Session 4 Agenda

8:30-8:45	Prior Sessions Recap and Session 4 Intro
8:45-10:45	Energy Efficient Envelope Strategies
10:45-11:00	Break
11:00-12:15	Energy Efficient Envelope case studies
12:15-12:30	Conclusion / Q&A

Logistics and Expectations

- Be on time
- Be open, honest and candid
- Safe learning environment
- Smartphone/Blackberry off please

-Get to know your new BSA Space- feel at home here!

Quick overviews-Three related 2030 advocates:

The 2030 Challenge

AIA 2030 Commitment

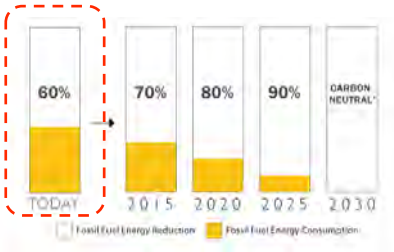
AIA+2030 Professional Series

Architecture 2030

- Non-profit organization founded by Ed Mazria in 2002.
- Authors of “The 2030 Challenge”
- Major Goal: To achieve a dramatic **reduction in greenhouse gas (GHG) emissions of the Building Sector** by changing the way buildings and developments are planned, designed and constructed.

Architecture 2030

The 2030 Challenge



How:

- Design strategies
- Technologies/systems
- Off-site renewables

Source: www.architecture2030.org

60% of what?

AIA 2030 Commitment

American Institute of Architects requirements

Two months	Six months	One year	Annually
Establish a team or **leader** to guide the firm's plan	Implement min. of four actions items related to firm **operations**	Develop sustainability **action plan** that demonstrates success toward 2030 goals	**Report** progress toward goals and share publicly

Source: www.aia.org

AIA 2030 Commitment

Reporting summary

AIA 2030 Commitment Annual Report

FIRM NAME ALL OFFICES
Design Work 2009

AIA 2030™

Overall Course Goals

"The AIA+2030 Professional Series helps design professionals **create buildings that meet the ambitious energy efficiency goals of the Architecture 2030 Challenge.** Ten 4-hour sessions offer strategies to reach 60% reduction in fossil fuel greenhouse gas emissions, giving design professionals the knowledge and leverage to create next-generation, super efficient buildings-and providing firms with the skills that will set them apart in the marketplace."

LAND USE WATER **ENERGY** MATERIALS HEALTH AIR QUAILITY

AIA 2030

3/16/12 SETTING + ACHIEVING ENERGY GOALS WITH INTEGRATED DESIGN™

3/30/12 DEFINING AND ACHIEVING POWER OF TARGETS + LOAD REDUCTIONS™

Boston Series (Today)

5/11/12 ACCENTUATE THE POSITIVE: CLIMATE RESPONSIVE DESIGN™

6/8/12 **SKINS: THE IMPORTANCE OF THE THERMAL ENVELOPE™**

7/13/12 PASSIVELY AGGRESSIVE: EMPLOYING PASSIVE SYSTEMS FOR LOAD REDUCTION™

8/10/12 ILLUMINATING SAVINGS: DAYLIGHTING AND INTEGRATED LIGHTING STRATEGIES™

9/7/12 RIGHT-SIZED: EQUIPMENT AND CONTROLS FOR **SUPER-EFFICIENT BUILDING SYSTEMS™**

10/12/12 SITE POWER: RENEWABLE ENERGY OPPORTUNITIES™

11/9/12 THE HAND-OFF + STAYING IN SHAPE: OPERATIONS, MAINTENANCE + EDUCATION™

12/14/12 PUTTING IT ALL TOGETHER: ACHIEVING 2030 GOALS ON THE PROJECT AND AT THE OFFICE™

Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

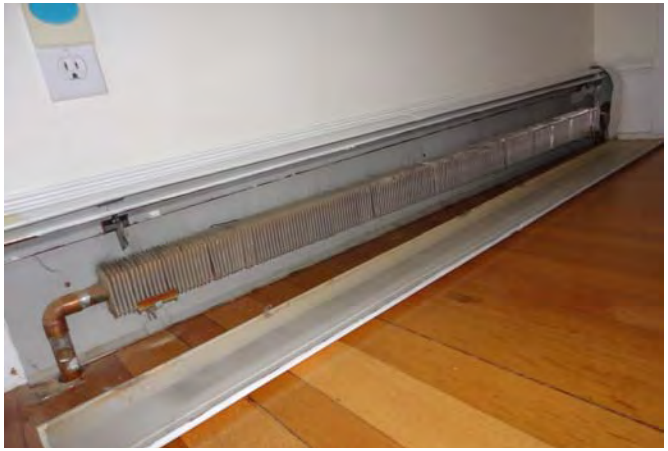
Adventures In Building Science

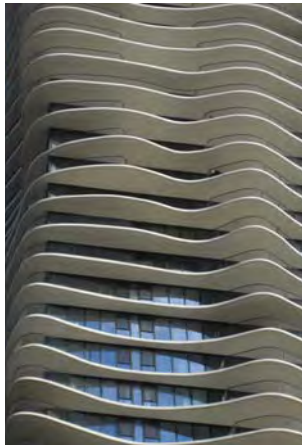
www.buildingscience.com

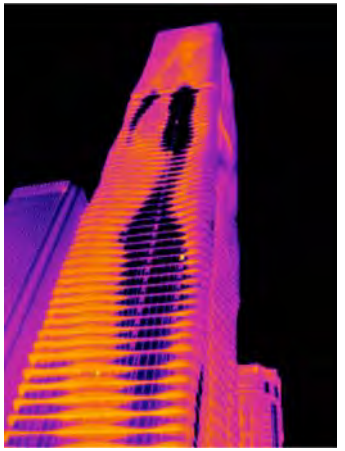
Life is Tough Enough As it Is…

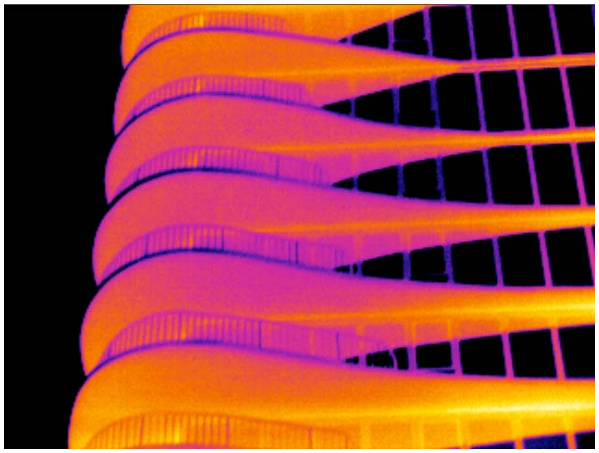
Life is Tough Enough As it Is…
It's Harder When You Are Stupid

Don’t Do Stupid Things









What Is A Building?

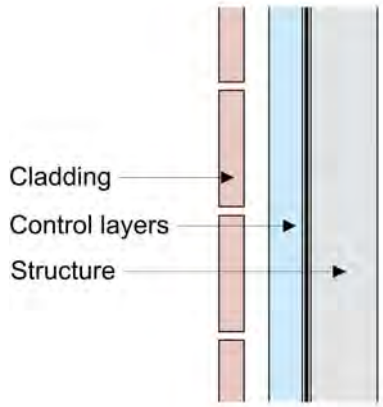
It is an environmental separator

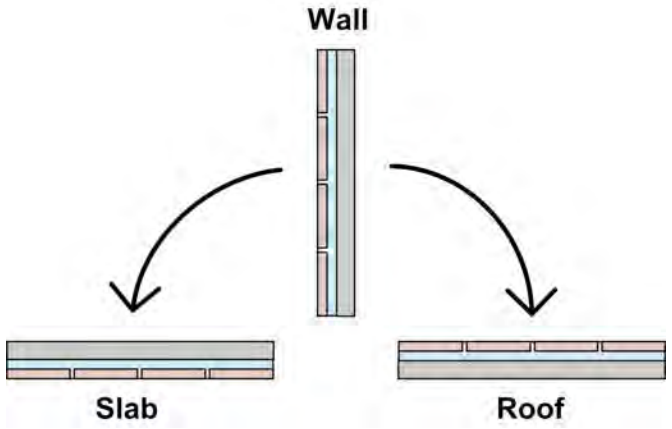
At the most basic level a building provides shelter - shelter from the elements as well as from other dangers. Its' function is to separate the inside from the outside as required by the local environment and the wishes of its occupants. A building creates an interior environment that is different from the exterior environment – it is an environmental separator. This interior environment should be controllable by the occupants in a manner that meets their needs.

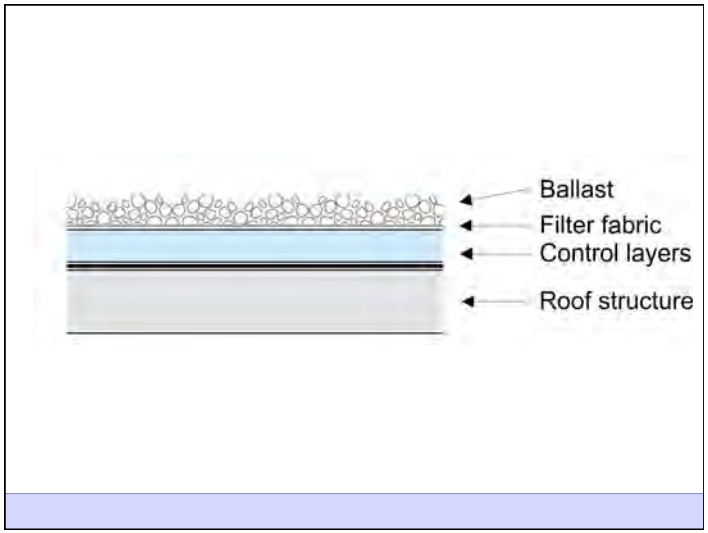
- Control heat flow
- Control airflow
- Control water vapor flow
- Control rain
- Control ground water
- Control light and solar radiation
- Control noise and vibrations
- Control contaminants, environmental hazards and odors
- Control insects, rodents and vermin
- Control fire
- Provide strength and rigidity
- Be durable
- Be aesthetically pleasing
- Be economical

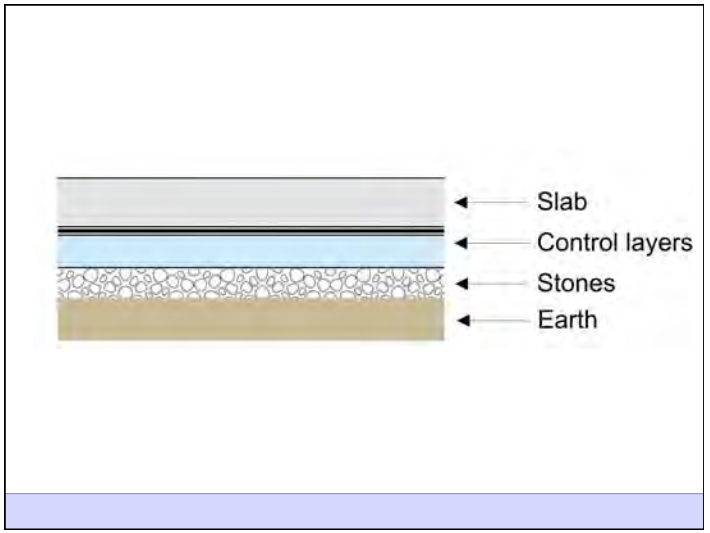
Heat Flow Is From Warm To Cold
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Air Flow Is From A Higher Pressure to a Lower Pressure
Gravity Acts Down

