Roof Drainage Design:

Pitfalls to Avoid and Retrofit Options

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Roof Drainage Design:

Pitfalls to Avoid and Retrofit Options

Why don't we want standing water on the roof?

Water roof in Apeldoorn, Netherlands

Why don't we want standing water on the roof?

- Roof deterioration
  - Risk of leaks or catastrophic leaks
- Overloading structure
  - Deck deflection or collapse
- Ice and slippery surfaces
- Unwanted birds, feces, and drain plugging debris
- Disease/Infection
  - Legionnaires' disease
  - West Nile
  - Mould spores

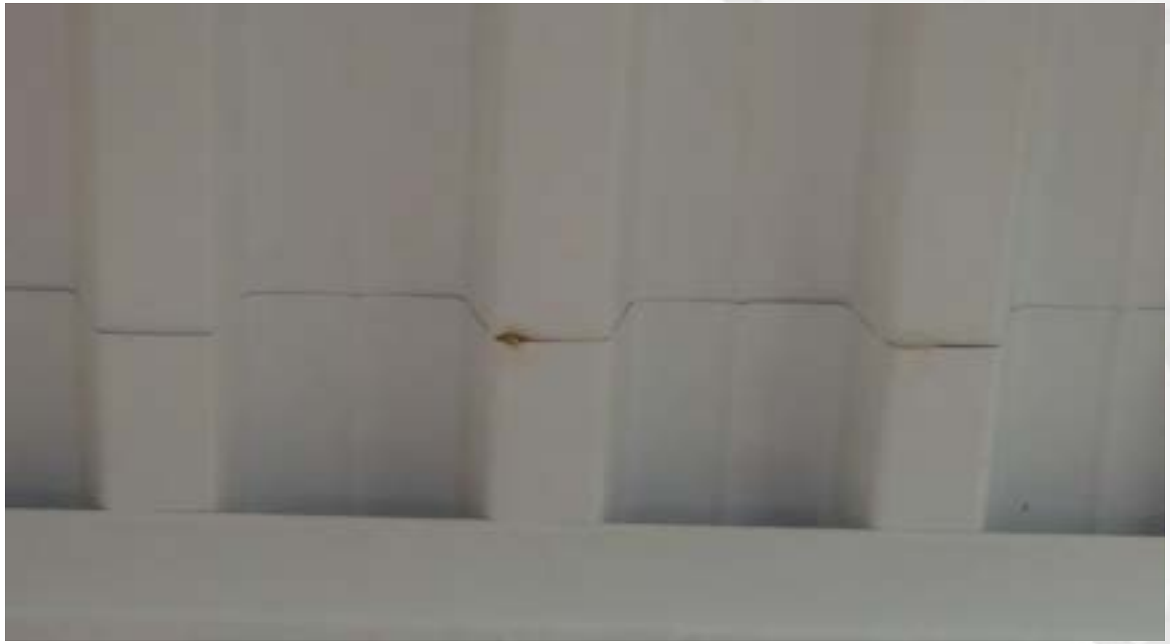
Roof Drainage Design:

Pitfalls to Avoid and Retrofit Options

- Water Concerns on Low Sloped Roofs
- Proactive Roof Drainage Considerations
- Common Pitfalls
- Retrofit Options
- Case Studies

Roof Deterioration

- Risk of leaks



Roof Deterioration

- Risk of leaks

Roof Deterioration

- or catastrophic leaks

Roof Deterioration

- or catastrophic leaks

Overloading structure

- Deck deflection

Overloading structure

- Deck collapse

Ice and Slippery Surfaces

Unwanted drain plugging debris

- Unwanted birds, feces, and drain plugging debris

Disease

- Legionnaires disease

Disease

- West Nile

Disease

- Mould spores

Proactive Roof Drainage Considerations

- Design/build drainage system to code – NPC
- Check design loads
- Understand drainage anatomy
- Provide redundant drains
- Evenly locate drains
- Provide overflow drains
- Provide adequate slope to drain

Proactive Roof Drainage Considerations

- Design/build drainage system to code – NPC

2.4.10.4. Hydraulic Loads from Roofs or Paved Surfaces

1) Except as provided in Sentence (2), the hydraulic load in litres from a roof or paved surface is the maximum 15 min rainfall determined in conformance with Subsection 1.1.3. of Division B of the NBC, multiplied by the sum of

a) the area in square metres of the horizontal projection of the surface drained, and

b) one-half the area in square metres of the largest adjoining vertical surface.

(See Note A-2.4.10.4.(1).)

