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R-TRAC
Meeting # 8
Topic: Building Envelope and Energy Efficiency
Wednesday August 25, 2010, 3 – 5:30 pm

PARTICIPANTS IN ATTENDANCE

Utilities Green Building Team

Amanda Sutton – Green Building Program Coordinator
Doug Swartz - Green Building Program Manager - Energy Services Engineer
Felix Lee – Green Building Code Project Manager
John Phelan - Energy Services Manager
Kim DeVoe - Energy Services Specialist

Facilitator

Susanne Durkin-Schindler

R-TRAC Members

Company	Representative
Energy Logic	Robby Schwarz
HighCraft Builders	Gordon Winner
Aspen Homes of Colorado	Rob Sabin
Dana McBride Custom Homes	Dana McBride
The Green Team Real Estate	Lara Williams
The Group Real Estate	James Mitchell
Sovick Design Builders	Dennis Sovick
Crown Jade Design and Engineering, Inc.	Mark Benjamin
Vignette Studio	Terence Hoaglund
National Center for Craftsmanship	Nick Benson
Armstead Construction	Jeff Schneider
Vaught-Frye-Ripley Design	Linda Ripley
The Atmosphere Conservancy	Alex Blackmer
Merten Design Studio	Rob Ross

Building Officials

Jurisdiction	Representative
Larimer County	Tom Garton
Safe Built	Russ Weber
City of Longmont	Chris Allison
City of Fort Collins	Russell Hovland

Members of the Public

Alan Cram

Key Points

Announcements:

Kim DeVoe has joined the green building team to assist with research and code development. Kim has experience as a builder and inspector and is currently working on the Home Efficiency Program for the City of Fort Collins Utilities.

Building Envelope Performance - Doug Swartz

The building envelope is what separates the inside of the house from the outside and it is important to get it right. The benefits of a good envelope include occupant comfort, lower energy use, outside pollutant control, moisture control, and a reduction in heating and cooling loads. Even though a building envelope that is installed correctly can have numerous benefits, some builders continue to neglect important parts of its installation and insulation. Several examples of poorly installed building envelopes have been seen in a field study that was conducted in 2007 (see appendix A). A poorly built building envelope is expensive to fix once the home has been completed.

The proposed code elements are low cost practices that can have a large impact on the building performance. Building science is continually progressing and new technologies and tools are available to assist builders with building efficient, high quality homes. Blower door tests and infrared cameras are available to test the level of performance of a building envelope. Energy raters have been performing these tests and are playing an important role in educating builders.

Air Sealing

The intent of this section is to require that new homes and major remodels be built with a continuous air barrier. The 2009 I code has a prescriptive list of sealing locations and has a performance path where the builder can meet the air sealing requirements by performing a blower door

test. Staff is proposing that the City adopt a more stringent code where a prescriptive list of sealing locations must be met and visually inspected.

Committee Comments:

- According to Energy Logic, the average cost of a blower door test is $375.00 for tests where the consultant determines the air change number. A basic blower door test reading would cost around $100.00.

- Flexible air barriers tend to have problems because they act a vapor barrier as well. They are not always installed correctly which can result in moisture problems.
    - A perforated, permeable vinyl has been created to be applied in unfinished basements.

- A concern exists for situations where the basement or walkout is unfinished and the homeowner wants to go back and finish it at a later date. A flexible air barrier is the best option for those situations.

- The 2009 IRC and IECC performance path would require that basements are insulated. A prescriptive path existed in the previous codes that allowed builders to pass an inspection without having in insulate the basements. That is going away with the adoption of the 2009 codes. The new codes will make it difficult for builders to get by without insulating the basement of a home.

- The performance path is a four step process. The first step is the plans analysis which is submitted to get a building permit. The plans analysis should be done using worst case scenario assumptions that would still meet code. The next two steps would be a field inspection to make those worst case scenarios meet the specifications for the real world house. The model is adapted to what is actually being built. The reality is that most builders are at a 0.15 natural air changes per hour which exceeds code. It is extremely rare for a builder to go though all of the steps and then fail the blower door test. It is more likely for the builder to fail the thermal bypass checklist in which case they would have to go back and make corrections before the drywall can be installed.