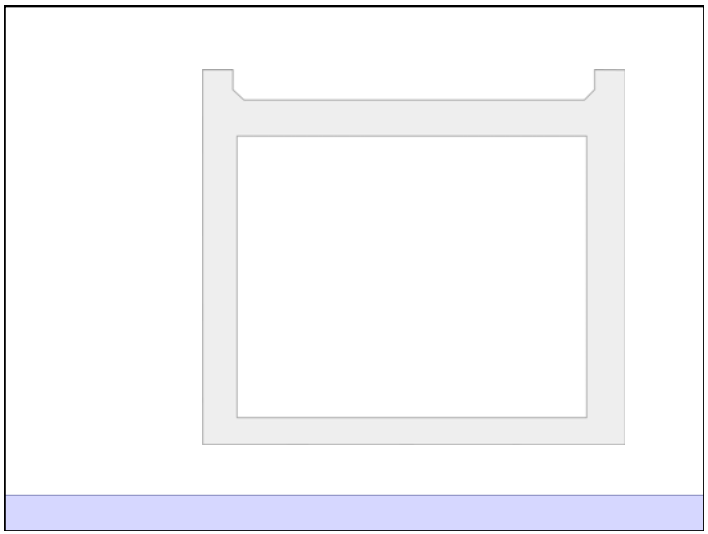
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

