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**Building Science**  
 Roofs

presented by [www.buildingscience.com](http://www.buildingscience.com)

## This presentation

- Roofing
  - Low-slope
  - Pitched
  - Membrane, metal, etc.

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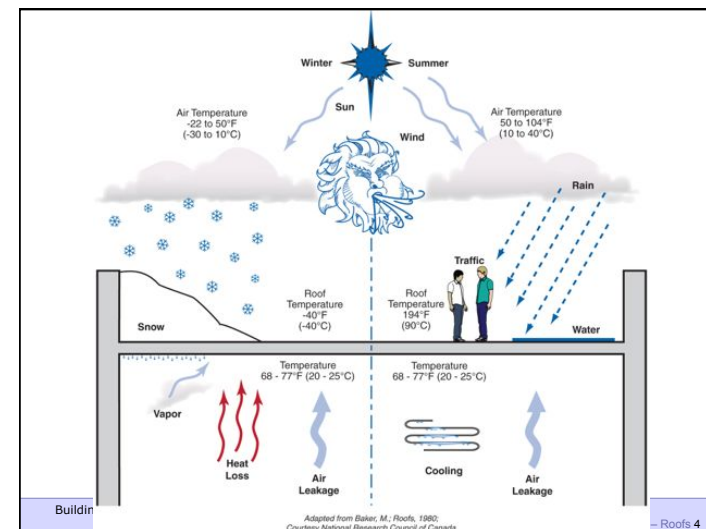
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## Roofs