2) *Flow control roof drains* may be installed, provided

a) the maximum drain down time does not exceed 24 h,

b) the roof structure is designed to carry the load of the stored water,

c) one or more scuppers are installed not more than 30 m apart along the perimeter of the *building* so that

i) up to 200% of the 15-minute rainfall intensity can be handled, and

ii) the maximum depth of controlled water is limited to 150 mm,

Proactive Roof Drainage Considerations

- Design/build drainage system to code – NPC

2.4.10.4. Hydraulic Loads from Roofs or Paved Surfaces

d) they are located not more than 15 m from the edge of the roof and not more than 30 m from adjacent drains, and
e) there is at least one drain for each 900 m².

3) Hydraulic loads, in litres per second, for *flow control roof drains* and restricted paved area drains shall be determined according to rain intensity-duration frequency curves as compiled by Environment Canada using 25-year frequencies.

4) Where the height of the parapet is more than 150 mm or exceeds the height of the adjacent wall flashing,
a) emergency roof overflows or scuppers described in Clause (2)(c) shall be provided, and
b) there shall be a minimum of 2 *roof drains*.

Proactive Roof Drainage Considerations

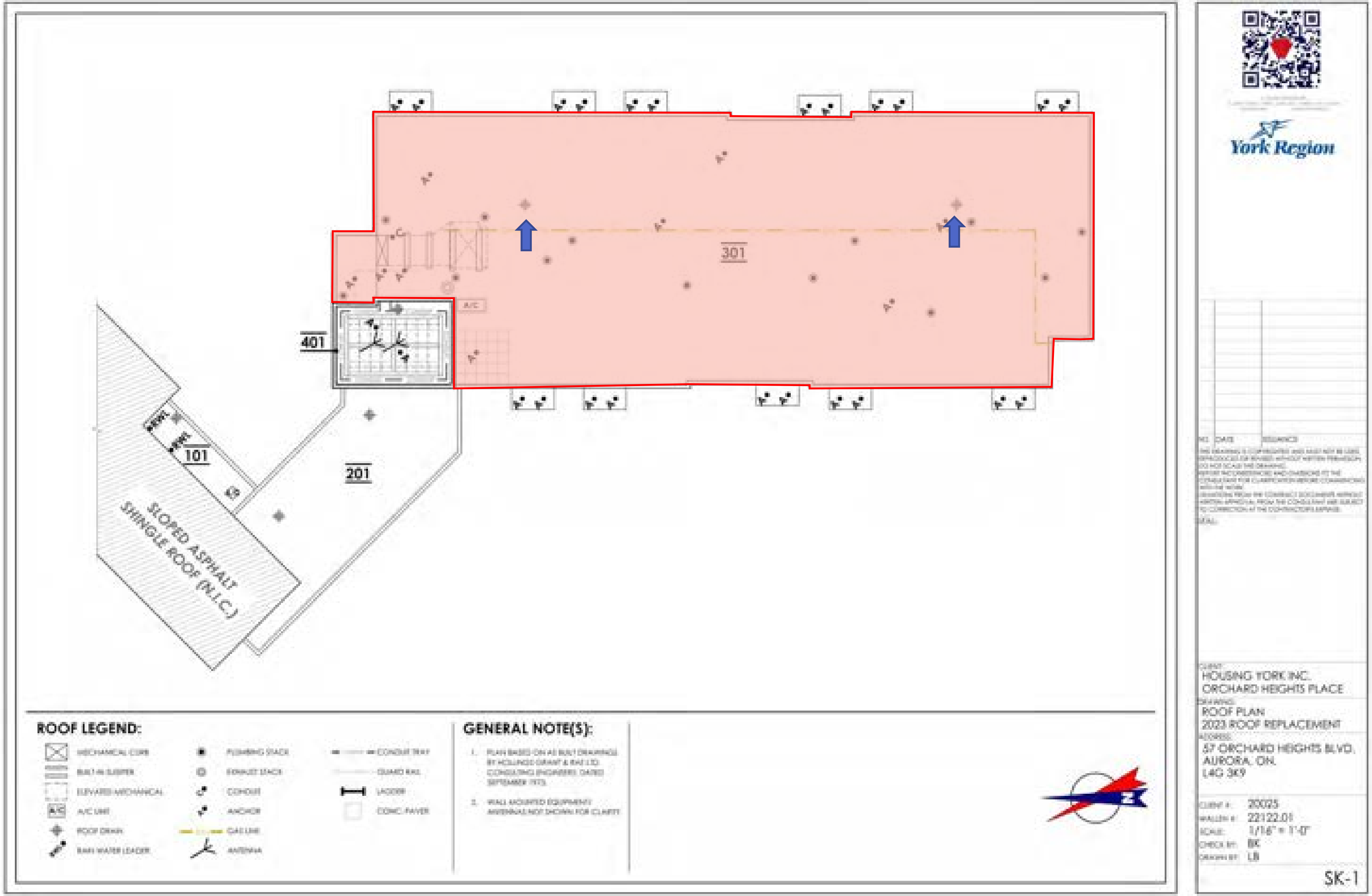
- Design/build drainage system to code – NPC

Table 2.4.10.11.
Maximum Permitted Hydraulic Load Drained to a Leader
Forming Part of Article 2.4.10.11.