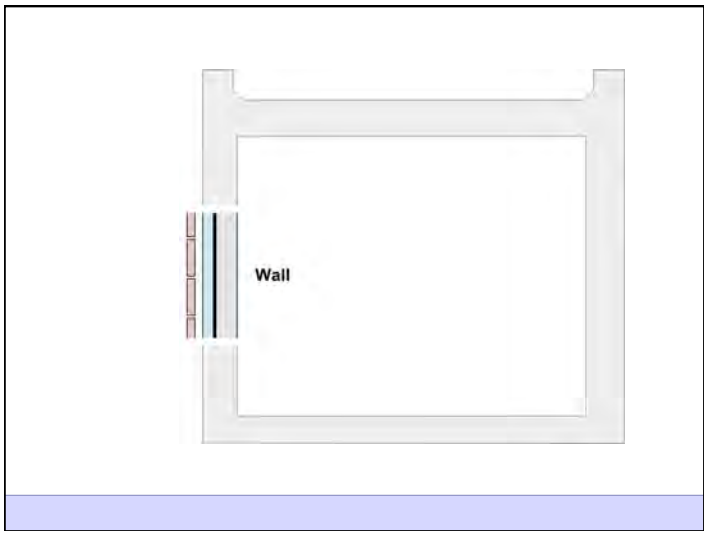


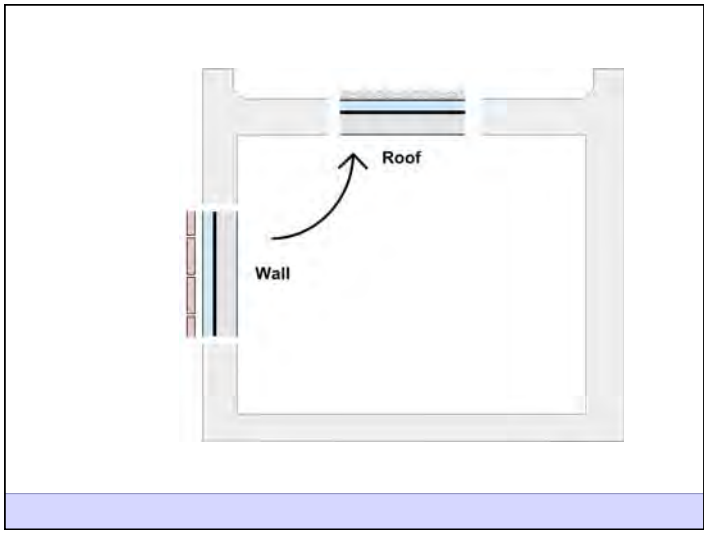


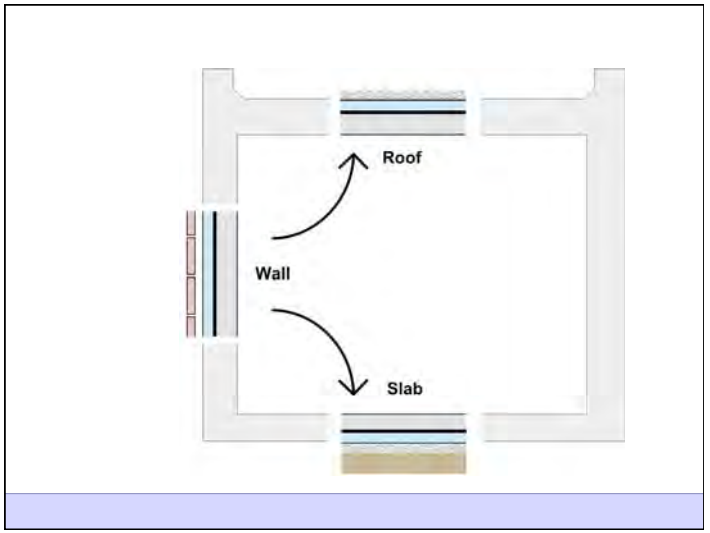

Ballast
Filter fabric
Control layers
Roof structure

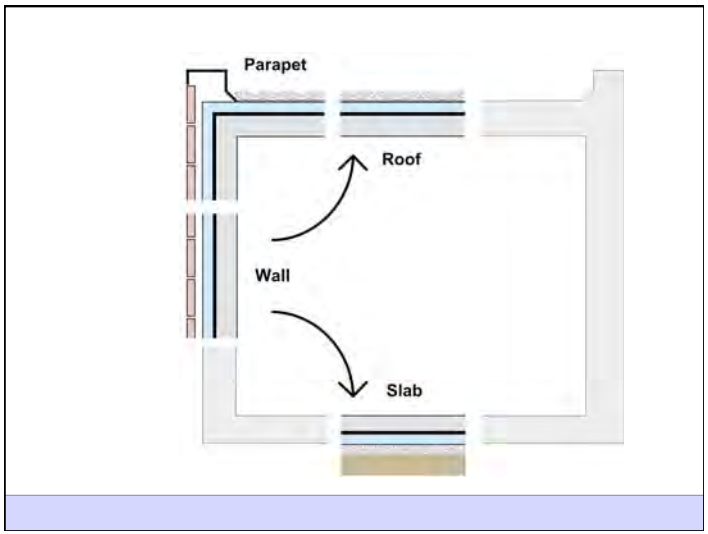

Slab
Control layers
Stones
Earth

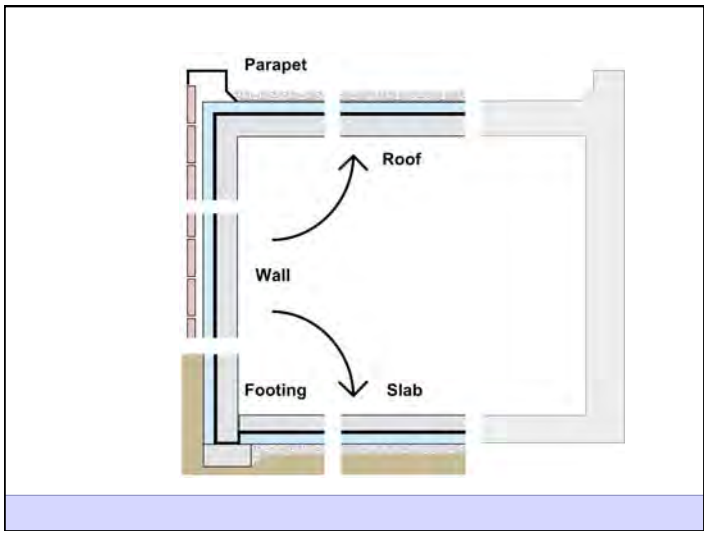


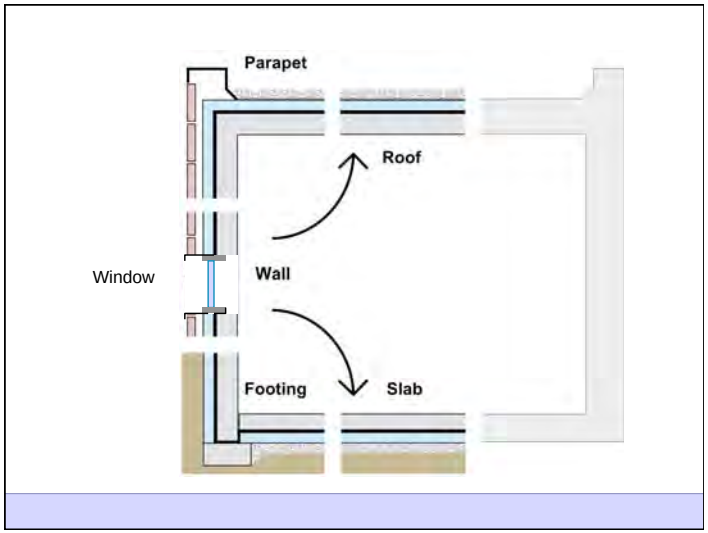

Wall

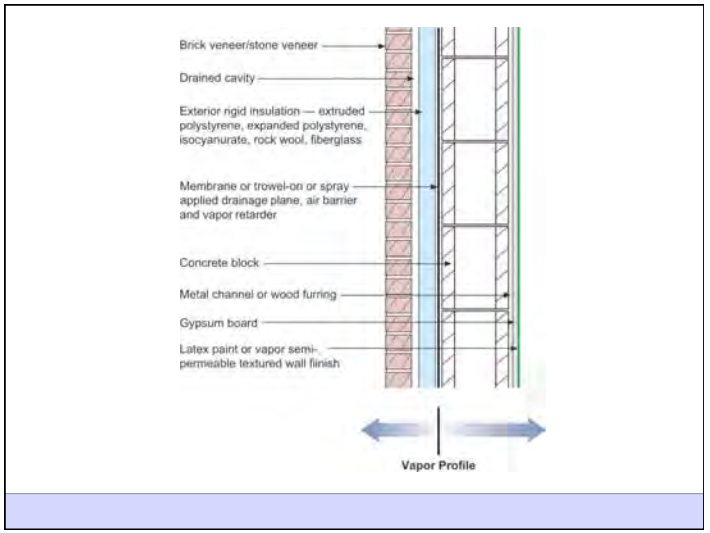

Roof
Wall

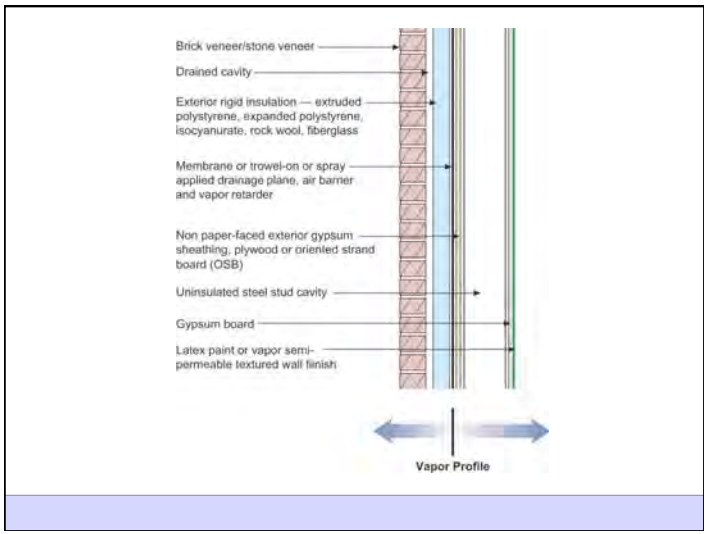

Roof
Wall
Slab

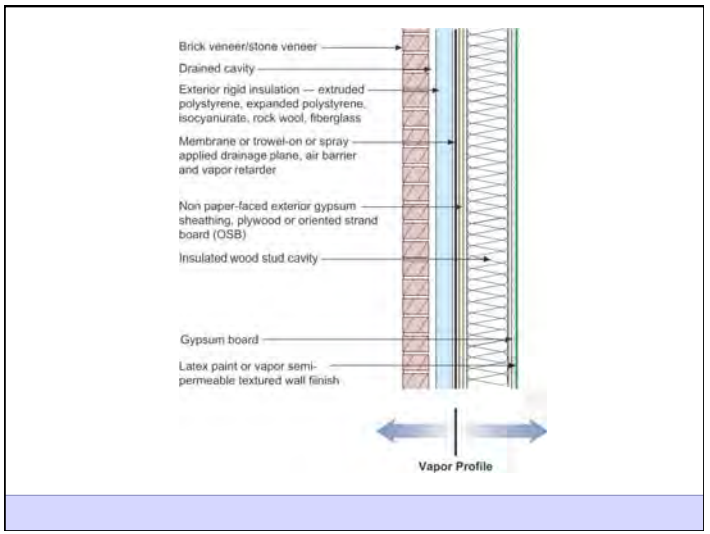

Parapet
Roof
Wall
Slab


Parapet
Roof
Wall
Footing
Slab


Parapet
Roof
Window
Wall
Footing
Slab

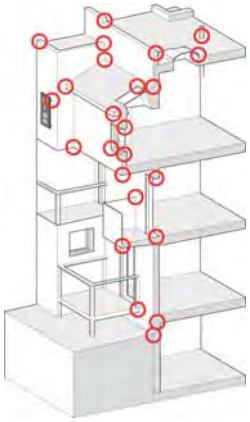

Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Vapor Profile

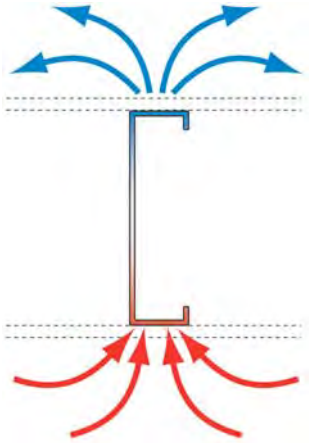

Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Vapor Profile


Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Vapor Profile

Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish

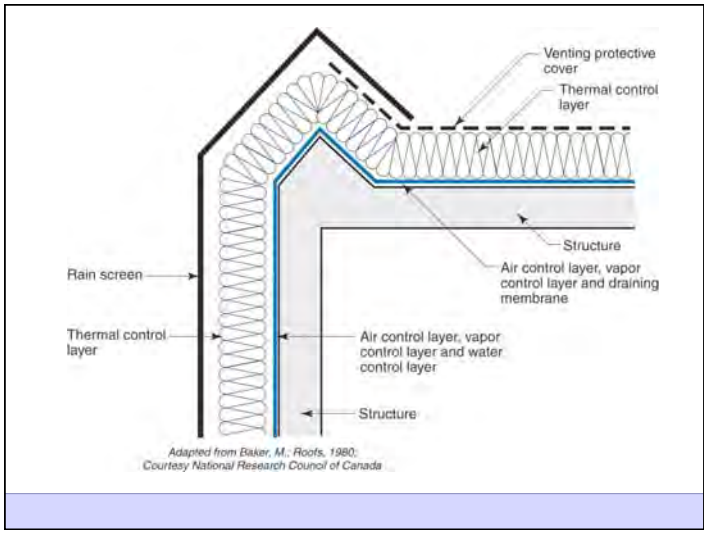


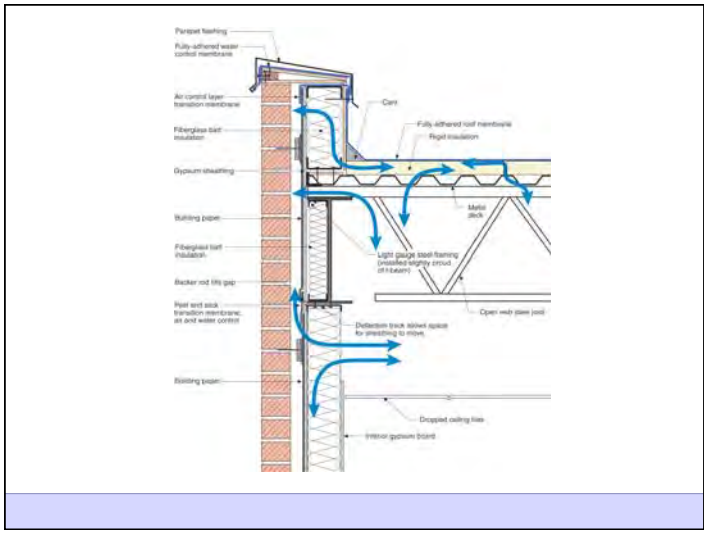


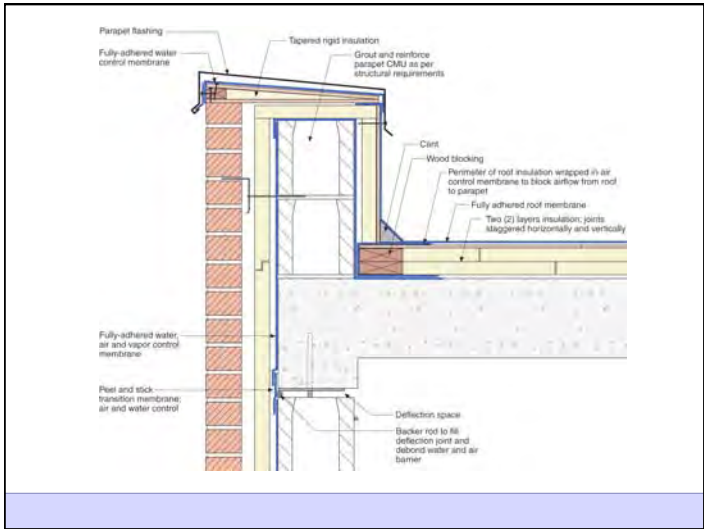

HARVARD SCHOOL OF PUBLIC HEALTH

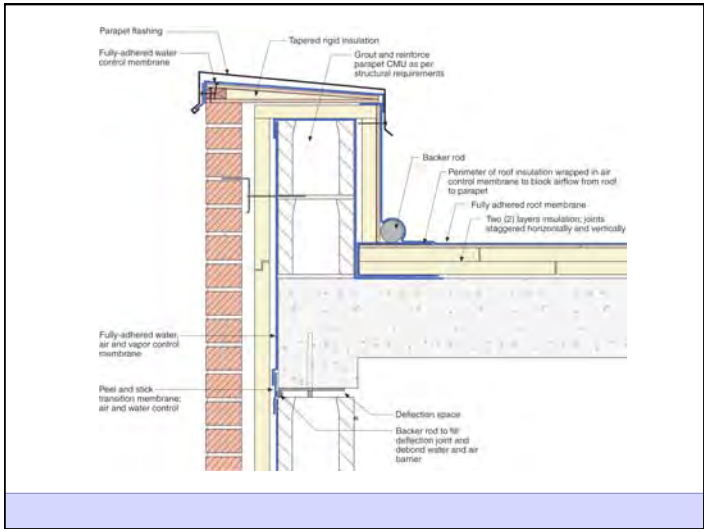

GP
DENSGLASS GOLD
GP
DENSGLASS GOLD

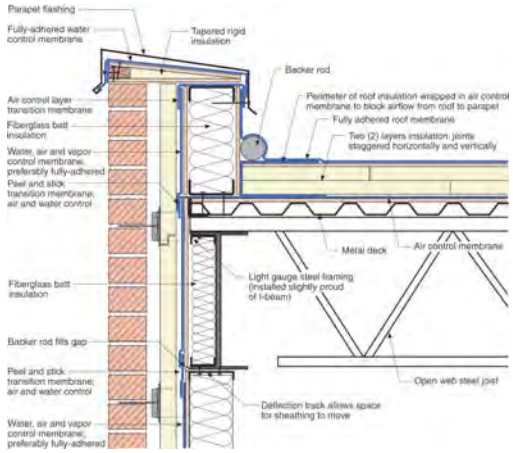

Blueskin

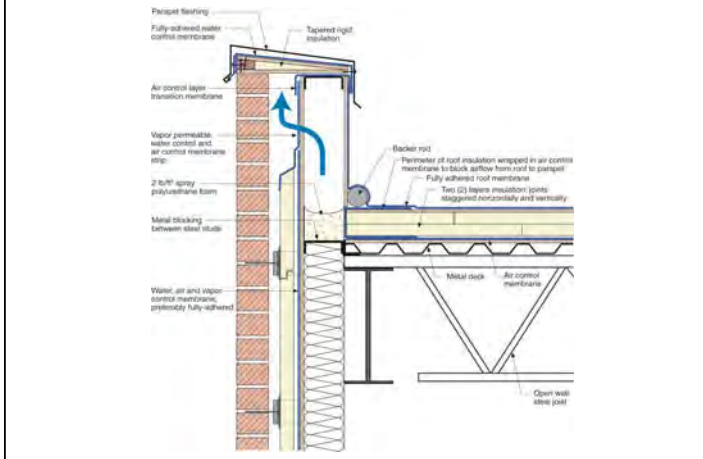

Venting protective cover
Thermal control layer
Structure
Air control layer, vapor control layer and draining membrane
Rain screen
Thermal control layer
Air control layer, vapor control layer and water control layer
Structure
Adapted from Baker, M.; Roofs, 1980;
Courtesy National Research Council of Canada

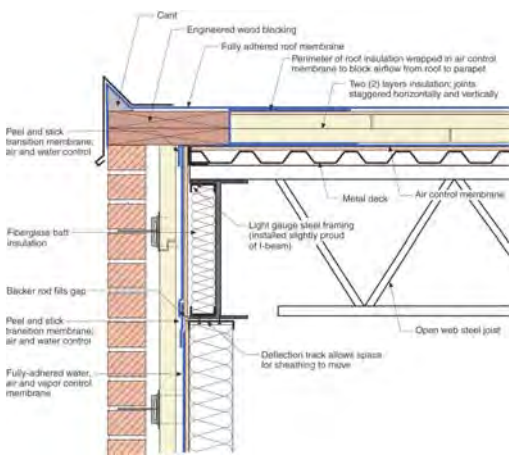


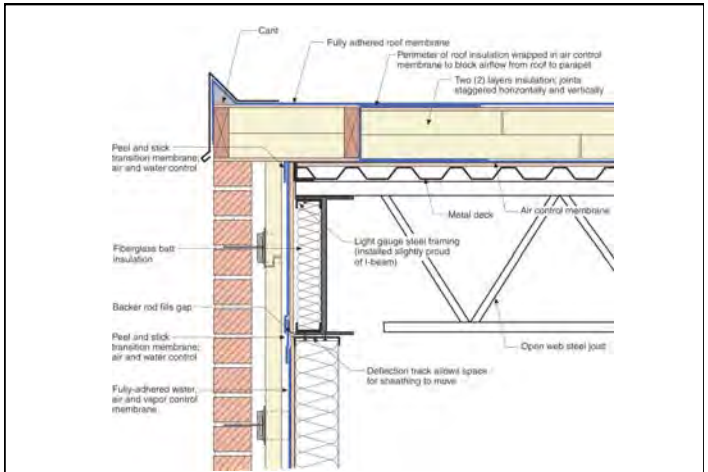

Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Grout and reinforce parapet CMU as per structural requirements
Cant
Wood blocking
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Fully-adhered water, air and vapor control membrane
Peel and stick transition membrane; air and water control
Deflection space
Backer rod to fill deflection joint and debond water and air barrier

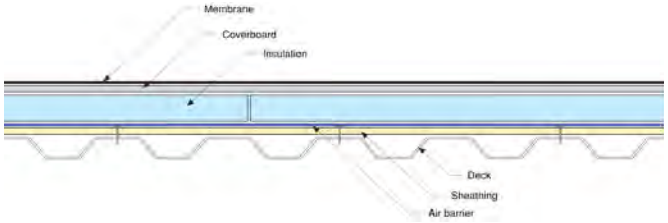

Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Grout and reinforce parapet CMU as per structural requirements
Backer rod
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Fully-adhered water, air and vapor control membrane
Peel and stick transition membrane; air and water control
Deflection space
Backer rod to fill deflection joint and debond water and air barrier