- Should builders be concerned about making home too tight? At what point should mechanical ventilation be required?
    - ASHRAE 62.2 is a nationally recognized standard that says that if the house is tighter than 0.35 natural air changes it needs to have one of three types of whole house mechanical ventilation plus spot ventilation for high moisture areas of the house.

    - A builder cannot pass the performance path of code compliance without having a whole house ventilation system installed. It does not have to be a HRV. An exhaust ventilation strategy could be more energy efficient. If a fan is running for a substantial period of time it needs to be a low wattage so that it does not increase the overall yearly energy use of the home.

- Building practices have improved over the years but there continue to be issues with missing insulation in certain areas, inconsistency with installation, and trade sequencing. It is important that these issues are addressed and inspected carefully.

- The City needs to be careful about mandating the installation of whole house mechanical ventilation systems. Currently, the performance path could not be passed without mechanical ventilation.

- Requiring mechanical ventilation is tricky because the builder still needs to be worried about the energy use of the home.

Insulation

Staff is recommending that the majority of the R-values outlined in the 2009 IRC remain unchanged. Staff is recommending higher R-value requirements for electric heat homes and crawl space walls. Additional cost analysis is being done to determine the cost impacts of those two recommendations. Staff is also recommending that insulation be installed at a level that meets RESNET Grade I requirements with exceptions for rim joists and exterior walls with a minimum R value insulating sheathing. Those two components would have to meet RESNET Grade II standards.

Committee Comments:

- Homes that are on geo-thermal systems with electric heat as a back up have been traditionally grouped with natural gas heated homes because of their efficiency. The green building code would most likely be written in the same way.
- Separate systems that require electric heat may not be included in the electric heat home insulation requirements. Some technologies and applications that need to be considered when writing the code.
- The slab on grade insulation requirement would use a combination of vertical and horizontal installation to meet the code.

Advanced Framing

Staff found some language in Version 3.0 of ENERGY STAR for New Homes that addresses thermal bridges and advanced framing. It gives several options for builders to meet the requirement and the end result is

reduced thermal bridging which helps reduce heat flow to the outside and cold spots in the building envelope.

Committee Comments:

- If this is a requirement in code, the term "undocumented stud" needs to be clearly defined. ENERGY STAR defines an undocumented stud as a stud that does not need to be put in the structure. This requirement is not going to limit the studs needed for engineering a safe and structurally sound home.

- The number of studs in a home will vary depending on the engineer who designs the home. It may be difficult for an inspector to verify.

- If something is framed and documented by the engineer then it is not going to be a problem.

- It may be difficult to enforce this requirement in the field. A great deal of training will be required to train inspectors to look for unneeded studs.

Windows: Rated thermal properties

Staff is recommending that all windows being installed in new homes meet the ENERGY STAR requirement of having a U factor of 0.30. Staff is also recommending that the option for conventional windows in basements is eliminated and that the same maximum U-value applies to all windows that are placed in the thermal enclosure throughout new homes.

Committee Comments:

- Additional cost information may be needed to determine how much this will impact the cost of the home.

- This also ties into solar orientation. If a builder is designing a passive solar design they may not want to have to install low U factor windows. Exceptions need to exist for passive solar homes, green houses, etc.

- Basements should be held to the same standard as the rest of the code. They are still part of the thermal envelope.

- This could be something that is going to be addressed in the 2012 I-codes. They should be available sometime this fall.

- The windows are the weakest part of the building envelope. This is something that is a fairly easy fix for builders in the field.

Skylights and Doors: Rated Thermal Properties

Staff is currently working on performing additional research on these sections. Staff is not recommending any changes to the 2009 I-codes at this time.

Fenestration Installation

Additional research is underway to determine if this is something that is adequately addressed in the 2009 IRC or not. If done properly, fenestration installation would help enhance the durability of a home.

Solar Gains - Doug Swartz

When the R-TRAC prioritized green building practices that should be included in code solar orientation was highlighted. Staff agrees that this is an issue that should be considered when designing and building a home, but it may be difficult to address in code.