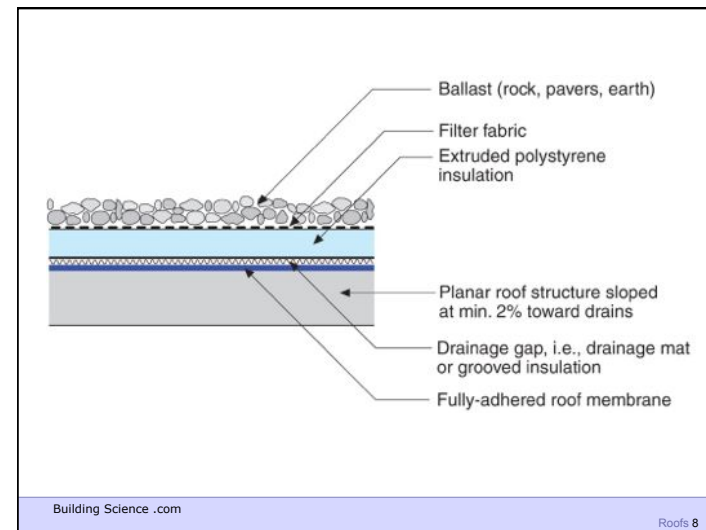
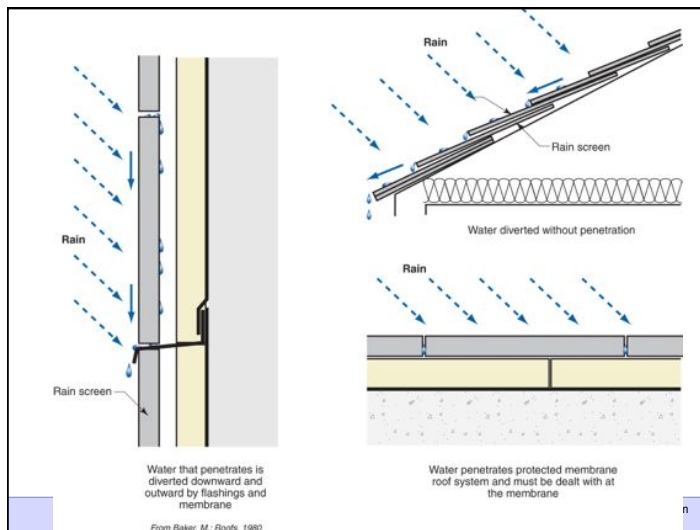
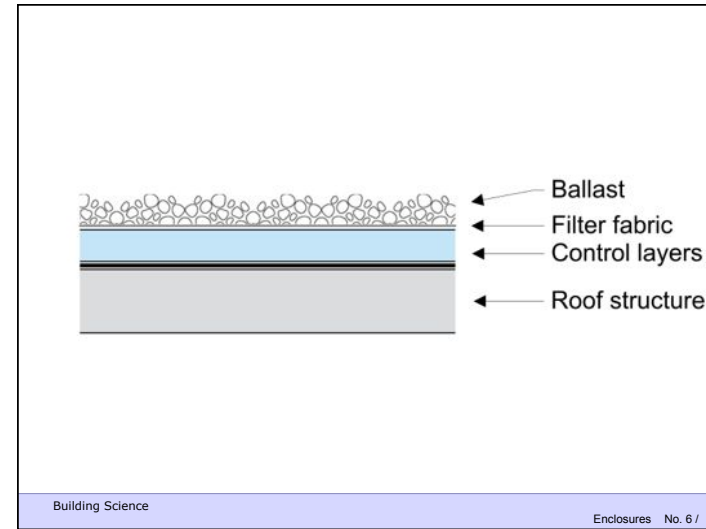
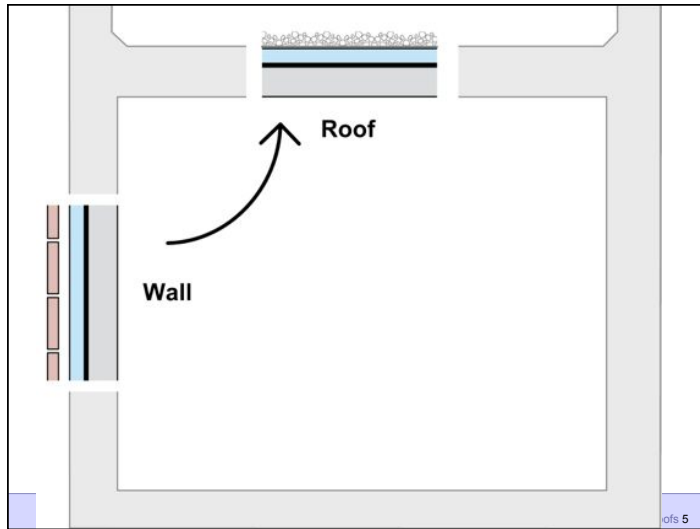
- Roofs are significant proportion of the area of *low-rise* buildings
  - Significant to total cost
  - Major area for heat loss / gain
  - Low-slope membranes usually need replacement every 15-25 yrs.
- Wide range of membrane choices
- Insulation on top *or* bottom of membrane
- Green roofs = organic ballast

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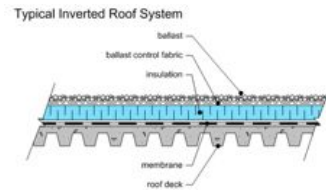


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## Inverted Roof

- Pros:
  - Preferred approach
  - Exterior insulation eliminates thermal bridges
  - Protects membrane
- Cons:
  - Added weight of ballast
  - Can only use XPS

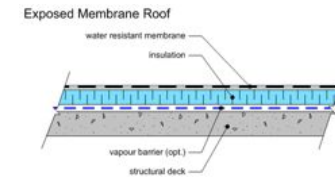


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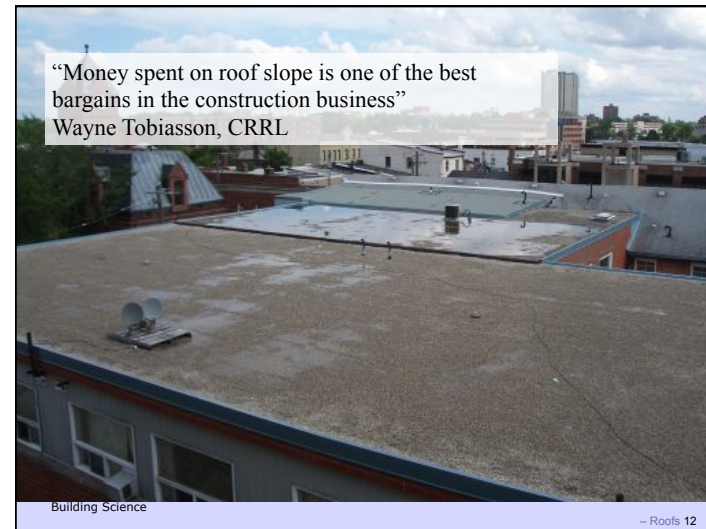
## Exposed membranes

- Pros:
  - Lightest weight
  - Wide variety of insulation and membranes
- Cons:
  - Exposed membrane!



