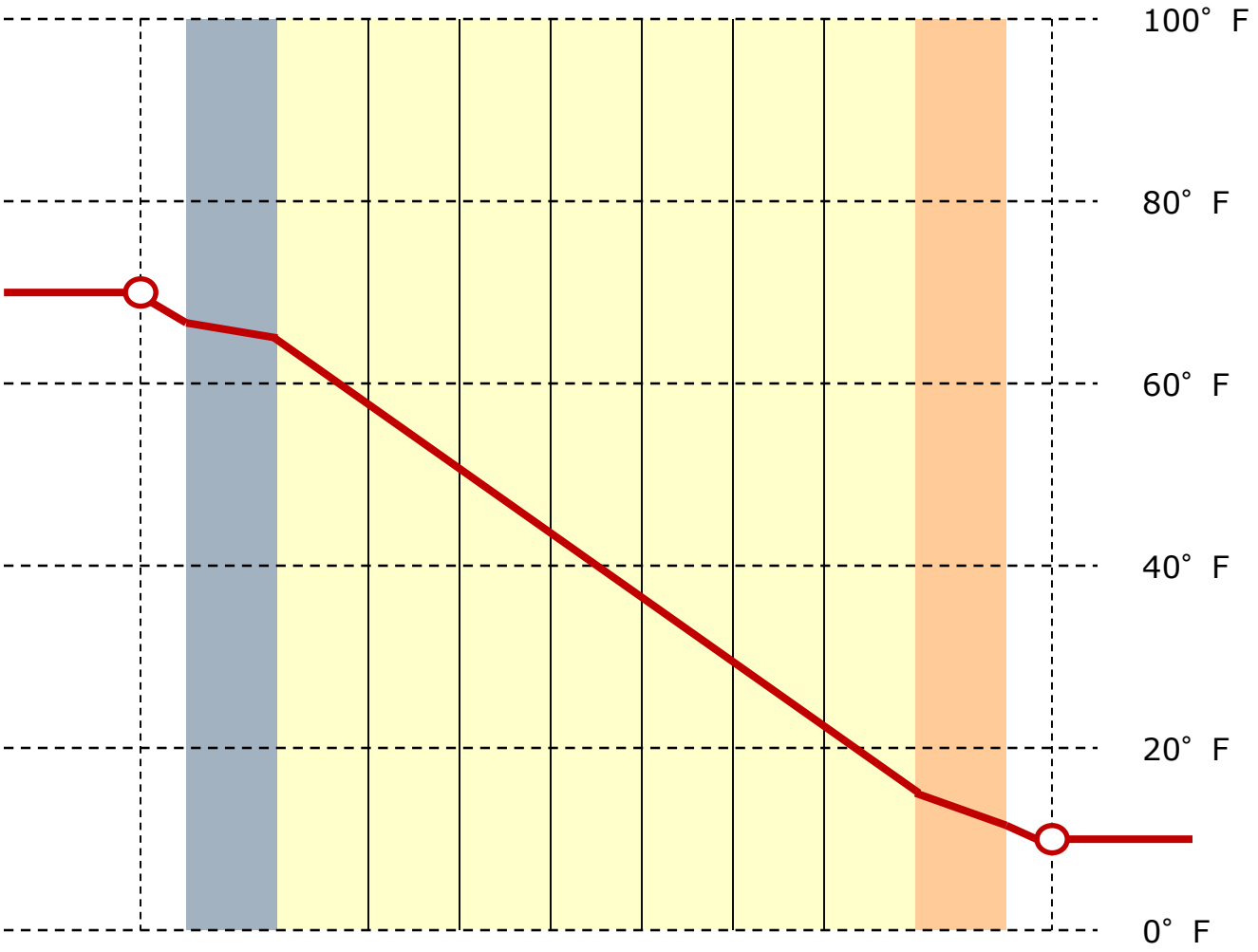
Create the graph

- Select "x" and "T" column
- Insert "Scatter Plot" (e.g. with straight lines and markers)

x	Layer name	t (in)	k	C (BTUh/sf.F)	R	dT (°F)	T (°F)
-1							70
-0.25							70
0	inside				0.68	2.74	67.3
0.5	Gypsum	0.5		2.22	0.45	1.82	65.4
1	Fiberglass	0.5	0.27	0.54	1.85	7.46	58.0
1.5		0.5	0.27	0.54	1.85	7.46	50.5
2		0.5	0.27	0.54	1.85	7.46	43.1
2.5		0.5	0.27	0.54	1.85	7.46	35.6
3		0.5	0.27	0.54	1.85	7.46	28.1
3.5		0.5	0.27	0.54	1.85	7.46	20.7
4		0.5	0.27	0.54	1.85	7.46	13.2
4.5	Sheathing	0.5		1.6	0.63	2.52	10.7
4.75	outside				0.17	0.69	10.0
5.5							10
				RT =	**14.89**	ΔT =	**60**