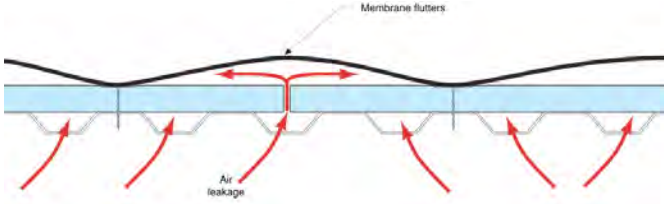

Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Backer rod
Air control layer transition membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fiberglass batt insulation
Fully adhered roof membrane
Water, air and vapor control membrane, preferably fully-adhered
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Water, air and vapor control membrane, preferably fully-adhered

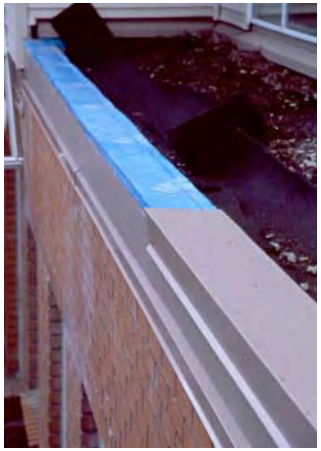

Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Air control layer transition membrane
Vapor permeable, water control and air control membrane strip
Backer rod
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
2 lb/ft³ spray polyurethane foam
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Metal blocking between steel studs
Metal deck
Air control membrane
Water, air and vapor control membrane, preferably fully-adhered
Open web steel joist

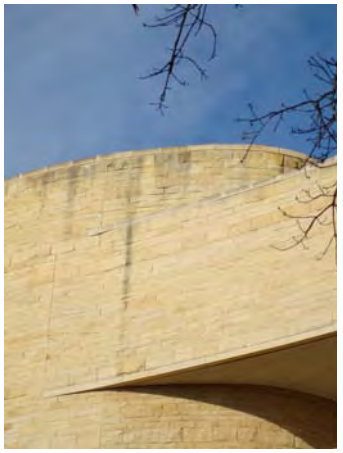

Cant
Engineered wood blocking
Fully adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Fully-adhered water, air and vapor control membrane

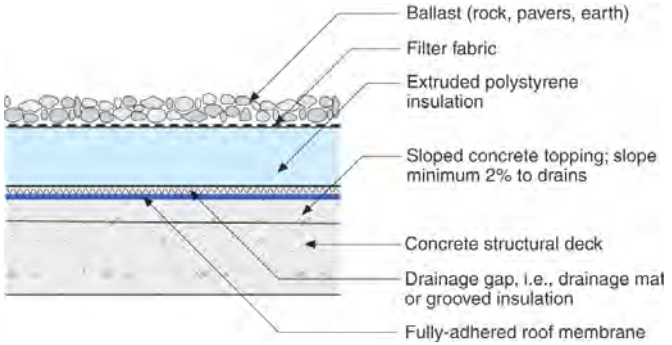

Cant
Fully adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Fully-adhered water, air and vapor control membrane

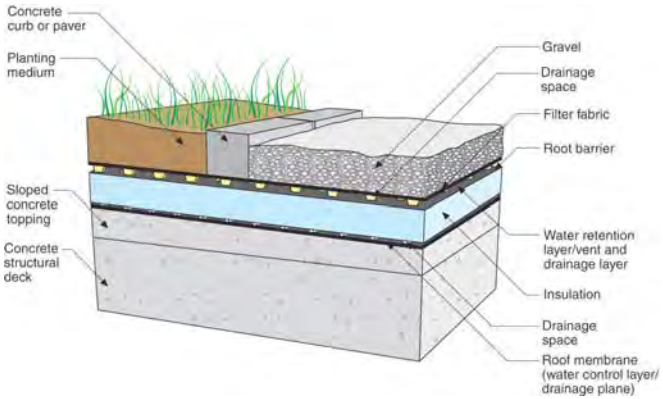

Membrane
Coverboard
Insulation
Deck
Sheathing
Air barrier

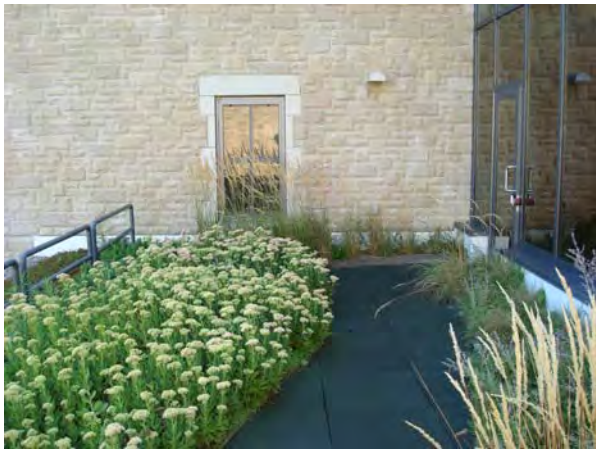

Membrane flutters
Air
leakage

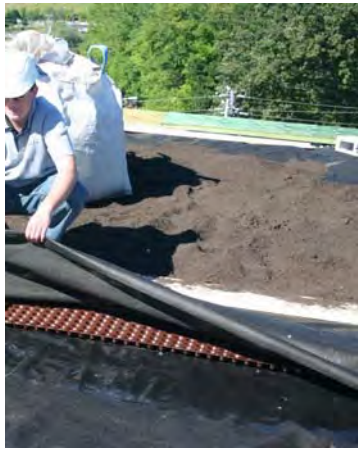


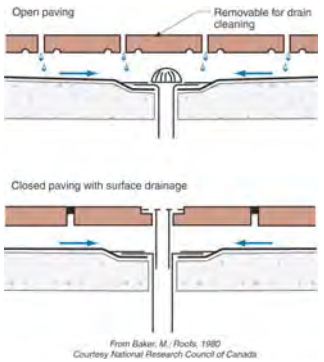


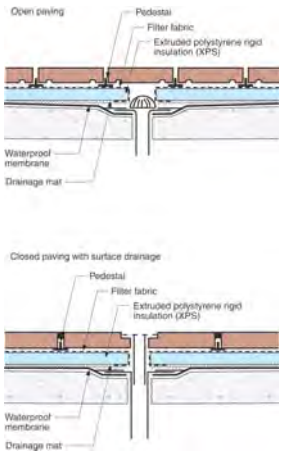

Ballast (rock, pavers, earth)
Filter fabric
Extruded polystyrene insulation
Sloped concrete topping; slope minimum 2% to drains
Concrete structural deck
Drainage gap, i.e., drainage mat or grooved insulation
Fully-adhered roof membrane

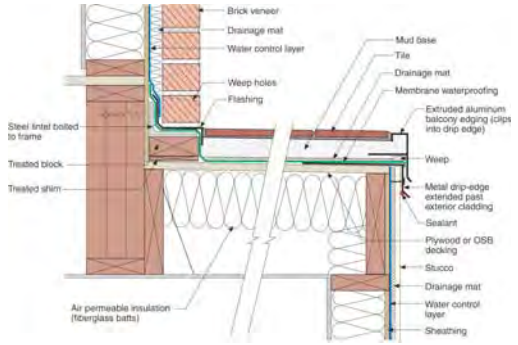

Concrete curb or paver
Planting medium
Sloped concrete topping
Concrete structural deck
Gravel
Drainage space
Filter fabric
Root barrier
Water retention layer/vent and drainage layer
Insulation
Drainage space
Roof membrane (water control layer/ drainage plane)

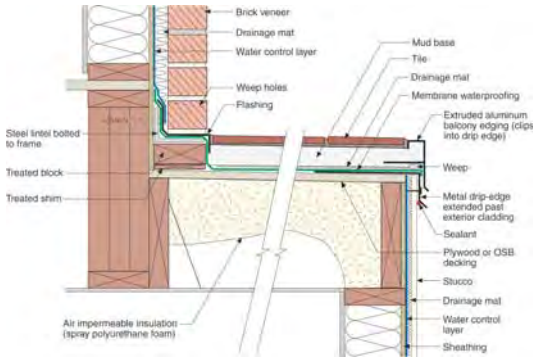


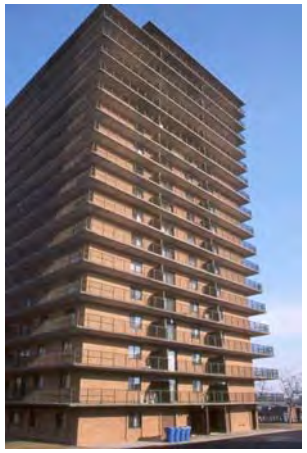


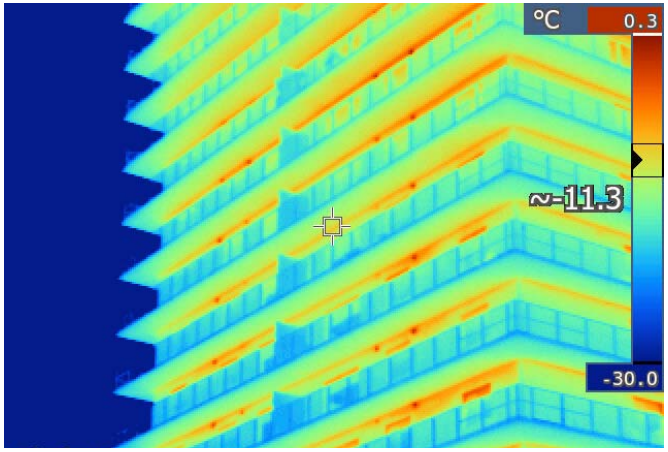

Open paving
Removable for drain cleaning
Closed paving with surface drainage
From Baker, M.: Roofs, 1980
Courtesy National Research Council of Canada

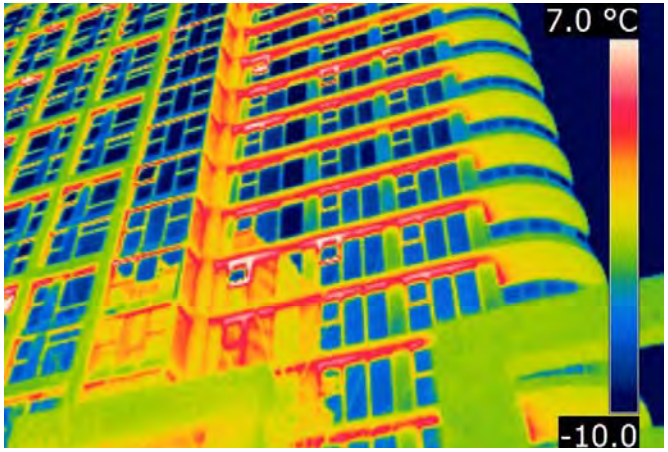

Open paving
Pedestal
Filter fabric
Extruded polystyrene rigid insulation (XPS)
Waterproof membrane
Drainage mat
Closed paving with surface drainage
Pedestal
Filter fabric
Extruded polystyrene rigid insulation (XPS)
Waterproof membrane
Drainage mat

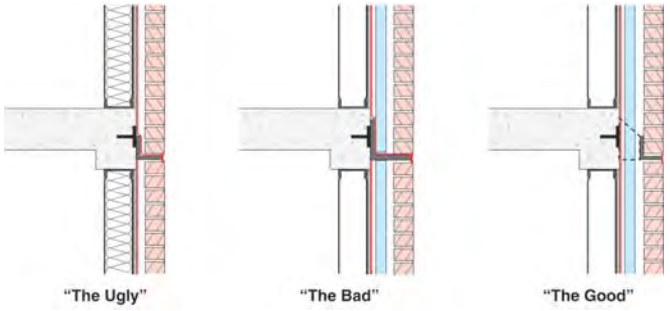

Brick veneer
Drainage mat
Water control layer
Weep holes
Flashing
Steel lintel bolted to frame
Treated block
Treated shim
Air permeable insulation (fiberglass batts)
Mud base
Tile
Drainage mat
Membrane waterproofing
Extruded aluminum balcony edging (clips into drip edge)
Weep
Metal drip-edge extended past exterior cladding
Sealant
Plywood or OSB decking
Stucco
Drainage mat
Water control layer
Sheathing