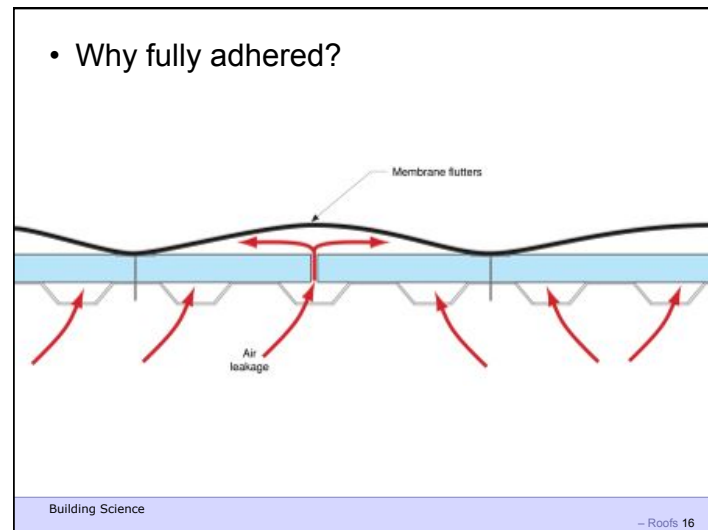
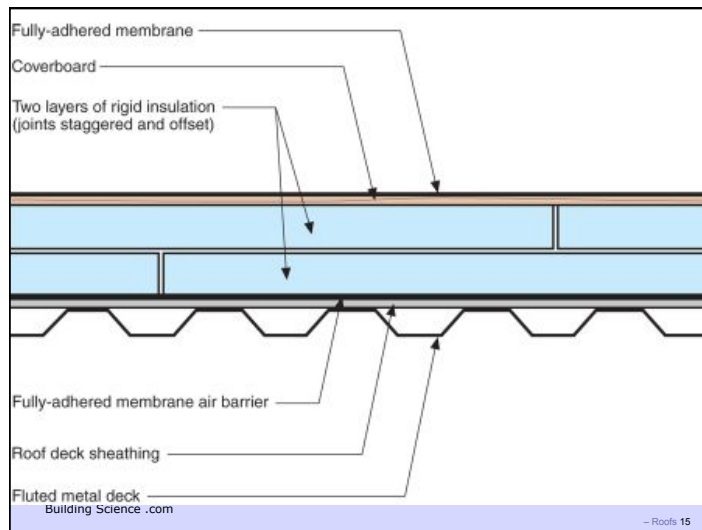
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## Low-level air barriers

- Roof membranes can be air barriers
- In practise, a deck level air barrier is more reliable, easier to control
  - Other benefits include secondary roof during construction and re-roofing