Temperature Gradient

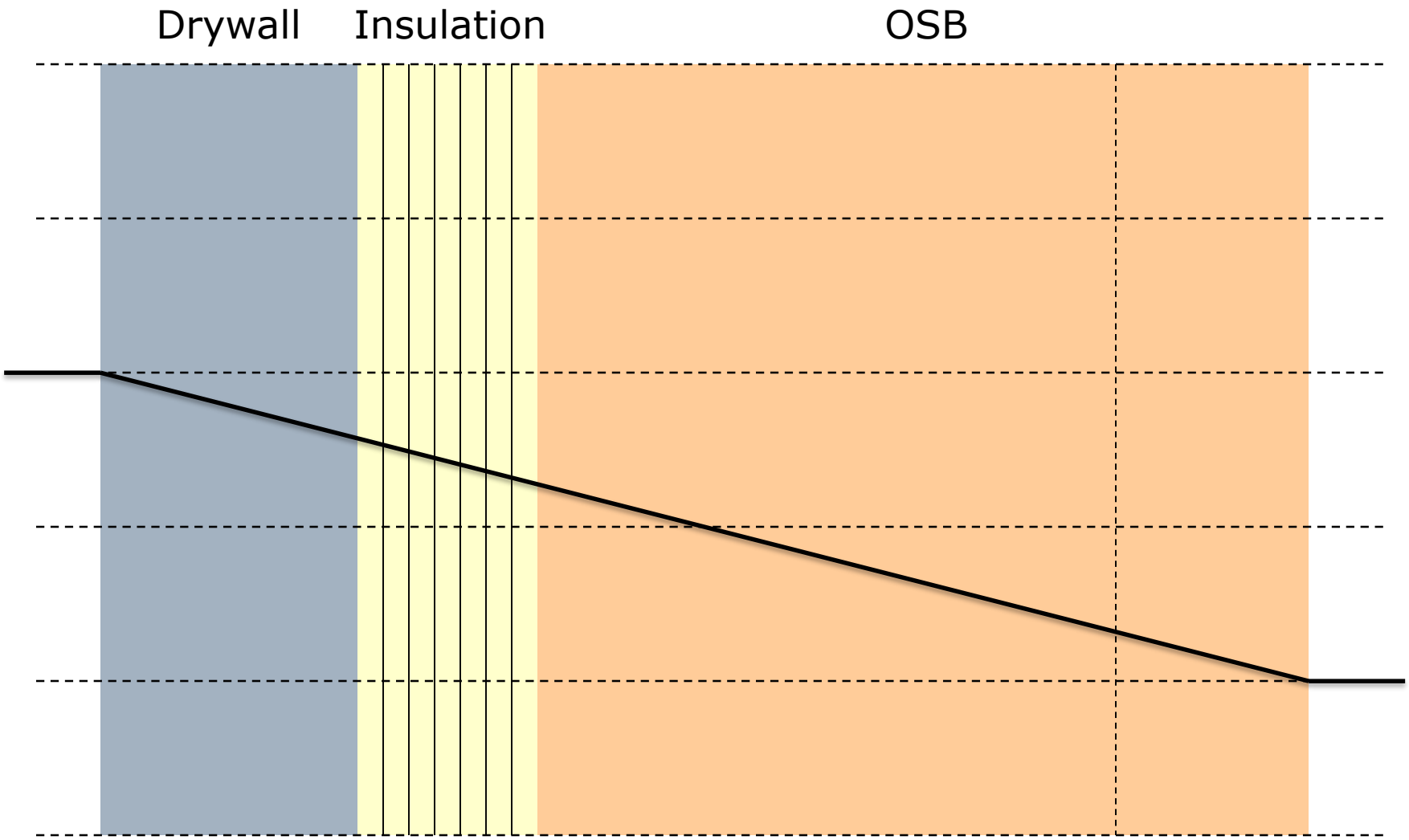


New running variable for depth

	A	B	C	D	M	N	O
1				in	perm -in	in	in
2		x	Layer name	t	μ"	aet	vx
3		-1			120		
4		-0.3	air				
5		0	inside				0.0
6		0.5	Gypsum	0.5	15.0	4.00	4.0
7		1	Fiberglass	0.5	118	0.51	4.5
8		1.5		0.5	118	(	=O7+N8
9		2		0.5	118	0.51	5.5
10		2.5		0.5	118	0.51	6.0
11		3		0.5	118	0.51	6.5
12		3.5		0.5	118	0.51	7.1
13		4		0.5	118	0.51	7.6
14		4.5	Sheathing	0.5	5.00	12.00	19.6
15		4.75	outside				
16		5.5	air				
17				t_T = 4.5	aet_T =	19.56	

- We need a new running variable for the depth x as we progress through layers
  - Start at 0
  - Add individual equivalent thicknesses (aet_i)
  - End should be the same as total air equivalent thickness aet_T

Vapor pressure gradient through permeability equivalent thickness



Development of a "Hygrothermal Guide"

- Open Discussion
  - Is this going in the right direction (for this audience)?
  - Where does it make sense?
  - What needs to be altered
  - What needs to be added?
  - Are there alternative methods to assess?

Building Science Infusion & Fundamentals (Research Underway)

- Infusion of Building Science into Traditional Courses (see Website)

- Near Term – Improve Traditional Courses
  - Review curricula, texts, slides
  - Provide best practice errata (slides/handouts) to counter bad practices and misleading resources
  - Introduce “why” of best building science practices

Building Science Infusion & Fundamentals (Research Underway)

- Longer Term – Key Textbooks/References
  - Infusion of building science best practices into textbooks & associated supporting materials (slides, etc.)
  - Identify & engage authors and reviewers
    - Please Identify and Share
  - Recommended Target Courses for Infusion
  - Recommended Modules/Other Resources
- Note Online BSC and BSL resources

Building Science Infusion
Priority Targets

- Environmental Controls I & II (or Environmental Systems I & II)
  - Typically touches on heat transfer and air flow
  - Generally includes discussion of RH & IAQ
  - Popular references/texts include:
    - Mechanical & Electrical Equipment for Buildings: Grondzik, W., Kwok, A., Stein, B., Reynolds, J.
    - Heating, Cooling, Lighting: Sustainable Design Methods for Architects: Lechner, N.