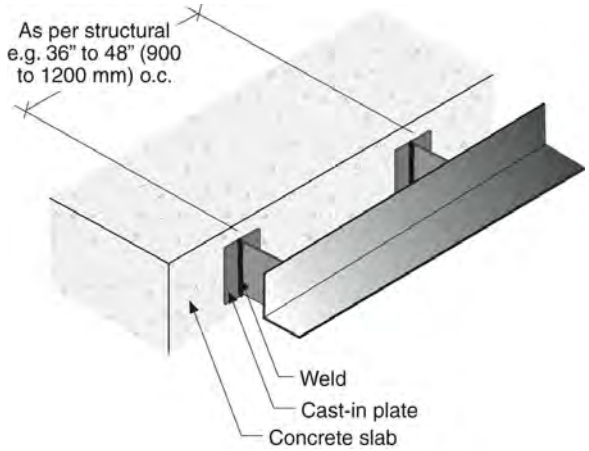

Brick veneer
Drainage mat
Water control layer
Weep holes
Flashing
Steel lintel bolted to frame
Treated block
Treated shim
Air impermeable insulation (spray polyurethane foam)
Mud base
Tile
Drainage mat
Membrane waterproofing
Extruded aluminum balcony edging (clips into drip edge)
Weep
Metal drip-edge extended past exterior cladding
Sealant
Plywood or OSB decking
Stucco
Drainage mat
Water control layer
Sheathing

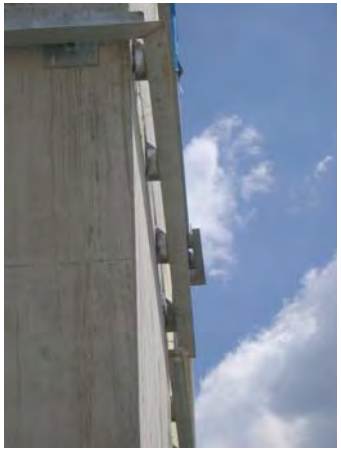


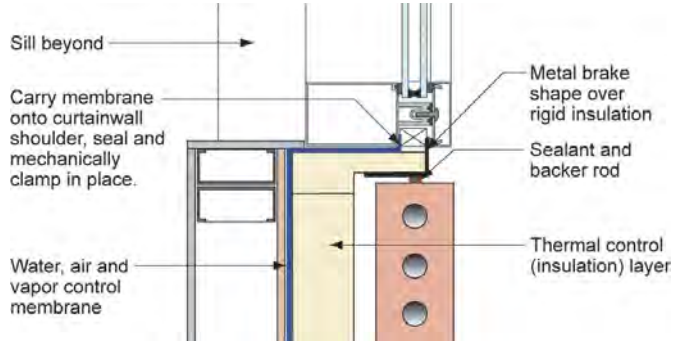

°C
0.3
~-11.3
-30.0

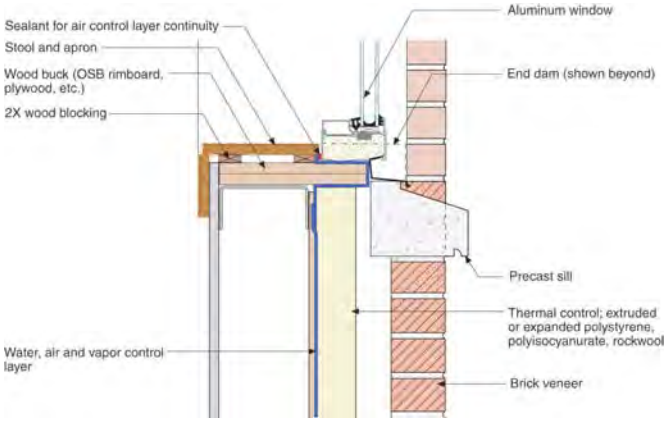

7.0 °C
-10.0

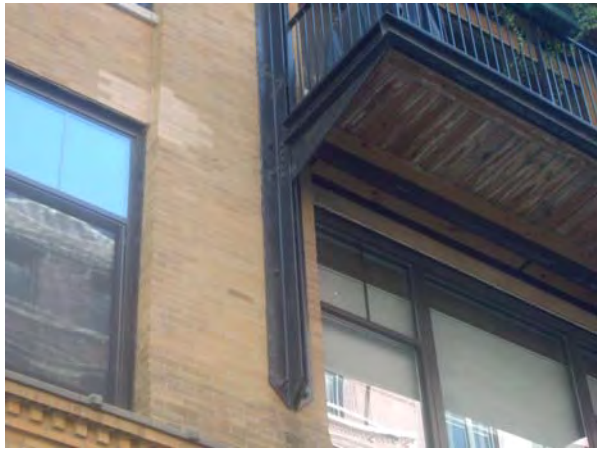

"The Ugly"
"The Bad"
"The Good"

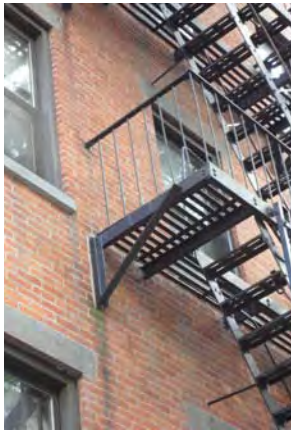

As per structural
e.g. 36" to 48" (900
to 1200 mm) o.c.
Weld
Cast-in plate
Concrete slab




Sill beyond
Carry membrane onto curtainwall shoulder, seal and mechanically clamp in place.
Water, air and vapor control membrane
Metal brake shape over rigid insulation
Sealant and backer rod
Thermal control (insulation) layer

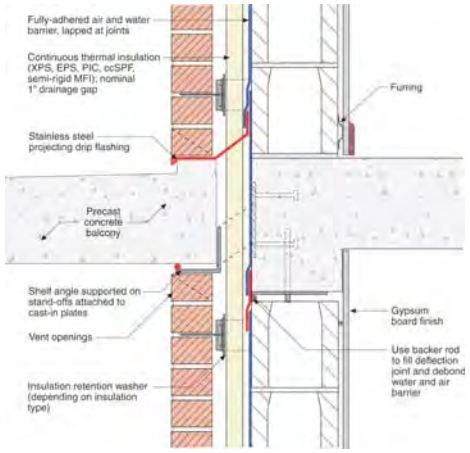

Sealant for air control layer continuity
Stool and apron
Wood buck (OSB rimboard, plywood, etc.)
2X wood blocking
Aluminum window
End dam (shown beyond)
Precast sill
Thermal control; extruded or expanded polystyrene, polyisocyanurate, rockwool
Water, air and vapor control layer
Brick veneer






BUS
ONLY


Schöck Isokorb


Fully-adhered air and water barrier, lapped at joints
Continuous thermal insulation (XPS, EPS, PIC, ccSPF, semi-rigid MFI); nominal 1" drainage gap
Furring
Stainless steel projecting drip flashing
Precast concrete balcony
Shelf angle supported on stand-offs attached to cast-in plates
Vent openings
Insulation retention washer (depending on insulation type)
Gypsum board finish
Use backer rod to fill deflection joint and debond water and air barrier

Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Adventures In Building Science

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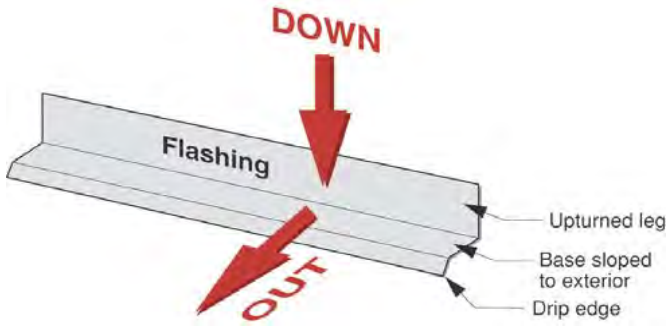
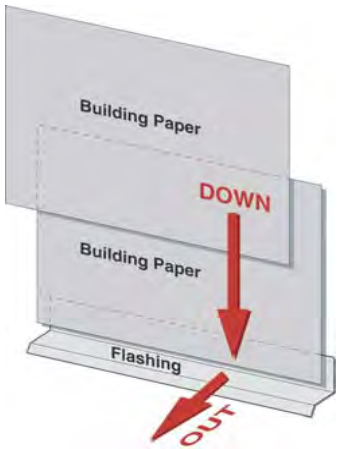
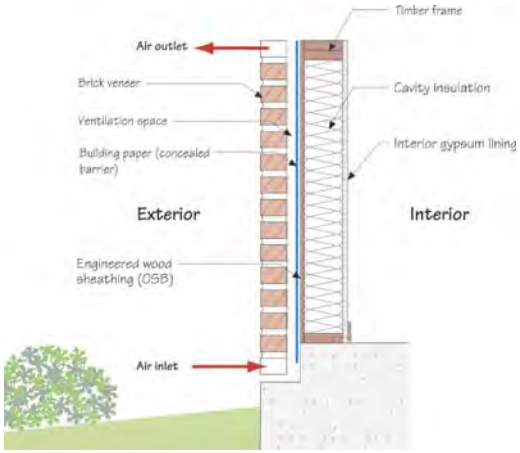
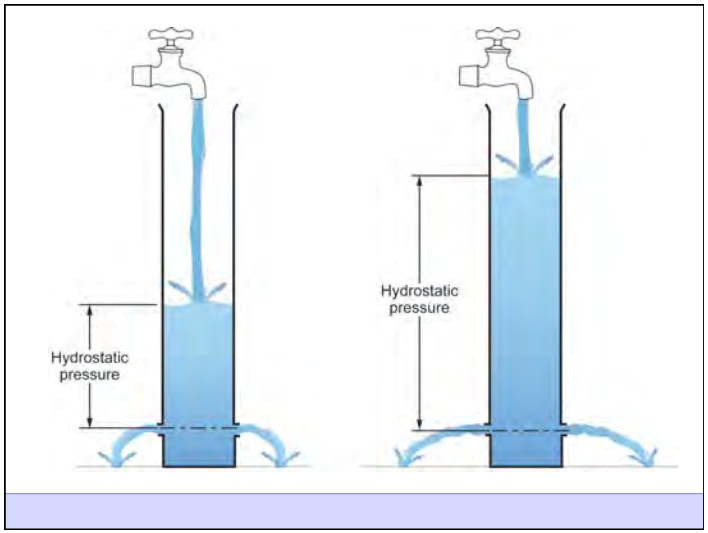
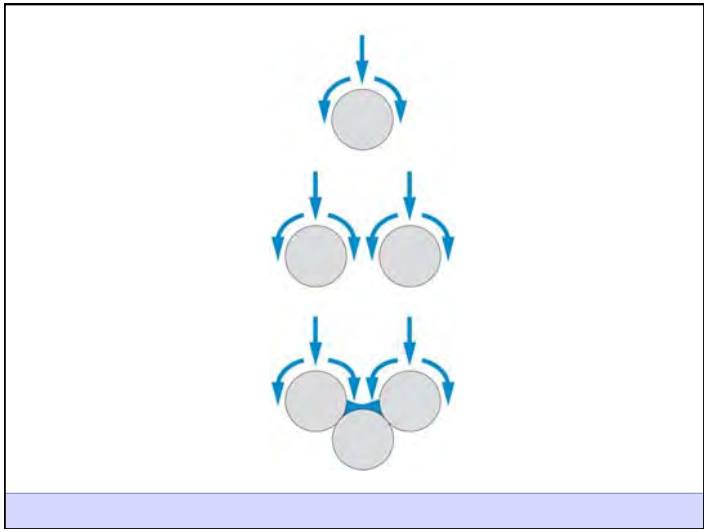
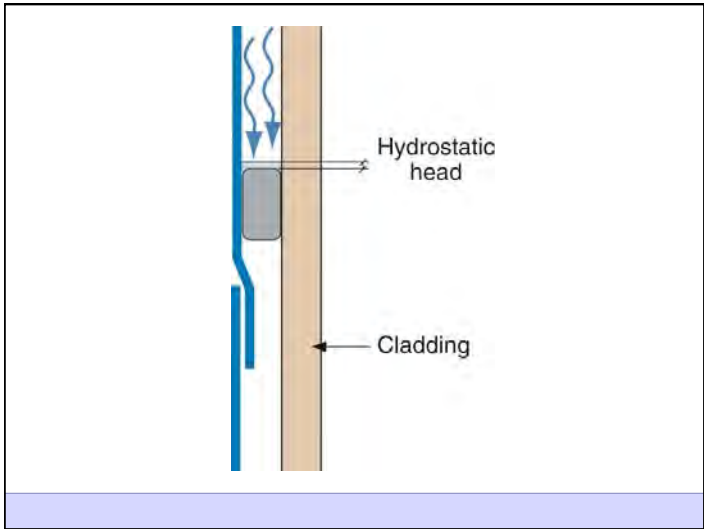