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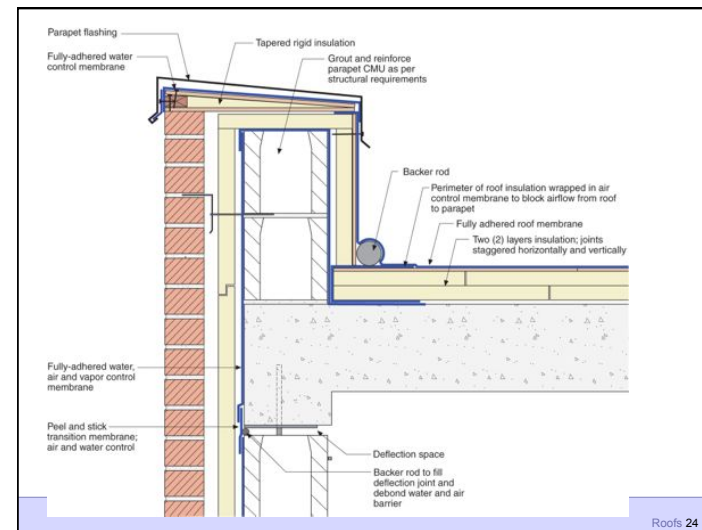
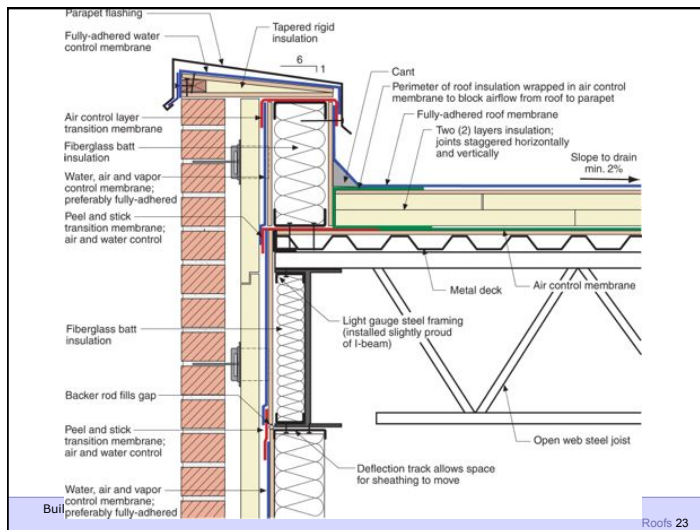
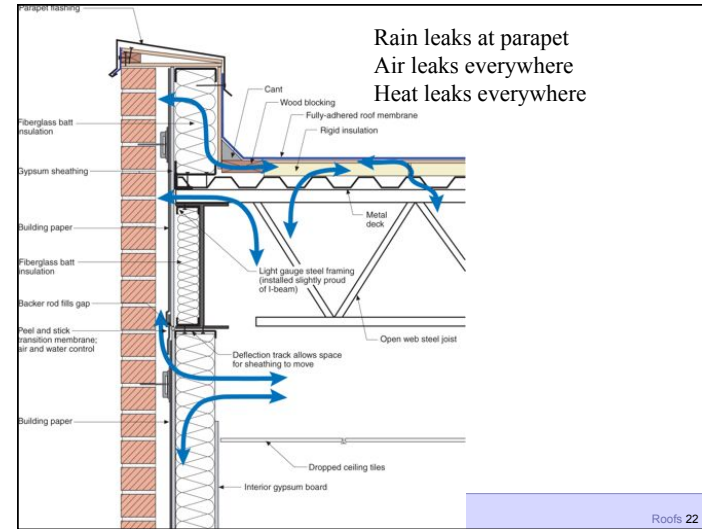
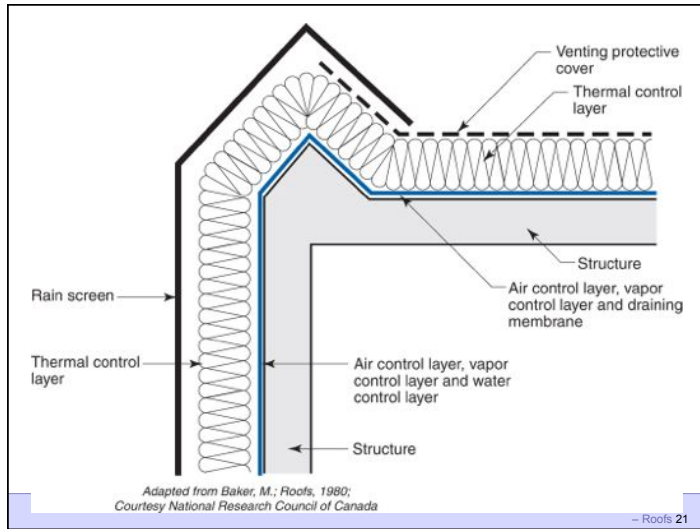
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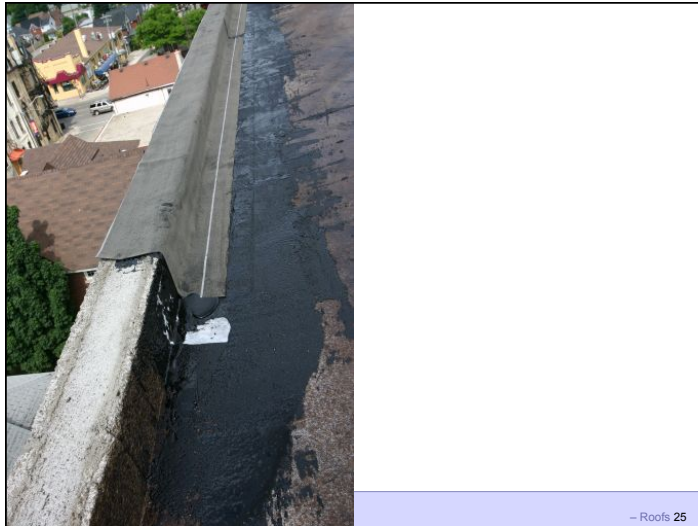


