Building Science

Adventures In Building Science

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Arrhenius Equation
For Every 10 Degree K Rise
Activation Energy Doubles

\[ k = Ae^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
2nd Law of Thermodynamics
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
Wind across the corner of a roof produces a vortex spreading along edges from the windward corner.

Low uplift

Flat roof with parapets
blow-off hazard: low
slippage hazard: low

Sloped roof with parapets
blow-off hazard: low
slippage hazard: medium

High uplift

Flat roof or overhang
blow off hazard: high
slippage hazard: low

Outward sloping roof
blow-off hazard: high
slippage hazard: high

From Baker, M.; Roofs, 1980
Building Science Corporation

Joseph Lstiburek

Gravel

Bitumen top pour

Felt

Bitumen

Felt

Bitumen saturated felt laid dry and nailed to deck

Dry sheathing or rosin paper nailed to deck

Wood deck

From Baker, M.; Roofs, 1980
Supply air into occupied zone returns to AHU by passing through deliberately porous dropped ceiling or through return grilles installed in dropped ceiling.

Air handling unit extracts air from dropped ceiling, conditions it and injects it into the occupied zones via supply ductwork.

Dropped ceiling depressurized by air handling units extracting air from dropped ceiling.
Air barrier system not present to prevent air from being extracted from roof assembly

Corrugated metal roof deck

Membrane roof

Rigid insulation

Brick veneer

Building paper

Interior gypsum should extend to underside of roof deck and be sealed

Exterior sheathing

Metal stud wall

Cavity insulation

Suspended ceiling

Top chord bearing roof truss

Return plenum operates under negative pressure relative to occupied space and exterior
Parapet flashing

Tapered rigid insulation

Grout and reinforce parapet CMU as per structural requirements

Fully-adhered water control membrane

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

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

Air control layer transition membrane

Fiberglass batt insulation

Water, air and vapor control membrane; preferably fully-adhered

Peel and stick transition membrane; air and water control

Fiberglass batt insulation

Backer rod fills gap

Peel and stick transition membrane; air and water control

Water, air and vapor control membrane; preferably fully-adhered

Light gauge steel framing (installed slightly proud of I-beam)

Deflection track allows space for sheathing to move

Metal deck

Air control membrane

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

Fiberglass batt insulation

Backer rod fills gap

Peel and stick transition membrane; air and water control

Fully-adhered water, air and vapor control membrane

Metal deck

Air control membrane

Light gauge steel framing (installed slightly proud of I-beam)

Open web steel joist

Deflection track allows space for sheathing to move
It’s a Case of Black or White
It’s a Case of Black or White
Arrhenius
It’s a Case of Black or White
Arrhenius
Every 10 degrees C – double the “badness”
Roof membrane extends up back side of parapet

Gypsum protection board

Pressure bar

Roof membrane

One layer rigid insulation

“Fluted” metal deck
Absorbed rain water on exterior face of masonry parapet is driven inward and condenses on back side of roofing membrane protecting roof side of parapet.

Condensed water drains down back side of parapet into roof assembly and into building.

Solar radiation strikes wall.

Absorbed rain water.
Vent

Vented "screen"

2" airspace

Fully adhered counter flashing membrane strip
Ballast
Filter fabric
Control layers
Roof structure
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
- Pavers
- Pedestals
- Insulation
- Drainage space/drainage layer
- Sloped concrete roof deck
- Roof membrane (water control layer/drainage plane)
- Concrete structural deck
Plaza Decks
Open paving

Removable for drain cleaning

Closed paving with surface drainage

*From Baker, M.; Roofs, 1980
Courtesy National Research Council of Canada*
Osmosis
Vapor diffusion

Top of membrane is wet
Vapor diffusion

Pore condensation dissolves minerals creating solute
Really Heavy Pink Stuff

Liquid Waterproofing over Concrete Deck
Shingles

Roofing paper

Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered

Nail base for shingles (plywood or OSB) screwed through rigid insulation to wood decking or timber rafters

Air barrier membrane

Wood decking

Timber rafter or exposed joist
Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered.
Legend

- Green arrows: Upper level air flows
- Blue arrows: Lower level air flows
- Red arrows: Air flow at panel joints connecting upper and lower air flows
Fully-adhered roofing membrane

Coverboard and hygric buffer

Rigid insulation (min. two layers; joints offset)

Gypsum sheathing (paperless)

Fully-adhered air control layer/vapor control layer

Screw attachment

Metal deck
Steel angle with flat extension inserted under lap in membrane and fastened to plywood sheathing.

Titanium cladding

Slip sheet

Paperless gypsum sheathing

Fully-adhered, single-ply EPDM membrane 36" (914 mm) wide with 6" (152 mm) lap

Metal purlins for cladding attachment at 24" (610 mm) o.c.

3/4" (19 mm) plywood fastened to purlins

2x4 purlins in two layers; lower purlins fastened to metal deck; upper purlins fastened to lower purlins

1 1/2" (38 mm) rigid insulation
Membrane air barrier

1 1/2" (38 mm) rigid insulation

Membrane

Gypsum sheathing

Metal deck