DOWN
Flashing
OUT
Upturned leg
Base sloped to exterior
Drip edge

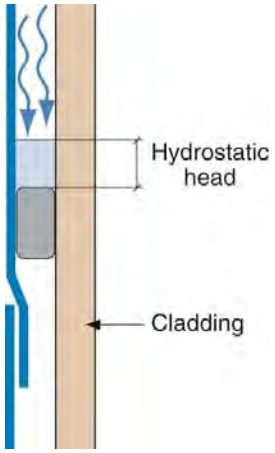

Building Paper
DOWN
Building Paper
Flashing
OUT

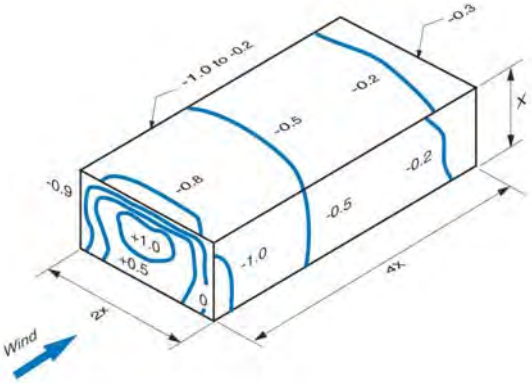

Timber frame
Air outlet
Brick veneer
Cavity insulation
Ventilation space
Interior gypsum lining
Building paper (concealed barrier)
Exterior
Interior
Engineered wood sheathing (OSB)
Air inlet


Hydrostatic pressure
Hydrostatic pressure

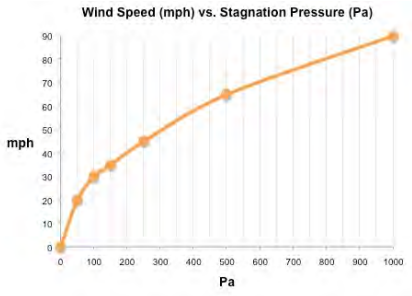


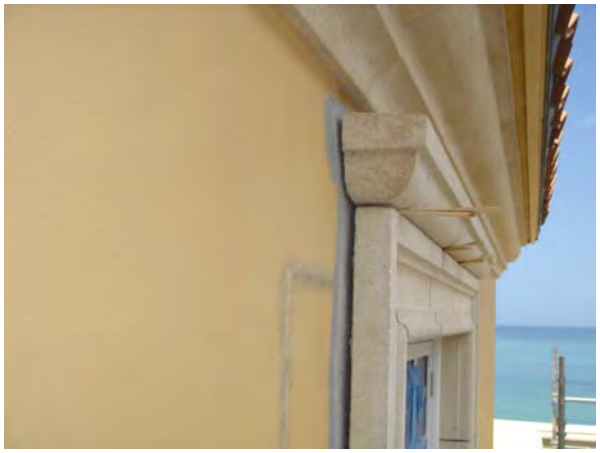

Hydrostatic head
Cladding



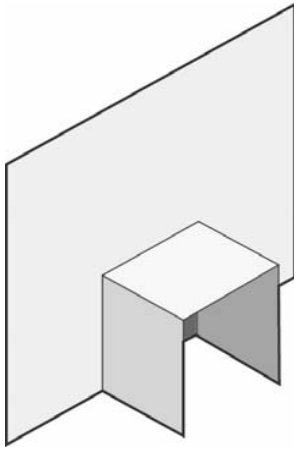


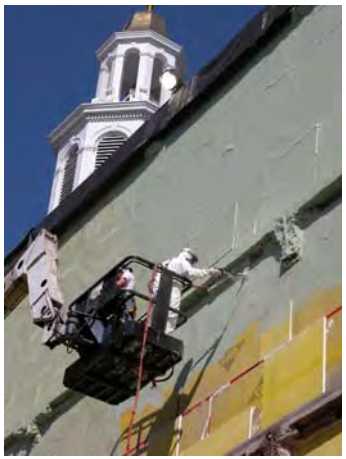
Pascals		mph
50	Pa =	20 mph
100	Pa =	30 mph
150	Pa =	35 mph
250	Pa =	45 mph
500	Pa =	65 mph
1,000	Pa =	90 mph



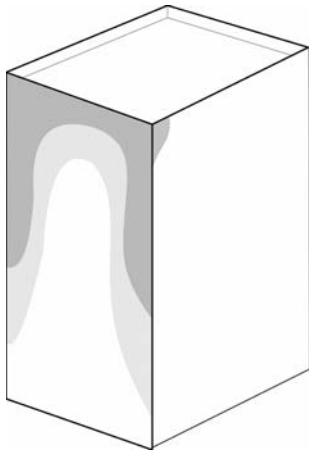



Pulte
Pulte
Pulte



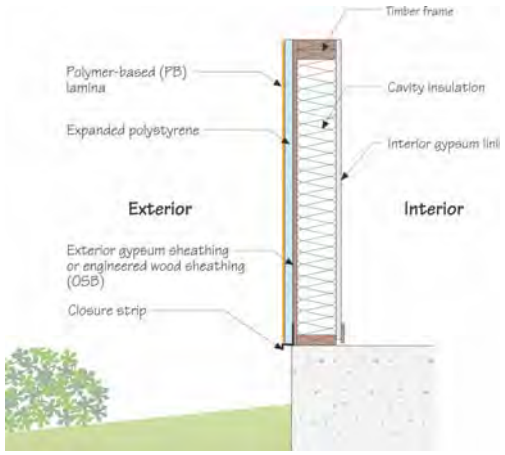



OZARK STEEL




Tyvek
omeWrap
Tyvek
HomeWrap


Habitat


Timber frame
Polymer-based (PB) lamina
Cavity insulation
Expanded polystyrene
Interior gypsum lini
Exterior
Interior
Exterior gypsum sheathing or engineered wood sheathing (OSB)
Closure strip