Circular *Leader*		Non-Circular *Leader*	
Nominal Pipe Size of *Leader, NPS*	Maximum Hydraulic Load, L	Area of *Leader*, cm²	Maximum Hydraulic Load, L
2	1 700	20.3	1 520
2½	3 070	31.6	2 770
3	5 000	45.6	4 500
4	10 800	81.1	9 700
5	19 500	126.6	17 600
6	31 800	182.4	28 700
8	68 300	324.3	61 500

Table 2.4.10.10.
Maximum Permitted Hydraulic Load Drained to a Roof Gutter
Forming Part of Article 2.4.10.10.

Nominal Pipe Size of *Gutter, NPS*	Area of *Gutter*, cm²	Maximum Hydraulic Load, L			
		Slope			
		1 in 200	1 in 100	1 in 50	1 in 25
3	22.8	406	559	812	1 140
4	40.5	838	1 190	1 700	2 410
5	63.3	1 470	2 080	2 950	4 170
6	91.2	2 260	3 200	4 520	6 530
7	124.1	3 250	4 600	6 500	9 190
8	162.1	4 700	6 600	9 400	13 200
10	253.4	8 480	12 000	17 000	23 600



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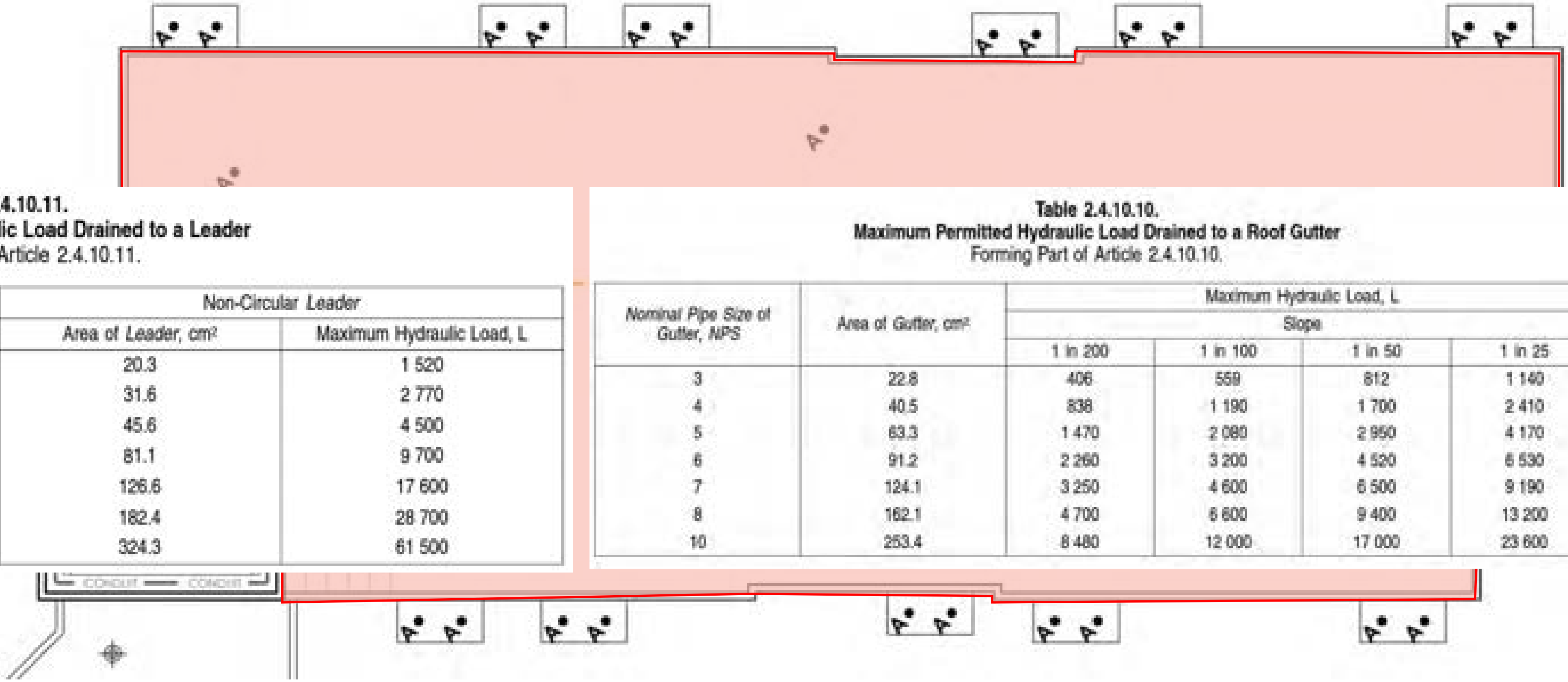
Design/build drainage system to code – NPC