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Parapets



White roofs: the coming storm

What air barrier

### White roofs

- Lower heat gain: great!
- Reduce stress on exposed roof membranes
- **But:** Reduces drying out of roof
- **Thus:** Require better moisture control!
  - Air barrier
  - Construction moisture

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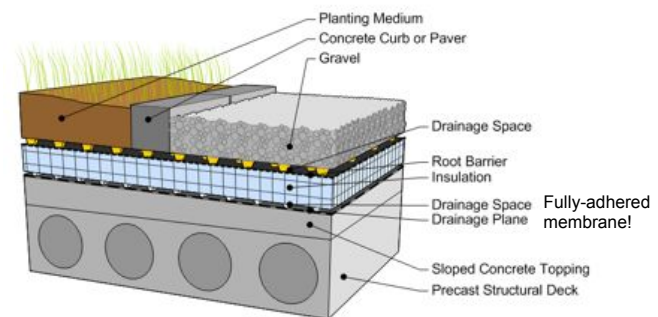
## Green Roofs

- Green roof acts as thermally massive, low solar absorption surface
  - Not insulation
- Save energy compared to black roof of same R-value
- White roof with more insulation is less expensive alternate
  - Don't feel good

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Green Buildings No. 31/51

## “Perfect” Green Roof

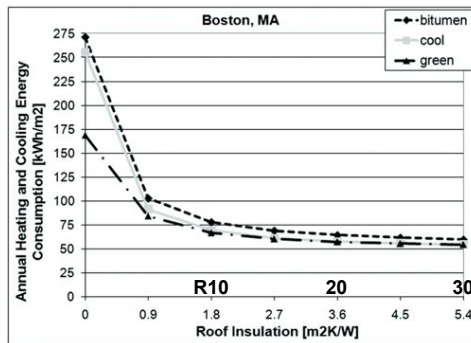


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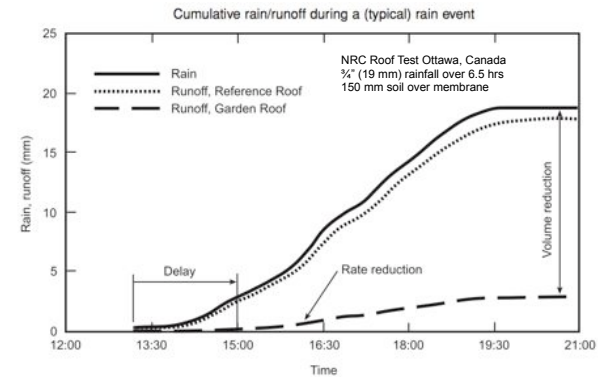


### Energy: Dirt is not insulation



Source: Ray, S., Glicksman, ASHRAE Buildings XI 2010

### Stormwater Management



### Green Roofs

- To save energy, use white roofs with lots of insulation
- Soil does store lots of stormwater
  - Retention mats can do the same
- Likely cleans water somewhat
- Likely absorbs particulates