Committee Comments:

- Homes along the Front Range are designed to capture the great view. Unfortunately, that means that a lot of homes have west facing windows which result in heat gain as the sun sets.

- This could have a large impact on the design of homes. It is difficult for a custom home builder and even harder for production builders.

- Could use a formula to determine the maximum amount of area that can be unshaded on South facing windows. This would provide some additional flexibility.

- Many homes have been built that have a lot of windows on the west side of the house due to the orientation of the home.

- A builder could use overhangs to shade windows on some of the home which could be easily quantified.

- This is a great idea but it would be very difficult to do on production homes.

- If the City is going to mandate anything it should require solar hot water systems on new homes. Those systems are fairly easy to install and have better payback than solar electric systems.

R-TRAC Subgroup

Staff is looking at using the NGBS as an alternate compliance path. It is important that the performance and prescriptive paths are comparable.

Staff would like to form a sub-group of the R-TRAC to help determine the most likely paths that a builder would take to reach the levels of the NGBS. That committee will start meeting in early September.

Committee Comments:

- Verification of the NGBS can be time consuming and expensive for the builder.

- The City could offer several options such as ENERGY STAR and LEED for Homes as alternative compliance paths. Some builders are more comfortable with those systems than they are with the NGBS.

NEXT MEETING

September 8, 2010 – R-TRAC Meeting #9
3-5:30 p.m. City of Fort Collins Streets Facility

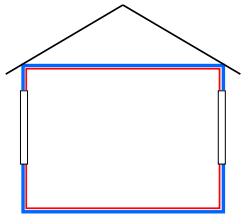
Building Envelope Solar Gains

R-TRAC Meeting
8/25/2010

Building Envelope

Windows
+ Air barrier
+ Insulation

Building envelope

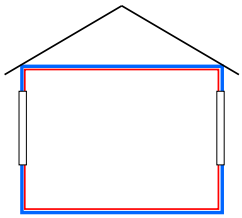


aka “Thermal shell,” “Thermal envelope”

Building Envelope

Efficient envelope . . .

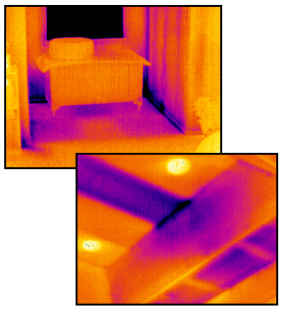
- Control: air, heat, moisture
- Comfortable (year-round)*
- Durable
- Pollutants isolated
- Lower energy use
- Smaller H+C system (whole-house approach)



* Assuming solar-smart design

AFSNA

- Air leaks
- Insulation flaws
- Misalignment
- Thermal bypasses
- Little problems add up = loss of control
- Details matter



Two Important Questions

	1. Is it there?	2. Does it **work?**
Conv	✓	(Assumed)
HPH	✓ (Components, specifications)	✓ (Whole house, installed performance)

Building Envelope: Evolution

Building science →

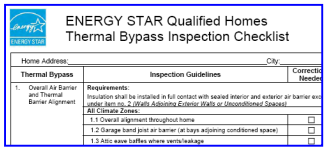
Fort Collins →

Energy / Green programs → - - ▸

Model codes →

Building Envelope: Evolution

Building Envelope: Evolution



ENERGY STAR Qualified Homes
Thermal Bypass Inspection Checklist

Home Address:_____City:_____

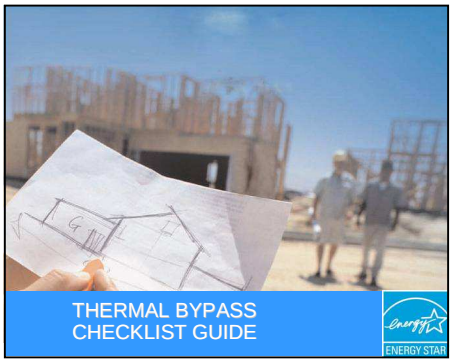
Thermal Bypass	Inspection Guidelines	Correctio Needed
1. Overall Air Barrier and Thermal Barrier Alignment	**Requirements:** Insulation shall be installed in full contact with sealed interior and exterior air barrier eq *(refer Item no. 2 (Walls Adjoining Exterior Walls or Unconditioned Spaces)*	
	All Climate Zones:	
	1.1 Overall alignment throughout home	☐
	1.2 Garage band joist air barrier (at bays adjoining conditioned space)	☐
	1.3 Attic eave baffles where vents/leakage	☐