Note: We are looking for current instructors to assist us in evaluating syllabi, texts, and resources.

Building Science Infusion
Priority Targets

- Materials & Methods I & II (aka Construction Technologies I & II)
  - Typically touches on enclosure design
  - Can include discussion of moisture, RH
  - Popular references/texts include:
    - Building Construction: Mehta, M.
    - Building Construction Illustrated: Ching, F.
    - Fundamentals of Building Construction: Allen, E., Iano, J.

- Note: We are looking for current instructors to assist us in evaluating syllabi, texts, and resources.

Building Science Infusion
Priority Targets

- Other Potential Course Targets
  - Construction Documentation
  - Construction Project Management
  - Systems Integration
  - Sustainable Design
  - ???

Building Science Infusion
Priority Targets

- Open Discussion
  - Are we pointed in the right direction?
  - Are there other critical targets
  - What methods can be used to reach the faculty?

Good News

- Significant progress is being made towards larger building science education goals and outcomes.
- Have achieved several short-term successes:
  - Uncovered a wealth of building science teaching resources that are (or will be) readily available,
  - Demonstrated that it is “not so difficult” to infuse building science into existing courses, and
  - We have several experiential learning opportunities to reinforce building science best practices.

Our Challenge

- Short-Term Objectives
  - Increase, improve, share building science resources
  - Continue to support “building science infusion”
  - Push for building science fundamentals courses
  - Expand experiential learning opportunities
- Medium-Term Targets
  - Push for revision of curriculum, credentials, accreditation, etc. to incorporate building science
- Long-Term Goals
  - Support graduate education and research in building science, so we will have future teachers and mentors

Please …

- Help us identify successful building science programs, courses, or modules.
- Work with “us” to review existing and potentially new building science materials and resources.
- Consider sharing your knowledge, experiences, and resources for use by others.

Thank You

- Be sure to visit the JCBSE website
  - www. BuildingScienceEducation.net

- Contact information
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