1. ESCALATING EXCELLENCE in ENVELOPES: stories from practice
2.

**Attitude Habits**

- **Be Bold** — make suggestions, bring up ideas, and set fear aside when confronted with new knowledge.

- **Be Committed** — keep the long view in mind and base decisions on getting closer, consistently.

- **Be Curious** — a list of stagnant questions is not enough, delve into the whys, why-nots and the how.

**Expertise Habits**

- **Be Knowledgeable** — this is about wisdom and applied experience and knowing what you don’t know.

- **Be Innovative** — don’t rest on what always has been — what applies to this moment and how do we do it?

- **Be Realistic** — limits define creativity, so understand and accept the limits so you can excel within them.

**Interdependence Habits**

- **Be Inclusive** — each design problem shows us that systems work together; people included.

- **Be Ready** — you must be ready for many changes and also not berate yourself in hindsight.

- **Be Celebratory** — thank your team, hold up success for others to see and love the moment you are in.
ESCALATING EXCELLENCE in ENVELOPES

stories from practice
Opaque Assemblies
Don't be Thick(e) about it...
The Code says...
Choose, identify your choice, and comply with:

The Code Book:
ASHRAE or IECC (or State Code as Applicable)

Compliance Path:
- Prescriptive R-Value
- Prescriptive U, C and F factor
- Component Trade-off (COMcheck or REScheck)
- Performance (modeling)
Challenges

The team moving together and in the same direction.

Transitions, transitions, transitions, oh my.

"The way we've always done it."

"You can only meet two: money, time, quality."
**Do the work**

**Compliance paths**

<table>
<thead>
<tr>
<th>R-Value</th>
<th>U, C, and F-Factor</th>
<th>Envelope Trade-Off</th>
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<tbody>
<tr>
<td>OK to average insulation</td>
<td>NO</td>
<td>YES, within component</td>
</tr>
<tr>
<td>Include full assembly</td>
<td>NO, just insulation</td>
<td>YES</td>
</tr>
<tr>
<td>Address non-stud thermal bridging</td>
<td>NO</td>
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And there is always Performance Modeling.
### Do the work

#### Compliance paths

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And there is always Performance Modeling.
You average the U!

If you average the R values (NO-NO) then -
(2 + 6 + 10) / 3 = R of 6
(again BIG NO)

Average the U-Factors (YES!!)
- (.5 + .17 + .10) / 3 = U of 0.26

This is an R of 3.9 (Correct)
Insulation Above Roof:  
**Rigid Mineral Fiber**  
*R-Value vs. U-Factor*  
Prescriptive Methods

- **R-3.7 per inch**

**R-Value: R-30 Minimum**
regardless of additional insulation thickness needed for tapering to drains

- **8.5” Mineral Fiber minimum**

**U-Factor: U 0.032 Max.**
Single-slope insulation options

- **U-0.032 (Avg.)**
  - 7” to 9½” Mineral Fiber
  - 6” to 11” Mineral Fiber
  - 5” to 12½” Mineral Fiber
  - 4” to 14½” Mineral Fiber

← distance doesn’t matter →
"... C402 Building Envelope requirements allow for EITHER; C402.1.3 Insulation component R-value-based method, OR, C402.1.4 Assembly U-factor, C-factor or F-factor-based method.

One could choose to provide a compliance path per Section C402.1.4 thereby averaging the roof insulation by U factor (rather than “R” value) of the entire roof assembly, and therefore not be concerned with limiting insulation thickness variation by “R” value, as is required by Section C402.1.3.”

Joseph Hill, RA
Assistant Director for Code Administration
NYS Division of Building Standards and Codes
31 Aug 2017
Averaging Insulation

1. Identify and tally areas with different insulation patterns.
2. Calculate average R-value for each area, using tables or other methods (do NOT average depth).
3. Invert \( U = 1/R \) for each area.
4. Tally total \( U \times A \) for all areas.
5. Divide by total area to get average U-factor for total area.

Joseph Hill, P.E.
Assistant Director
NYS Division
31 Aug 2017
Figure 3: Nominal and Clear Wall Insulation R-values (after ASHRAE 90.1-1999) for Several Different Stud Materials and Insulation
Assembly U, C, & F, and More!