- 610m^2 Roof
- 2 drains @ 4"Φ



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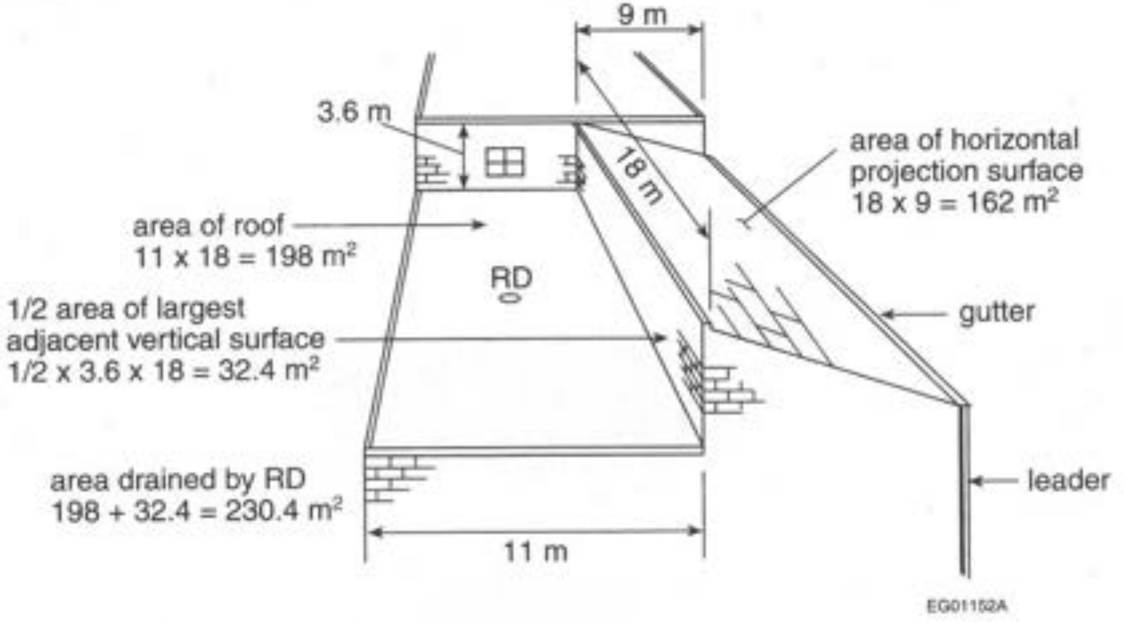
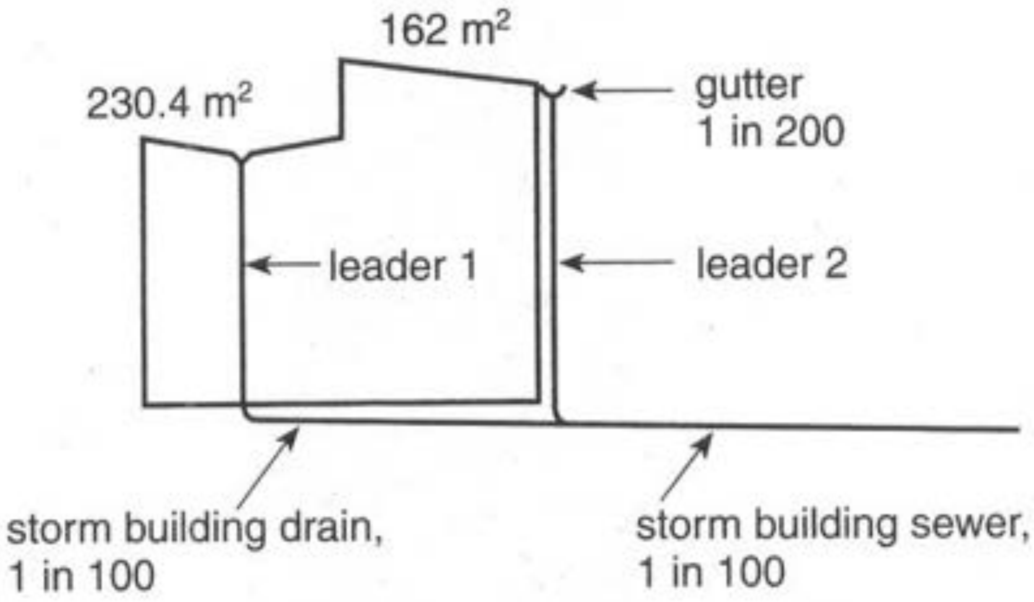
Proactive Roof Drainage Considerations