## Sloped roofs

- Basic Physics are the same
- Slopes allows non-waterproof materials to be lapped “shingle fashion”
- Air – vapor impermeable insulation needed OR ventilation of the sheathing
- Air leaky roofs require more ventilation

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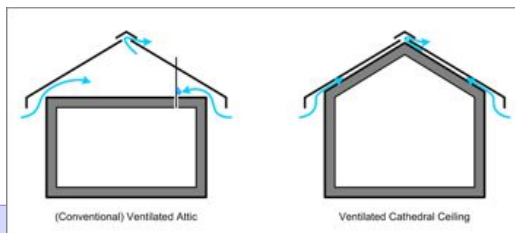


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## Vented Pitched Roof Types

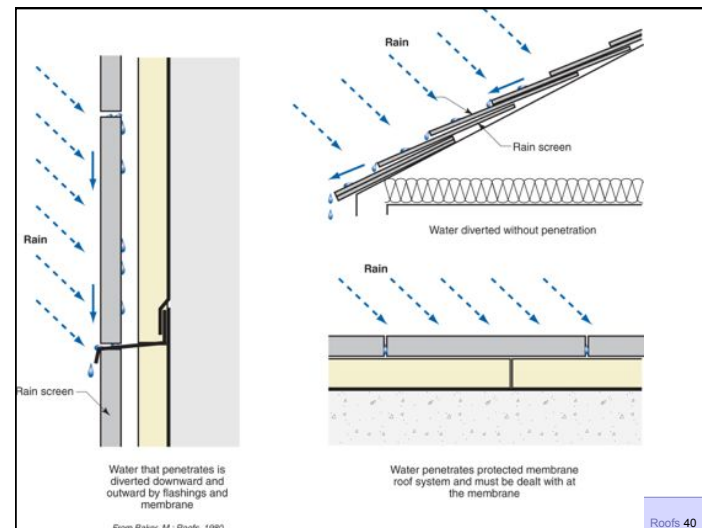
- Vented Attic
  - Insulation/air barrier at ceiling plane
- Cathedral Ceiling
  - Insulation/air barrier at roof plane