... But C402.1.4 takes into account the insulating value of entire assembly:
  + Air films
  + Gypsum board
  + Cavity insulation
  + Framing
  + Sheathing
  + Vapor barrier
  + Continuous insulation
  + Siding

And C402.1.5 is for Compliance Performance Alternative -

A+B+C+D+E ≤ 0

- A is the sum of the UA Dif for envelope assemblies
- B is the sum of the FL Dif for slab edge
- C is the CA Dif for below grade walls
- D is the excess vertical glazing area
- E is the Excess skylight area
Walls are 5 x better

Options for additions:
- Addition alone complies
- Addition PLUS existing building complies

IECC Comm. Zone 5
- Walls: U-0.064
- Windows: U-0.38
ECCC 2015 Climate Zones 5 and 6
- Insulation Above Roof - U-0.032 (R-31.25)
- Polyisocyanurate LTTR R-5.7/inch
- Prescriptive R-Factor or
- Unpitched Prescriptive U-Factor: 5.5" Thick

4" at drain → R-22.8  R Max needs to be R-36 → 6.5"
3" at drain → R-17.1 R Max needs to be R-40 → 7.0"
2" at drain → R-11.4 R Max needs to be R-46 → 8.0"
1" at drain → R- 5.7  R Max needs to be R-51 → 9.0"
Habits

- Attitude
- Expertise
- Interdependence

[Diagram with icons representing different habits]
Fenestration

EXPERT KITCHEN TIP
Q. DO YOU KNOW HOW TO MAKE CRYSTAL CLEAR ICE?
A. SIMPLY BOIL THE WATER AND LET IT COOL. BOIL AGAIN AND LET IT COOL. POUR INTO
Let's clear this up.

The Code says - Windows are valuable in so many ways: balance of light, visibility, and energy control

<table>
<thead>
<tr>
<th>ENERGY PERFORMANCE RATINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Factor (U, S, I, P)</td>
</tr>
<tr>
<td>Solar Heat Gain Coefficient</td>
</tr>
<tr>
<td>0.35</td>
</tr>
<tr>
<td>0.32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADDITIONAL PERFORMANCE RATINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible Transmittance</td>
</tr>
<tr>
<td>Air Leakage (U, S, I, P)</td>
</tr>
<tr>
<td>0.51</td>
</tr>
<tr>
<td>0.2</td>
</tr>
</tbody>
</table>

- Condensation Resistance: 51

What do you need to know:
- U-factor
- SHGC
- VT
- Projection above window
- Infiltration rating

As well as:
- Daylight Zone
- WWR
- Controls
- Installation details
Windows are complex

A big design issue is WWR.

Windows are never as good as walls and yet so many “green buildings” are fully glass buildings.

Solutions:
- Good windows
- Placed where needed
- Installed correctly
- With daylighting controls
<table>
<thead>
<tr>
<th>Building Component</th>
<th>Residential (quads)</th>
<th>Commercial (quads)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heating</td>
<td>Cooling</td>
</tr>
<tr>
<td>Roofs</td>
<td>1.00</td>
<td>0.49</td>
</tr>
<tr>
<td>Walls</td>
<td>1.54</td>
<td>0.34</td>
</tr>
<tr>
<td>Foundation</td>
<td>1.17</td>
<td>-0.22</td>
</tr>
<tr>
<td>Infiltration</td>
<td>2.26</td>
<td>0.59</td>
</tr>
<tr>
<td>Window (conduction)</td>
<td>2.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Window (solar heat gain)</td>
<td>-0.66</td>
<td>1.14</td>
</tr>
</tbody>
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Windows are complex

A big design issue is WWR.

Windows are never as good as walls and yet so many "green buildings" are fully glass buildings.

Solutions:
- Good windows
- Placed where needed
- Installed correctly
- With daylighting controls
And where?

Don’t assume more is better
Check full assembly U-factors
And what about embodied carbon?
1 m² of window pane = 10.76 sf add for frame = 12.9
say 13 sf
1 kg = 2.2 lbs. 1 m = 3.28 feet

- Aluminum
  - 486 kg = 1070 lbs. /13 sf = 82 lbs. CO2e/sf
- PVC
  - 258 kg = 568 lbs. / 13 sf = 44 lbs. CO2e/sf
- Wood
  - 130 kg = 286 lbs. / 13 sf = 22 lbs. CO2e/sf

Source: http://www.mdpi.com/2075-5309/2/4/542/htm
The devil...

“The details are not the details. They make the design.”

Charles Eames
Mock-up and Test

The right details, done right.

Random testing of delivered units?
Habits

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Expertise</th>
<th>Interdependence</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>Brain</td>
<td>Handshake</td>
</tr>
<tr>
<td>Dartboard</td>
<td>Target</td>
<td>Backpack</td>
</tr>
<tr>
<td>Cat</td>
<td>Scales</td>
<td>Cake</td>
</tr>
</tbody>
</table>
Air barriers
Sometimes it is better to be dull.