- Check design loads





- 610m² Roof
- 18m2 Largest Adj. Wall
- Total Area
  - [(18/2)+610]*25=15,259L
- 2 drains @ 4"Φ
  - 2*10800=21,600L

✓21,600L>15,259L

Check Design Loads

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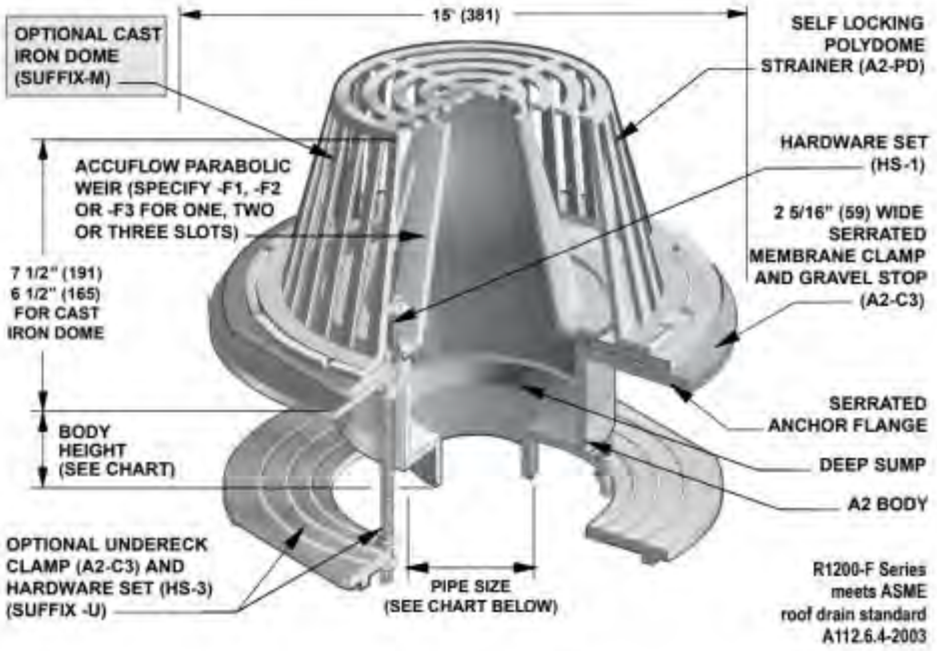
Proactive Roof Drainage Considerations

- Understand drainage anatomy



Understand Drainage Anatomy

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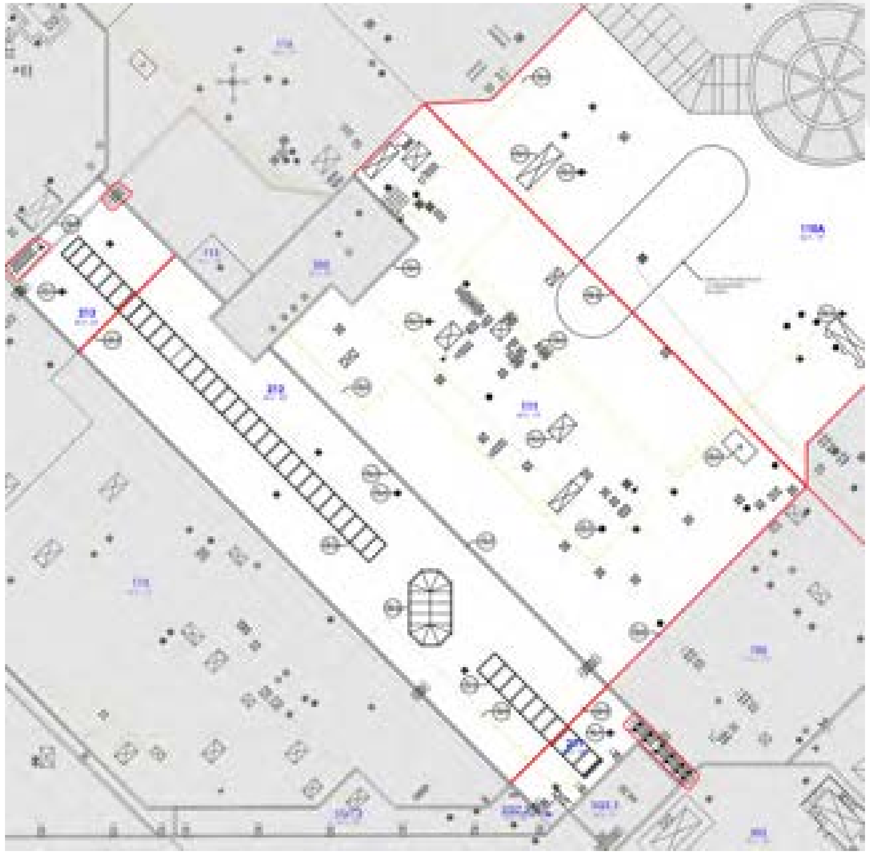
Understand Drainage Anatomy