ESNH V2

2006: ENERGY STAR New Homes

Thermal Bypass Checklist

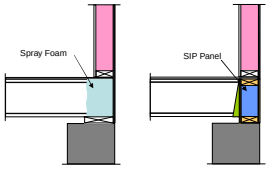
Building Envelope: Evolution



Building Envelope: Evolution

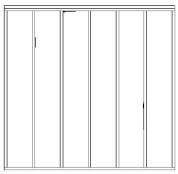
AIR BARRIER AND THERMAL ALIGNMENT

Figure 1.1.5 – Misalignment of insulation due to compression



Building Envelope: Evolution

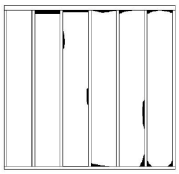
2006: Insulation Grading Standard (RESNET)



Grade I:

Occasional very small gaps acceptable

< 2% of area compressed



Grade II:

< 2% of area void

< 10% of area compressed

ENERGY STAR Evolution

ESNH V2 (2006)

ENERGY STAR Qualified Homes
Thermal Bypass Inspection Checklist

Home Address:

Thermal Bypass	Inspection Gui
1. Overall Air Barrier and Thermal Barrier Alignment	Requirements: Insulation shall be installed in full contact under item no. 2 Walls Adjoining Exterio
	All Climate Zones:
	1.1 Overall alignment throughout home
	1.2 Garage band joist air barrier (at bays
	1.3 Attic eave baffles where vents/exha

ESNH V3 (2011)

ENERGY STAR Qualified Homes
Thermal Enclosure System Rater Checklist

Home Address: _____ City: _____

Inspection Guidelines	Must Correct	Builder Approve
1. High-Performance Windows		
1.1 *Prescriptive Path*: Windows shall meet or exceed ENERGY STAR window requirements[2]	☐	☐
1.2 *Performance Path*: Windows shall meet or exceed 2009 IECC requirements[3]	☐	☐
2. Quality-Installed Insulation		
2.1 Ceiling, floor, and wall insulation levels shall meet or exceed 2009 IECC levels[4]	☐	☐
2.2 For Climate Zones 4 and higher, slab insulation shall meet or exceed 2009 IECC levels[4]	☐	☐
2.3 Insulation shall achieve RESNET-defined Grade I installation or, alternatively, Grade II for walls with insulated sheathing, (see checklist item 4.3.1 for required insulation levels)	☐	☐
3. Fully-Aligned Air Barriers [5]		
At each location noted below, a complete air barrier shall be provided that is fully aligned with the insulation as fol • At interior surface of ceilings in all Climate Zones • At exterior surface of walls in all Climate Zones, and also at interior surface of walls for Climate Zones 4-8[6] • At interior surface of floors in all Climate Zones, including supports to ensure permanent contact and blocking		
3.1 Walls		
3.1.1 Walls behind showers and tubs	☐	☐
3.1.2 Walls behind fireplaces	☐	☐
3.1.3 Attic knee walls	☐	☐
3.1.4 Skylight shaft walls	☐	☐
3.1.5 Wall adjoining porch roof	☐	☐

Building Envelope: Evolution

Fort Collins: 1990s to 2007

- Low-e windows widely used
- More attention to air sealing detail, much tighter buildings
- Insulation materials
  - Much more variation
  - Products easier to correctly install