(Conventional) Vented Attic

Vented Cathedral Ceiling

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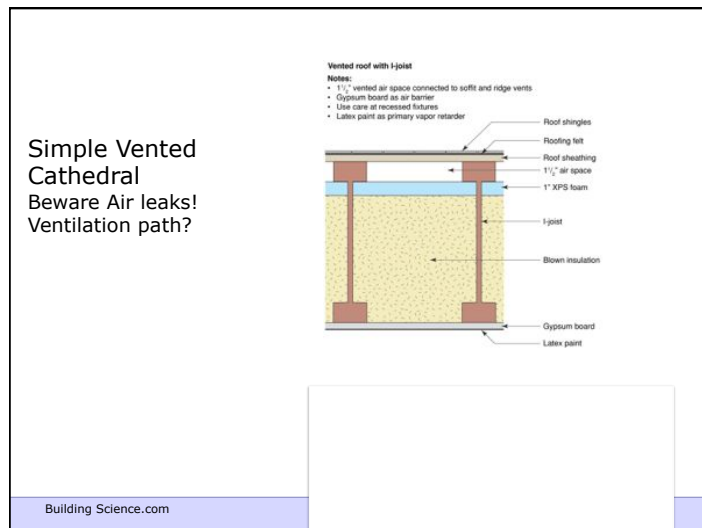
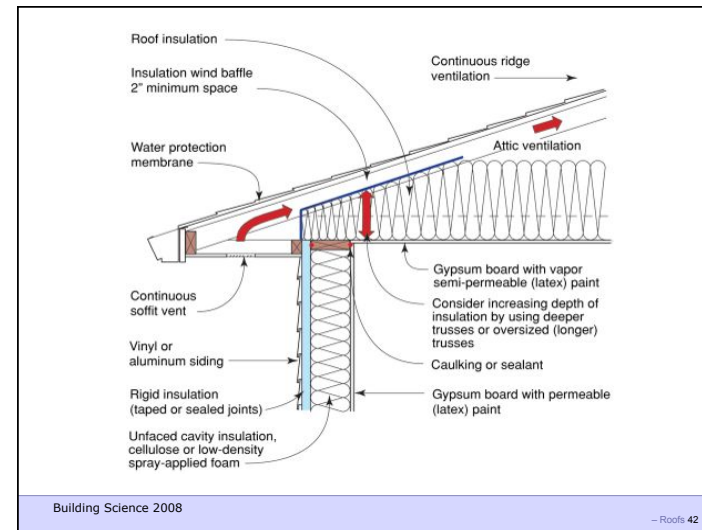
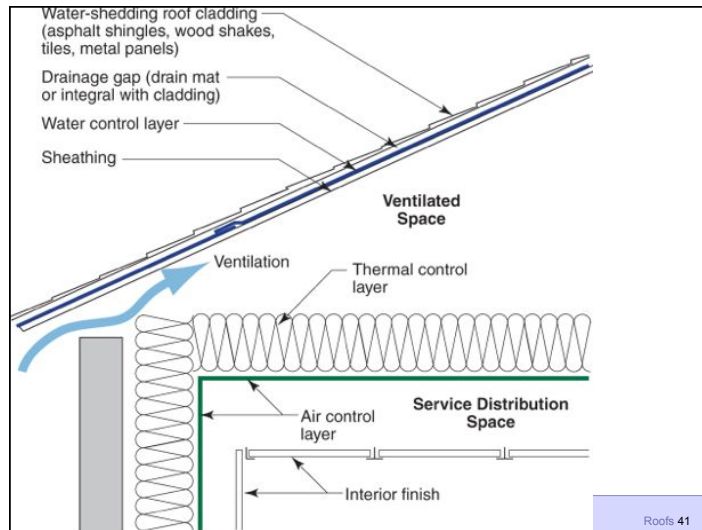


Water that penetrates is diverted downward and outward by flashings and membrane

Water penetrates protected membrane roof system and must be dealt with at the membrane

From Baker, M., Roofs, 1980

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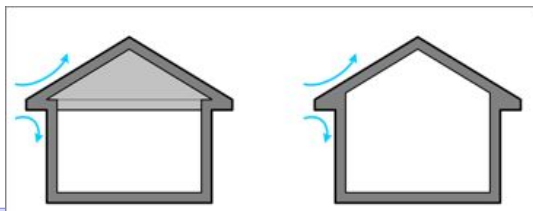




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### Pitched Roof Types

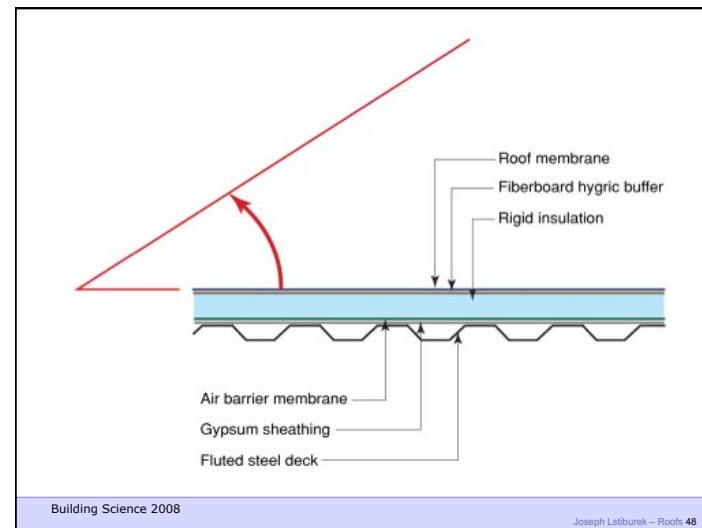
- Unvented Cathedralized Attic
  - As cathedral but no venting above insulation
- Unvented Cathedral



Unvented Cathedralized Attic

Unvented Cathedral Ceiling

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Joseph Lstiburek – Roofs 48