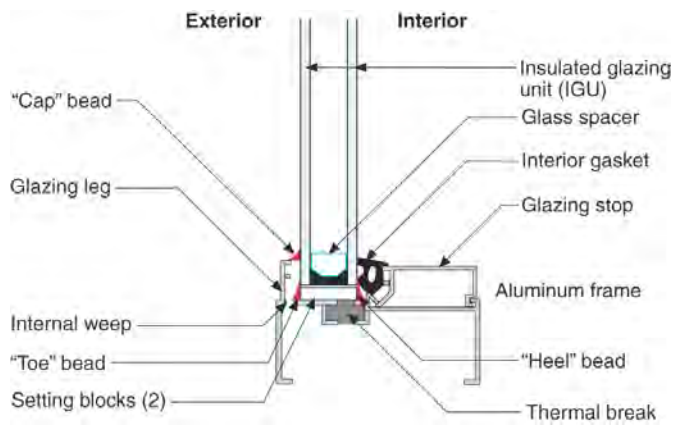

DUPONT

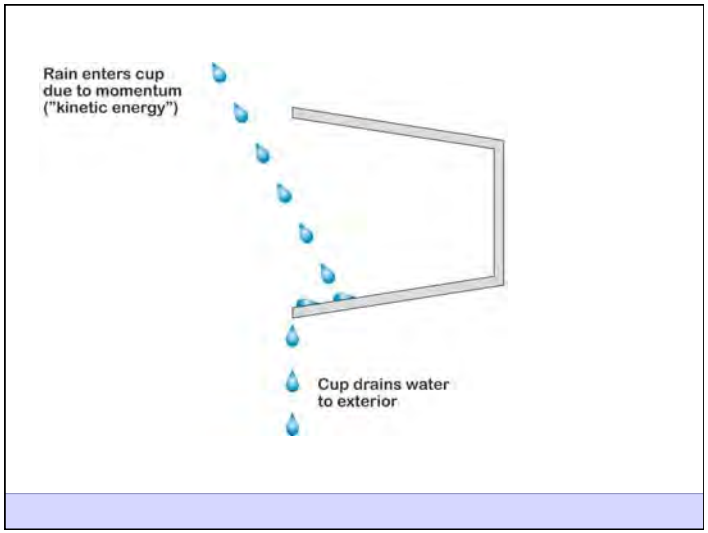

Styrofoam

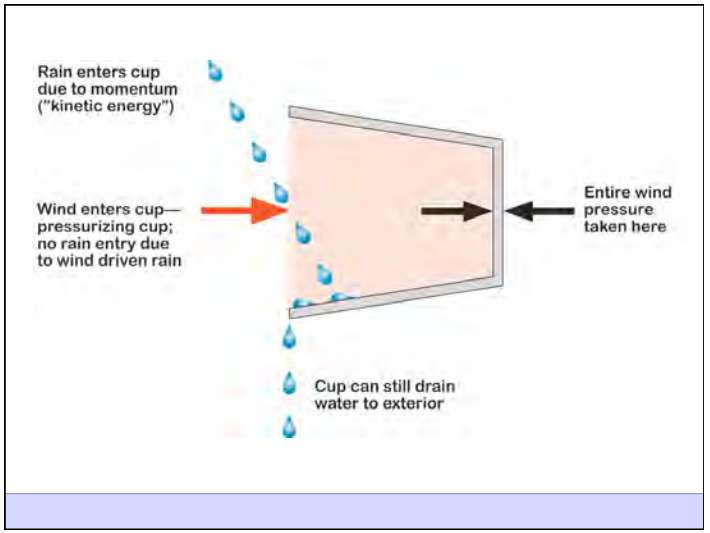

Ludlow
Coated
Products
www.ludlowcp.com

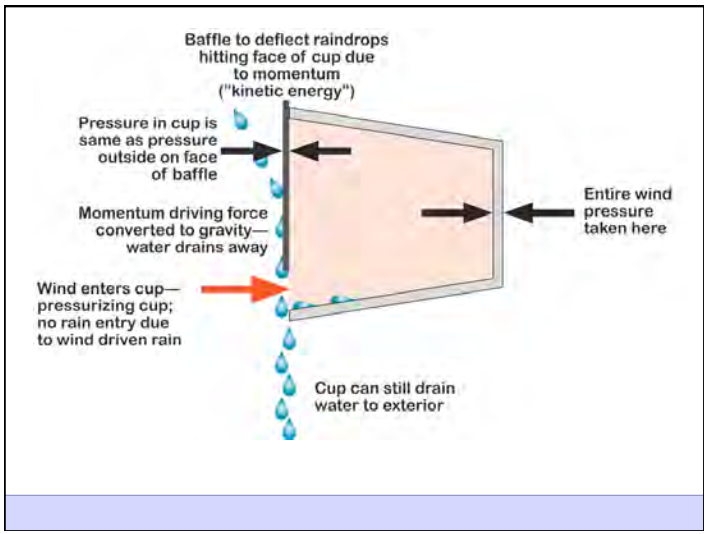

Thermo-Sheath

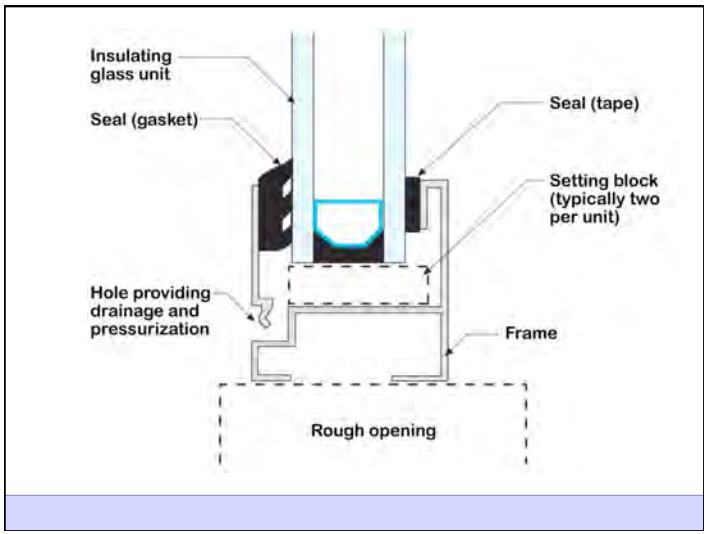

2004 11 18

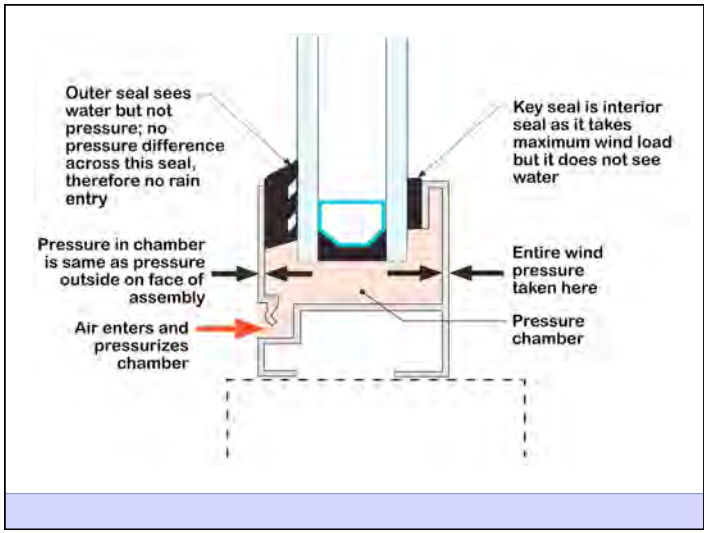

Exterior
Interior
"Cap" bead
Glazing leg
Internal weep
"Toe" bead
Setting blocks (2)
Insulated glazing unit (IGU)
Glass spacer
Interior gasket
Glazing stop
Aluminum frame
"Heel" bead
Thermal break

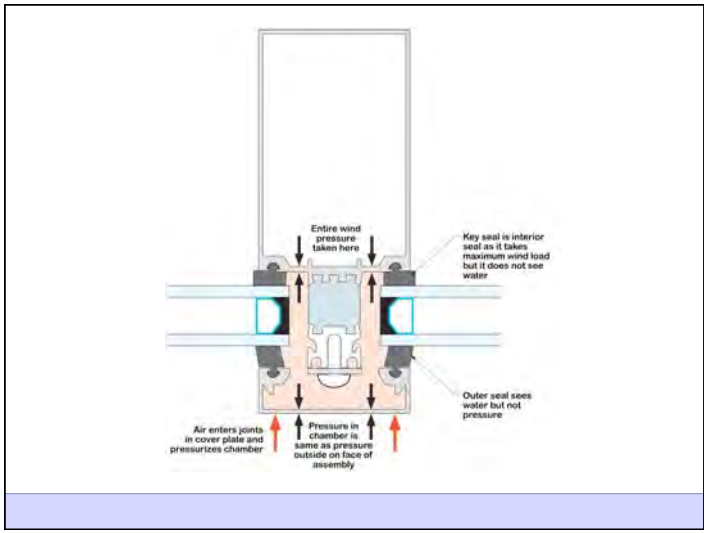

Rain enters cup due to momentum ("kinetic energy")
Cup drains water to exterior

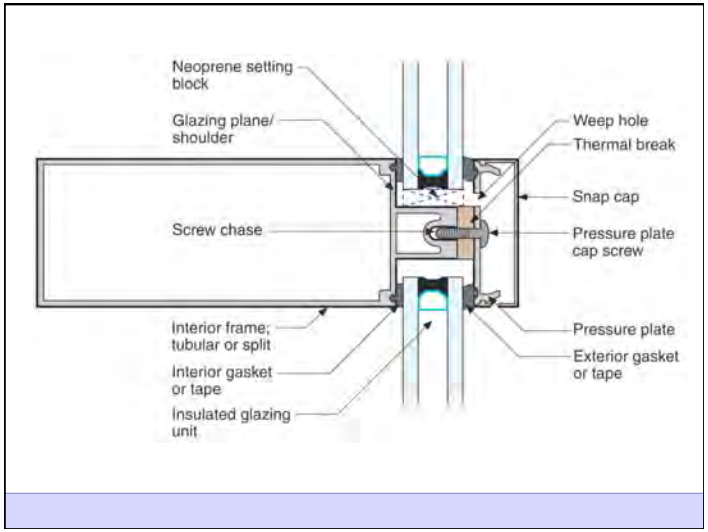

Rain enters cup due to momentum ("kinetic energy")
Wind enters cup— pressurizing cup; no rain entry due to wind driven rain
Entire wind pressure taken here
Cup can still drain water to exterior

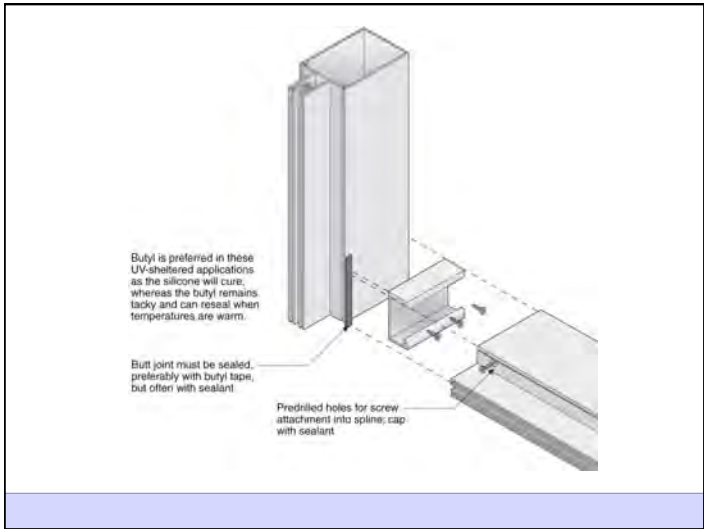

Baffle to deflect raindrops hitting face of cup due to momentum ("kinetic energy")
Pressure in cup is same as pressure outside on face of baffle
Momentum driving force converted to gravity— water drains away
Entire wind pressure taken here
Wind enters cup— pressurizing cup; no rain entry due to wind driven rain
Cup can still drain water to exterior

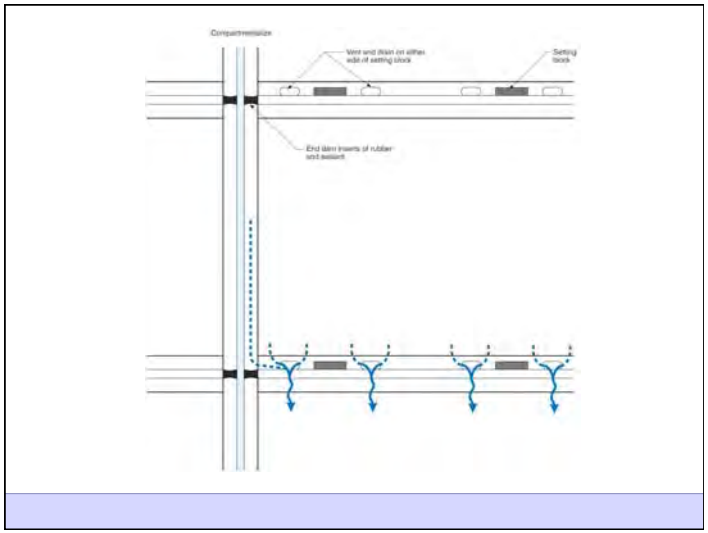

Insulating glass unit
Seal (gasket)
Seal (tape)
Setting block (typically two per unit)
Hole providing drainage and pressurization
Frame
Rough opening

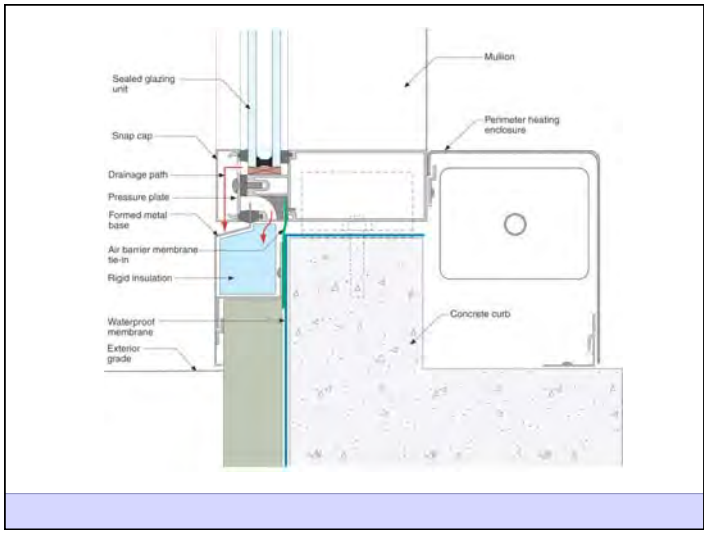

Outer seal sees water but not pressure; no pressure difference across this seal, therefore no rain entry
Key seal is interior seal as it takes maximum wind load but it does not see water
Pressure in chamber is same as pressure outside on face of assembly
Entire wind pressure taken here
Air enters and pressurizes chamber
Pressure chamber

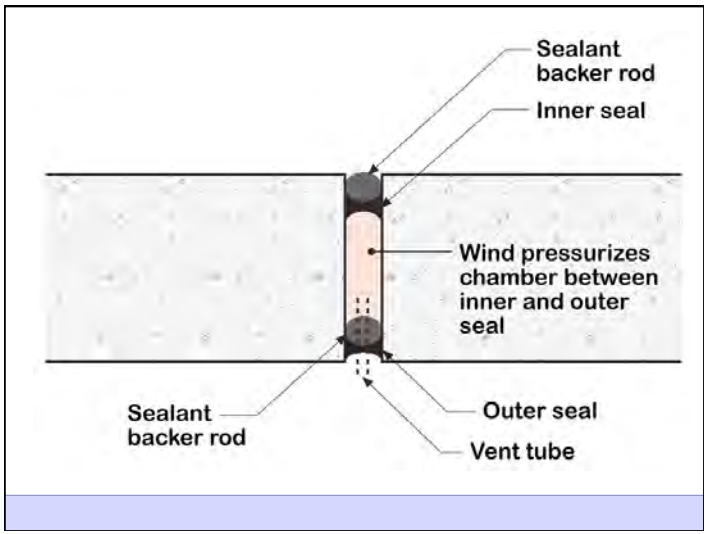

Entire wind pressure taken here
Key seal is interior seal as it takes maximum wind load but it does not see water
Outer seal sees water but not pressure
Air enters joints in cover plate and pressurizes chamber
Pressure in chamber is same as pressure outside on face of assembly