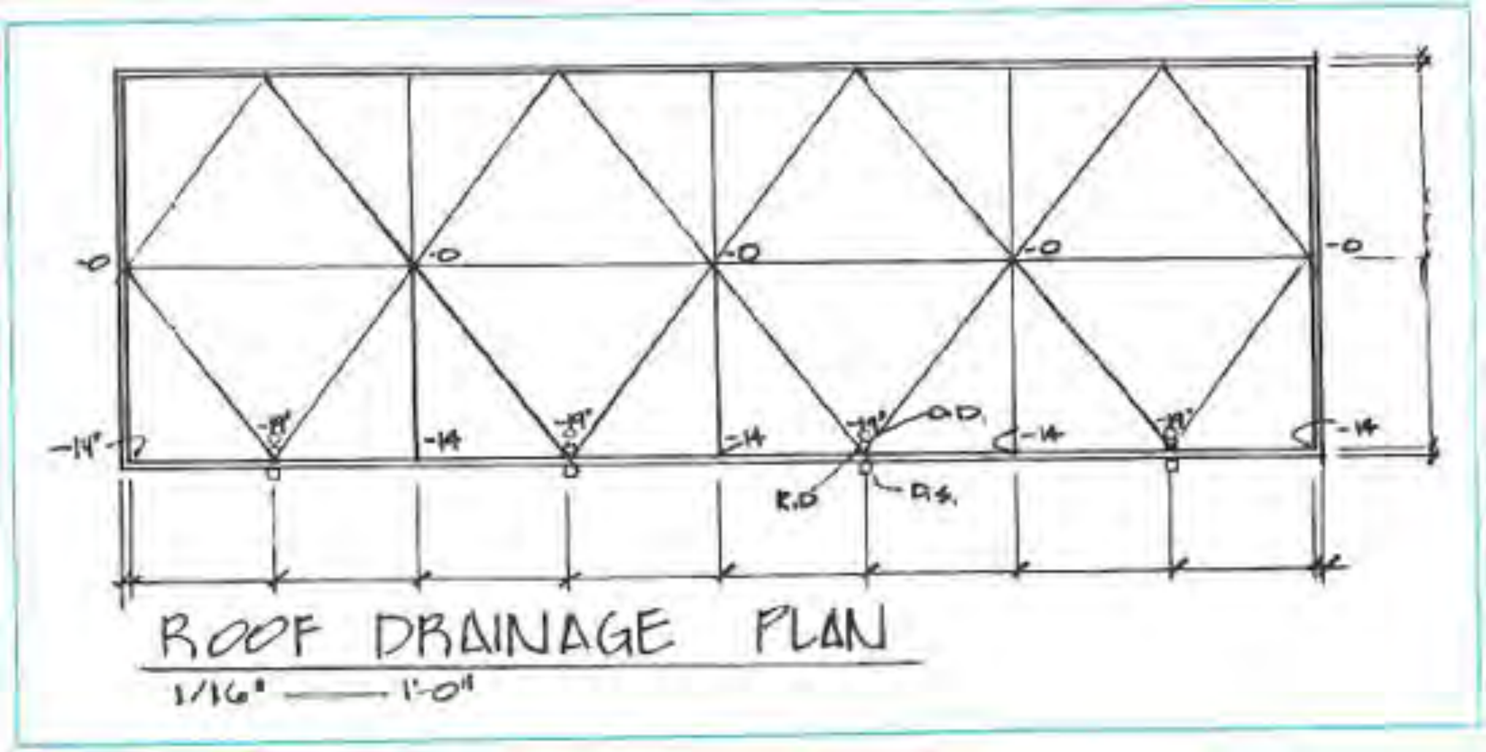
Proactive Roof Drainage Considerations

- Provide redundant drains



Proactive Roof Drainage Considerations