The Code says - Construct a continuous air barrier, including joints, seams, transitions, and penetrations
- Pre-approved or airtight materials
- Tested or pre-approved assemblies

Code lists 19 air barrier materials and assemblies that comply

Examples:
- Min. 3/8” plywood
- Min. 1/2” cement board
- Open/Closed cell spray foam
- Insulation board
- Painted concrete masonry
Material and installation

- Right material or assembly
- Installed correctly, including at transitions
- Maintained throughout construction
Good material gone wrong
Not quite complete
Good system and good installation
Whole vs. hole

"I gotta make a hole"
Whole vs. hole

"Talk to Joe!"

"I gotta make a hole"
Whole vs. hole

"Talk to Joe!"

"I gotta make a hole"

Joe witnesses and assigns repair after installation

Habits
Whole vs. hole

"Talk to Joe!"

Air barrier is whole!

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Habits
Whole vs. hole

"Talk to Joe!"

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Yay, Team!!!
Yay, Team!!!
Habits

Attitude | Expertise | Inter-dependance

B | ![Brain](image) | ![Handshake](image)

![Target](image) | ![Arrow](image) | ![Backpack](image)

![Cat](image) | ![Scales](image) | ![Cake](image)
Thermal Bridging
High-speed travel

The Code says - do the calculations and prove the efficacy

Prescriptive R-value:
- Follow R-value charts
- There is NOTHING about other thermal bridging (woefully inadequate)

All other paths:
- Calculate conductive heat loss
  - UxA for stud wall assemblies
  - UxA, CxA, or FxL for all other bridging conditions
- Calculate area-weighted UA to determine compliance

Then build it correctly!
Thermal Bridging at Relieving Angles

**Unmitigated Detail:**
U-Factor for 36” height = 0.44

**Alternate Detail:**
U-Factor for 36” height = 0.13
"Skin of Our Teeth"

Insulative coatings (example):
- Aerogel insulation in paint
- R-4.1 per inch (WOW)
- Means R-0.1 to R-0.2 in total (wow)
- Install on steel 24" out to exterior and interior
- There are imposters.
Who is responsible?

Does YOUR energy modeler put in Thermal Bridging information?

MSTBA

Habits
Habits

Attitude  Expertise  Interdependence

B  Head  Handshake

Target  Arrow  Backpack

Cat  Scale  Cake
Foundation - Insulation and edge
No respect!

Look what a lack of slab insulation can do!
Ensure slab edge is protected

Detail continuous insulation plane

It is categorically unacceptable if slab is not thermally broken to outside.
Overview

To depth shown in Table C402.1.3

Ensure slab edge is protected

Detail continuous insulation plane

It is categorically unacceptable if slab is not thermally broken to outside.
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Slab on Grade "F- Factors"

ASHRAE 90.1-2013 Appendix A

Table A6.3.1 Assembly F-Factors
- 6" concrete slab on grade
- defined soil conductivity

Defined Variables include:
- Heated or Unheated slab
- Horizontal and/or vertical insulation
- Extent of insulation
- R-value of insulation

Undefined variables Include:
- Foundation wall thickness
- Type of concrete
- Type and extent of fill
- Alternate insulation configurations or locations

ASHRAE 90.1-2013 Appendix A
A.9 Determination of Alt Assembly

U-C- and F- Factors
Slab-on-Grade Floors "no testing or calculations allowed"
Slab on Grade "F- Factors"

ASHRAE 90.1-2013 Appendix A

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Defined Variables include:
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ASHRAE 90.1-2013 Appendix A
A.9 Determination of Alt Assembly

U-C- and F- Factors
Slab-on-Grade Floors "no testing or calculations allowed"
IECC-2015 Commercial, Climate Zone 5
Code Compliance Path:
- Prescriptive UCF Factor
- R-10, 24" Horizontal and/or Vertical from top of slab

ASHRAE 90.1-2013 Appendix A
Table A6.3.1 Assembly F-Factors
Unheated 6" thick concrete slab
- R-10, 24" vertical insulation is F-0.54/ft
- R-10, 36" vertical insulation is F-0.51/ft
- R-10, 48" vertical insulation is F-0.48/ft
Habits

Attitude  Expertise  Inter-
dependence

B

Brain

Handshake

Target

010

011

Backpack

Cat

Balanced

Cake
ESCALATING EXCELLENCE in ENVELOPES

stories from practice