. . . still room for improvement on many projects

Air Sealing

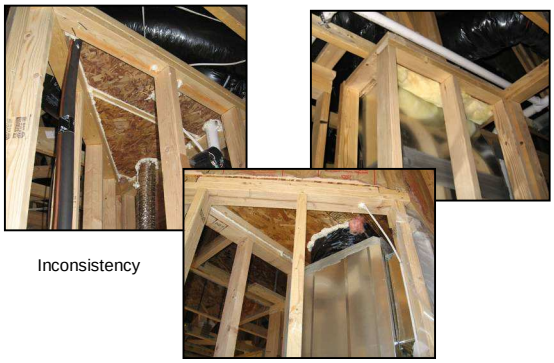
Air Leakage

Good progress at common problem areas

Air Leakage

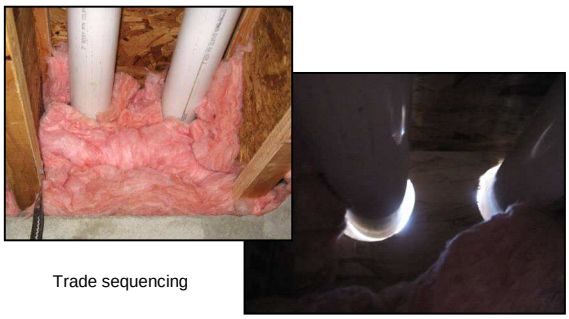
Some big holes occasionally missed

Air Leakage



Inconsistency

Air Leakage

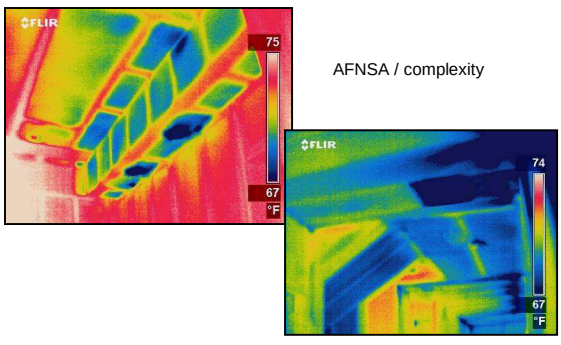


Trade sequencing

Air Leakage

Pollutant paths from garage

Air Leakage



AFNSA / complexity

Blower Door Testing

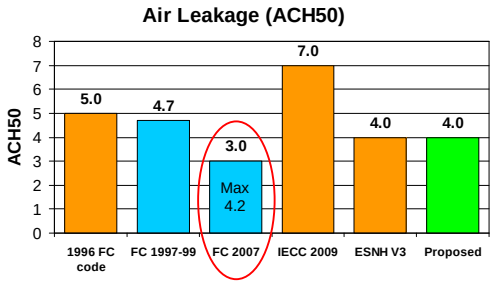
Blower door measures air flow (CFM) at standard test pressure (50 Pascals)

To compare homes of different sizes:

ACH50 (Air Changes per Hour at 50 Pa)

ACH50 = (CFM50 x 60) / Volume

Air Sealing



Ceilings

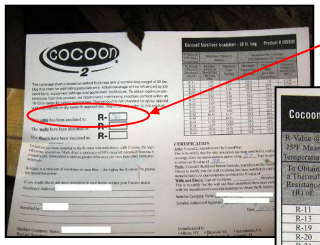
Ceilings: Attics Above

Obstructions ➔ uneven blow

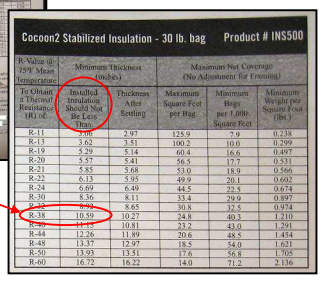
Flat attics: blown insulation

Cellulose predominant, some FG

Ceilings: Attics Above



R-38 universally claimed but rarely attained



R-38: 10.6" cellulose required

Typ measured: 9" average ~R-32

Similar shortfall for blown FG

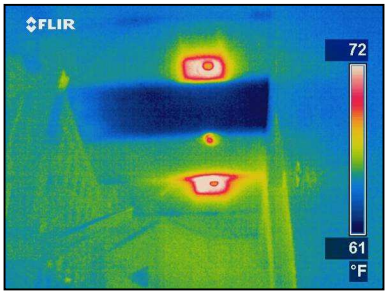
Ceilings: Attics Above

Batts installed at perimeter, prior to wallboard
Grade ??