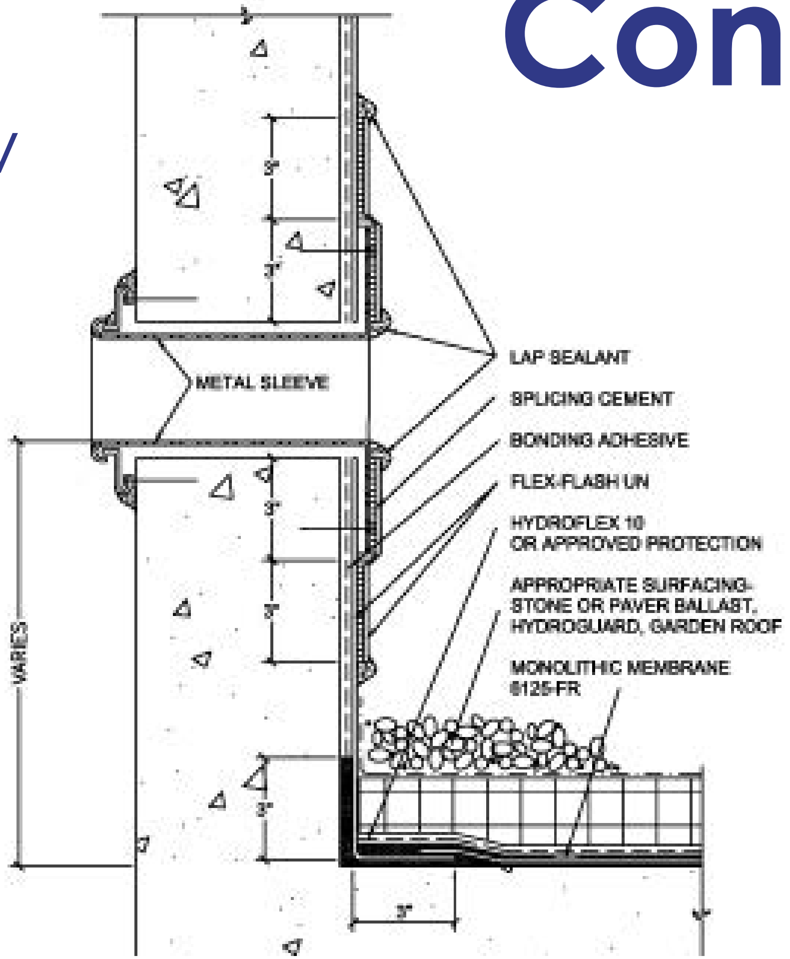
- Evenly locate drains



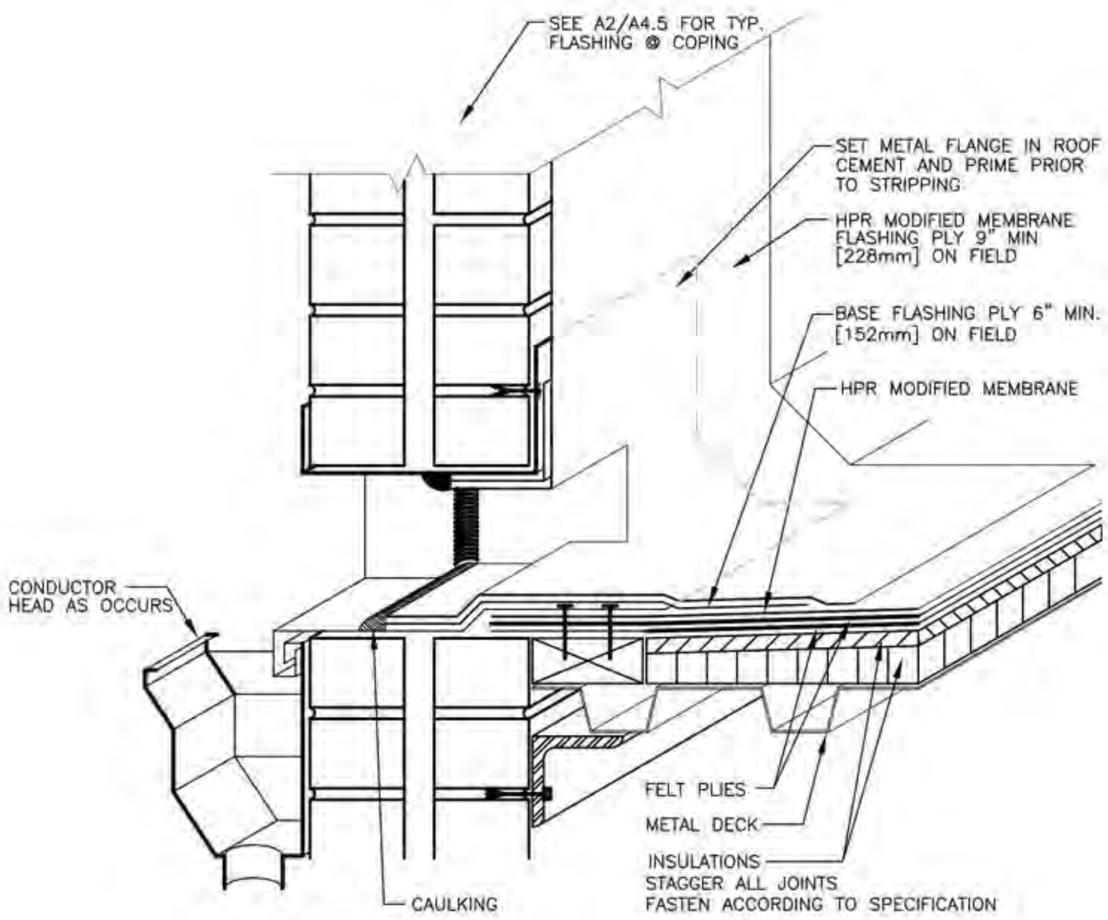
Understand Drainage Anatomy