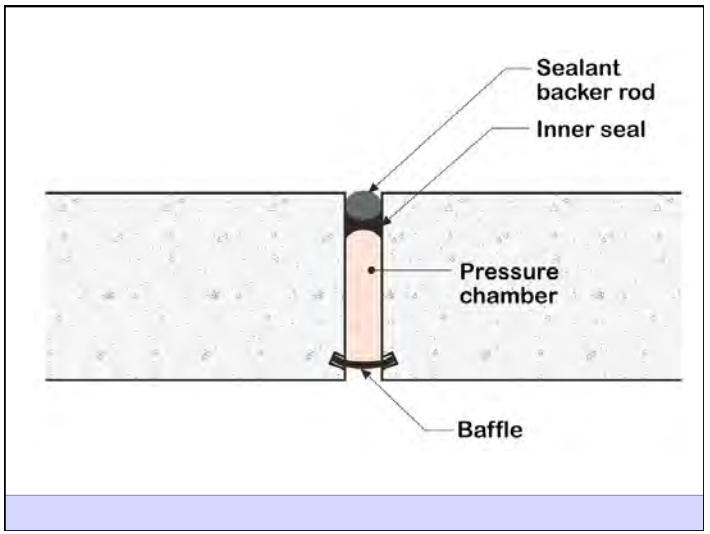

Neoprene setting block
Glazing plane/ shoulder
Screw chase
Interior frame; tubular or split
Interior gasket or tape
Insulated glazing unit
Weep hole
Thermal break
Snap cap
Pressure plate cap screw
Pressure plate
Exterior gasket or tape

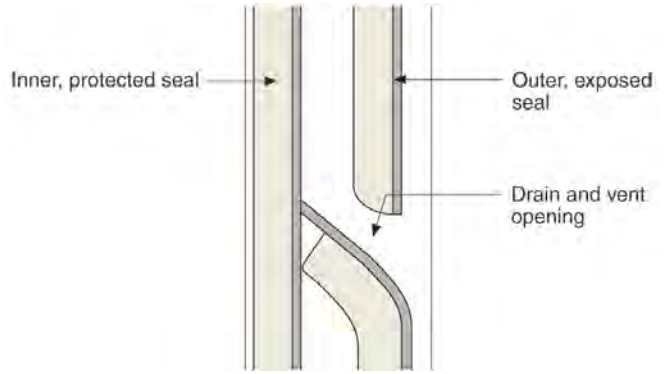

Butyl is preferred in these UV-sheltered applications as the silicone will cure; whereas the butyl remains tacky and can reseal when temperatures are warm.
Butt joint must be sealed, preferably with butyl tape, but often with sealant
Predrilled holes for screw attachment into spline; cap with sealant

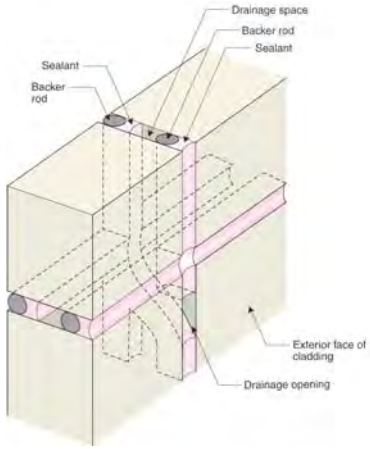


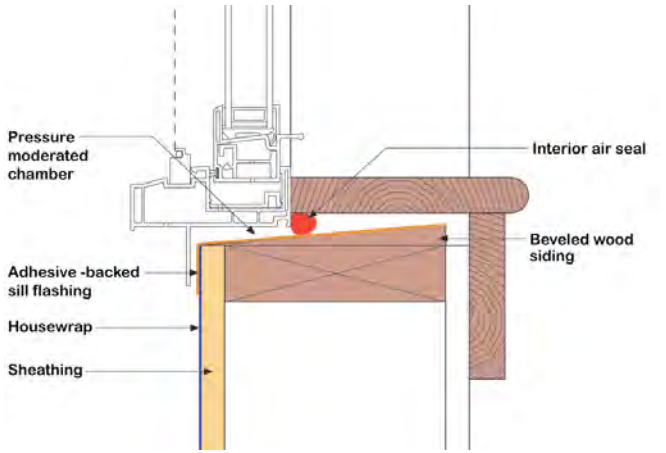

Mullion
Sealed glazing unit
Perimeter heating enclosure
Snap cap
Drainage path
Pressure plate
Formed metal base
Air barrier membrane tie-in
Rigid insulation
Concrete curb
Waterproof membrane
Exterior grade

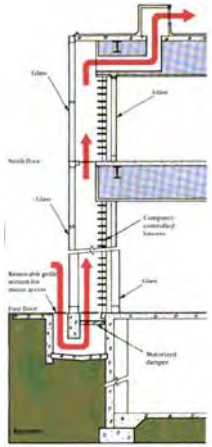

Sealant backer rod
Inner seal
Wind pressurizes chamber between inner and outer seal
Sealant backer rod
Outer seal
Vent tube


Sealant backer rod
Inner seal
Pressure chamber
Baffle

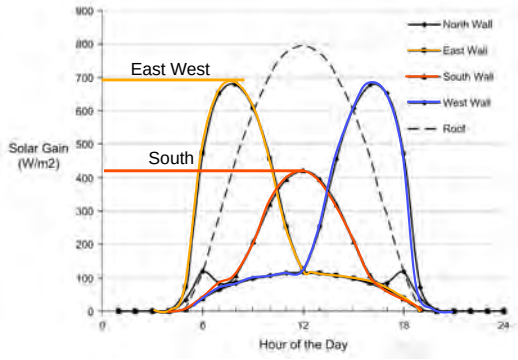

Inner, protected seal
Outer, exposed seal
Drain and vent opening


Drainage space
Backer rod
Sealant
Sealant
Backer rod
Exterior face of cladding
Drainage opening

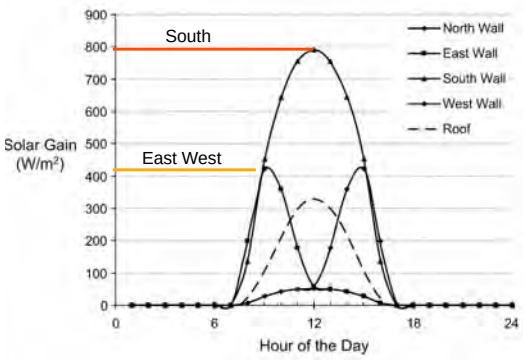

Pressure moderated chamber
Interior air seal
Beveled wood siding
Adhesive -backed sill flashing
Housewrap
Sheathing



Solar Gains - July 21 @45 N



Mother Nature is try to tell you something



Frames

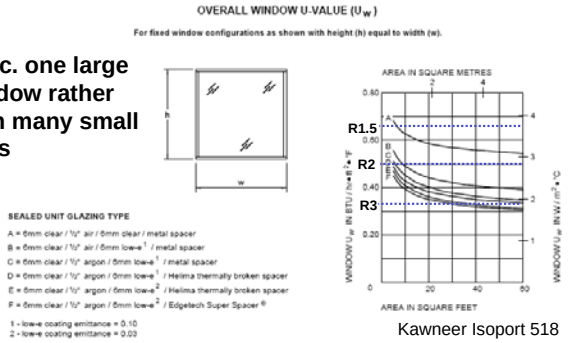
A large amount of heat can also be conducted through the frame

- Conductivity of the material (lower = better)
- Geometry of the frame

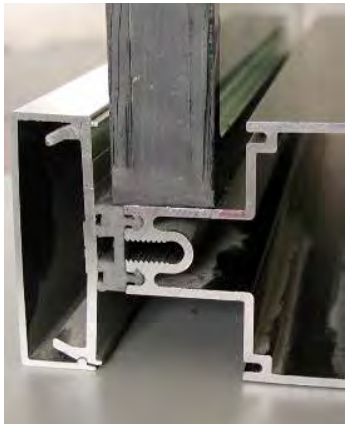
Frame Material	Conductivity W/mk	Conductivity R/inch
Wood	0.10 to 0.18	0.8 to 1.4
PVC	0.17	0.8
Fiberglass	0.30	0.5
Bronze	93	0.002
Aluminum	221	0.001

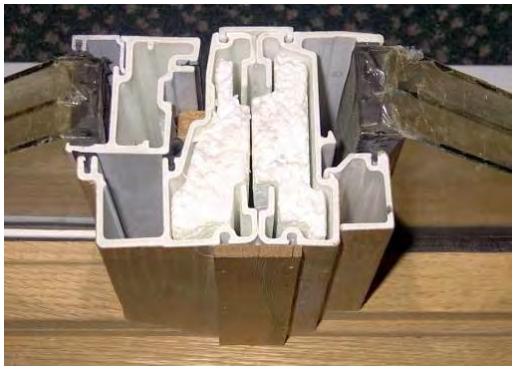
More Frames = More Heat flow

Spec. one large window rather than many small ones



Kawneer Isoport 518





Beware Thermal Flanking

- Beware heat flow around window frame

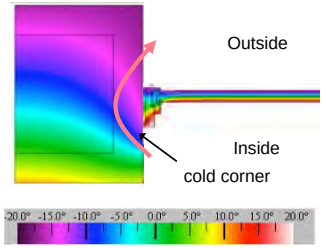


Figure 1: Thermal Flanking

Figure 2: Flanking Reduced

Low-e Coatings

- Low-e coatings reduce the amount of heat transferred by radiation

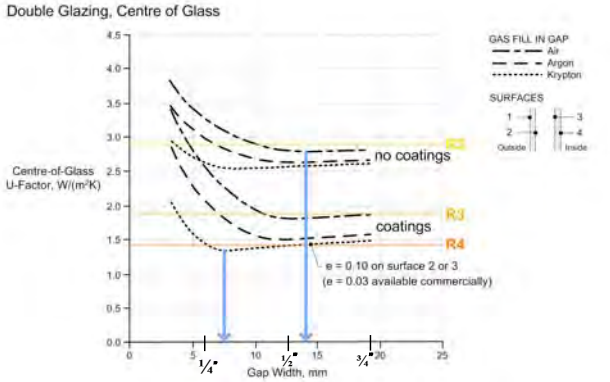
Coating	Emissivity	Radiation Reduction
Uncoated Glass	0.84	-
Low-e 0.2	0.20	62%
Low-e 0.1	0.10	79%
Low-e 0.03	0.03	93%

Gas Fills

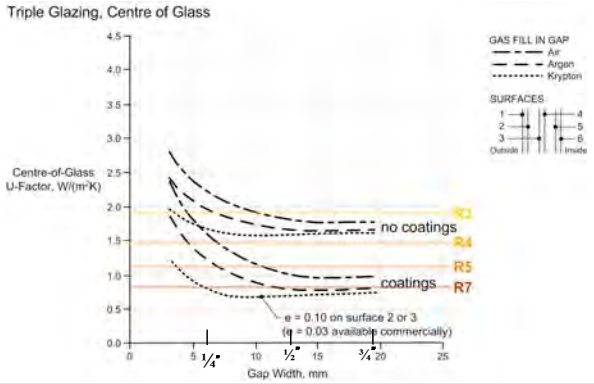
- Gas fills reduce the amount of heat transferred by conduction and convection through the space in the glazing unit

Fill	Conductivity W/mK	Conductivity R/inch	Reduction in Conduction
Air	0.0241	6.0	-
Argon	0.0162	8.9	33%
Krypton	0.0086	16.8	64%
Xenon	0.0051	28.3	79%

Double IGU



Triple IGU



Overall - Performance

Typical Window Performance Numbers

Including Frame	U	SHGC	VT
Double-glazed broken Alu	0.64	0.62	0.62
Dbl Clr Wood/vinyl	0.49	0.56	0.58
Dbl Low-E Gain Wood/vinyl	0.36	0.52	0.53
Dbl Low-E Solar Wood/vinyl	0.32	0.30	0.50
Triple Low E Fibreglass	0.18	0.39	0.49
Alu Curtainwall – no TB	1.2	0.60	0.60
Alu Curtainwall – normal TB	0.60	0.60	0.60
Alu Curtainwall –high perf TB	0.40	0.25	0.55