Ceilings: Attics Above

Air handler platform insulated with batts
Grade ??

Ceilings: Attics Above



Air handler platform insulated with . . . nothing

Ceilings: Cathedral

Only two surveyed homes had cathedral ceilings.

This one used FG batts

Grade ??

Ceilings: Cathedral

Grade ??

How does batt rated R-38 perform in 2x8 rafter bay?

Ceilings: Cathedral

This ceiling insulated with blown cellulose

Grade I

Frame Walls to Exterior

Frame Walls: Unfaced FG

Frame Walls: Unfaced FG

Frame Walls: Kraft-faced FG

Three installation methods

Frame Walls: Blown FG

Blown FG

Typically Grade I

Compare batt vs blown FG at partition wall intersection

Frame Walls: Blown FG

This wall blown at too low a density

Grade II

Frame Walls: Dry-blown Cellulose

Grade I

Frame Walls: Damp-spray Cellulose

Some small flaws

Overall: Grade I

Frame Walls: HD Polyurethane

Seals + insulates

Wide variation in thickness

Frame Walls: Exterior Sheathing

Most builders: 100% OSB

Two builders: 100% ext foam (R-5)

Knee Walls

Knee Walls

One room:
Three kneewalls,
three approaches

Knee Walls

Attic side:
Compression
Gaps
No attic air barrier

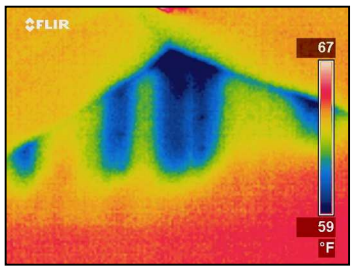
Does it work?

Knee Walls

Batts <u>labeled</u> R-19
2x4 framing laid flat
Inset stapling
No attic air barrier

Does it work?

Knee Walls



A sample of the symptoms

Knee Walls

1-1/2 story problems

Knee Walls

Knee walls in another 1-1/2 story

Attic side fully sheathed

Will perform like exterior wall

Grade I

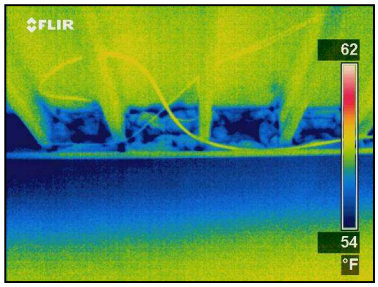
Rim Joists

Rim Joists

Box sills

Common problems:
Grade 3

Rim Joists



Rim Joists

Parallel rim joists

Is it there? YES

Does it work? NO

Grade 3

Rim Joists

Great job: Blown FG between rim joist and interior joist #1

Problem: No insulation between rim joist and interior joist #1

Cantilever Floors

Cantilevers

Main level cantilevers:
tough place to work
. . . and to inspect

Big gap in
soffit sheathing

Cantilevers

Challenges:
I-joists
Ducts, pipes, electrical
Trade sequencing

Is it there? Sort of

Does it work? NO

Cantilevers

Three bays
in one cantilever

(Daylight is a bad sign.)

Cantilevers

Grade I wall abutting garage

Room is cantilevered 1 ft into garage

Cantilevers

Grade ??

No sheathing

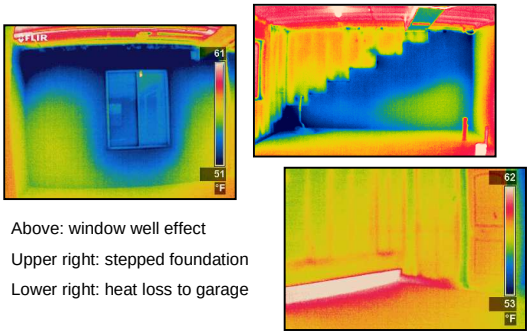
Cantilevers

Same house: interior MOSTLY blocked and sealed.

Direct pollutant pathway from garage

Basement Walls

Basements Lose Heat

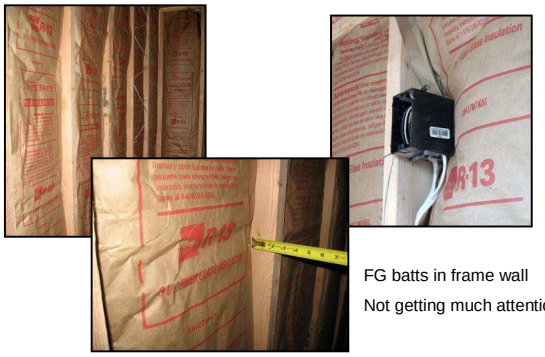


Above: window well effect

Upper right: stepped foundation

Lower right: heat loss to garage

Basement Insulation: FG Batts



FG batts in frame wall

Not getting much attention

Basement Insulation : FG Batts

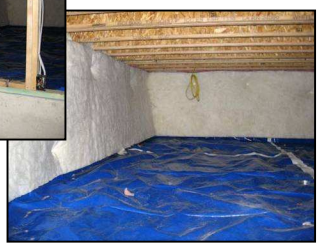
Garden level:
Transition from foundation to frame wall poses challenges

Basement Insulation: ICF

Alternative systems can address multiple needs

Crawl Spaces

Crawl Spaces



Conditioned
crawl space =
short basement

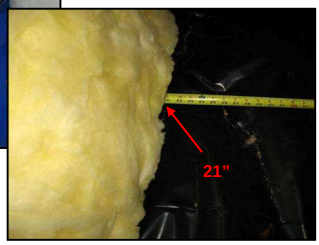
Crawl Spaces

Details matter

Insulation should extend to c.s. floor

Crawl Spaces

Wall insulation should be
aligned with foundation wall



Details matter
(these are 3.5” batts)

Crawl Spaces

Moisture barrier:
job not complete

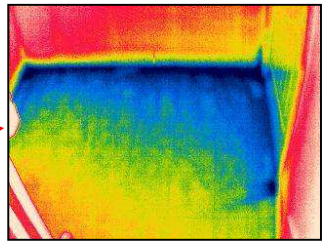
Crawl Spaces

Moisture barrier details
correctly handled

Slabs-on-Grade

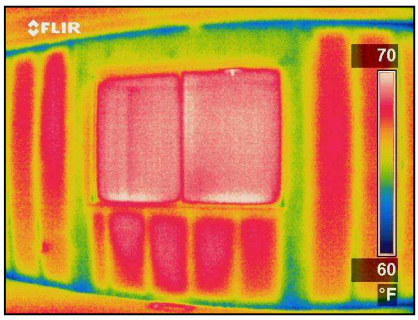
Slabs-on-Grade

- Uncommon in SF housing
- Walk-out basements
- Mudroom built into the garage
- Virtually never insulated

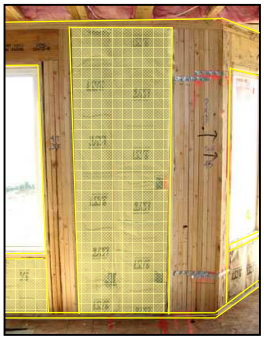


Thermal Bridging

Thermal Bridging



Framing Factor



Typical framing factor assumption: 20% to 25%

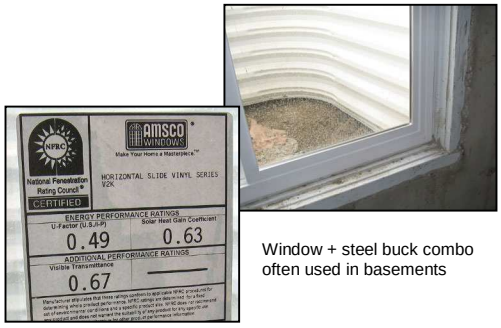
What is framing factor on this wall section?

Windows

Windows

Typical window in main living levels

Windows



Window + steel buck combo often used in basements