Proactive Roof Drainage Considerations

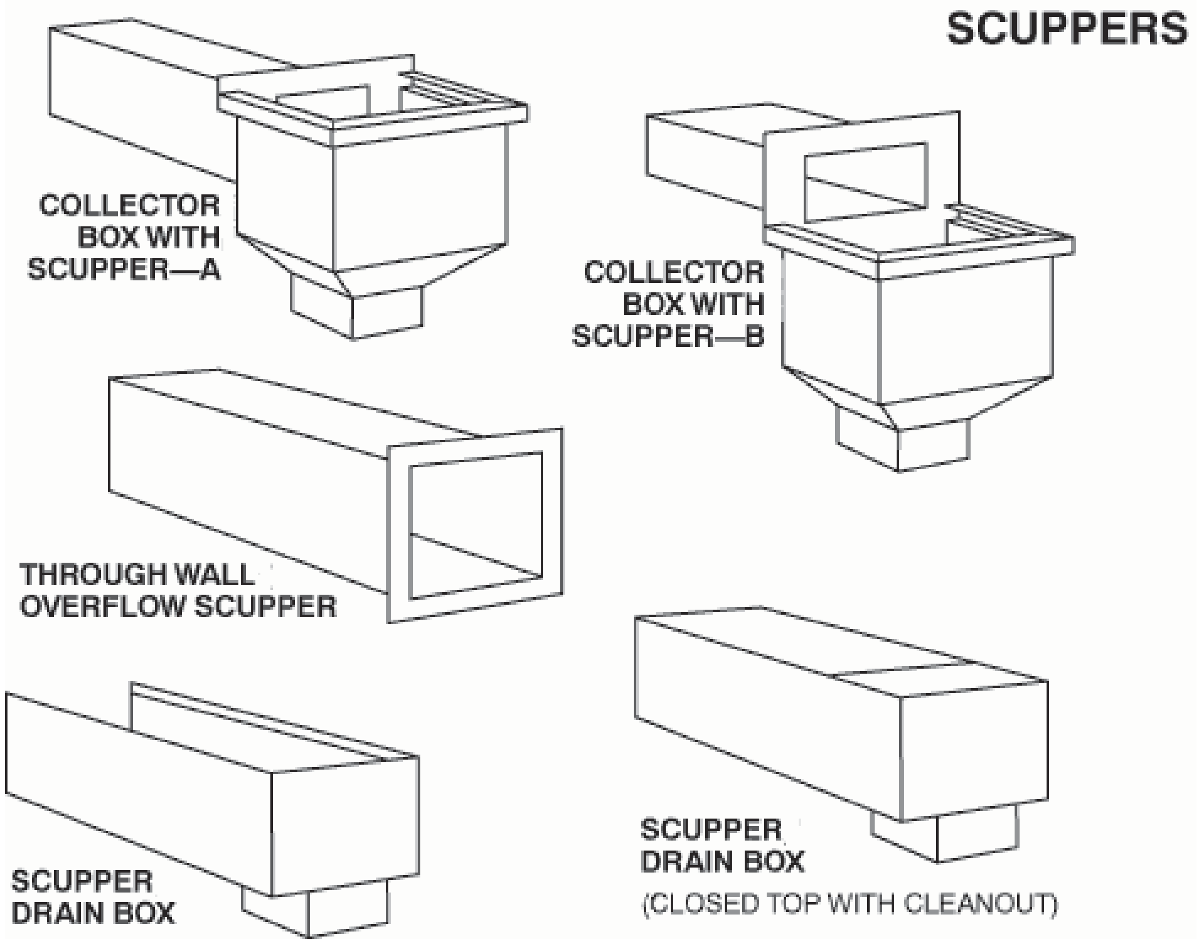
- Provide overflow drains



Scupper Drains



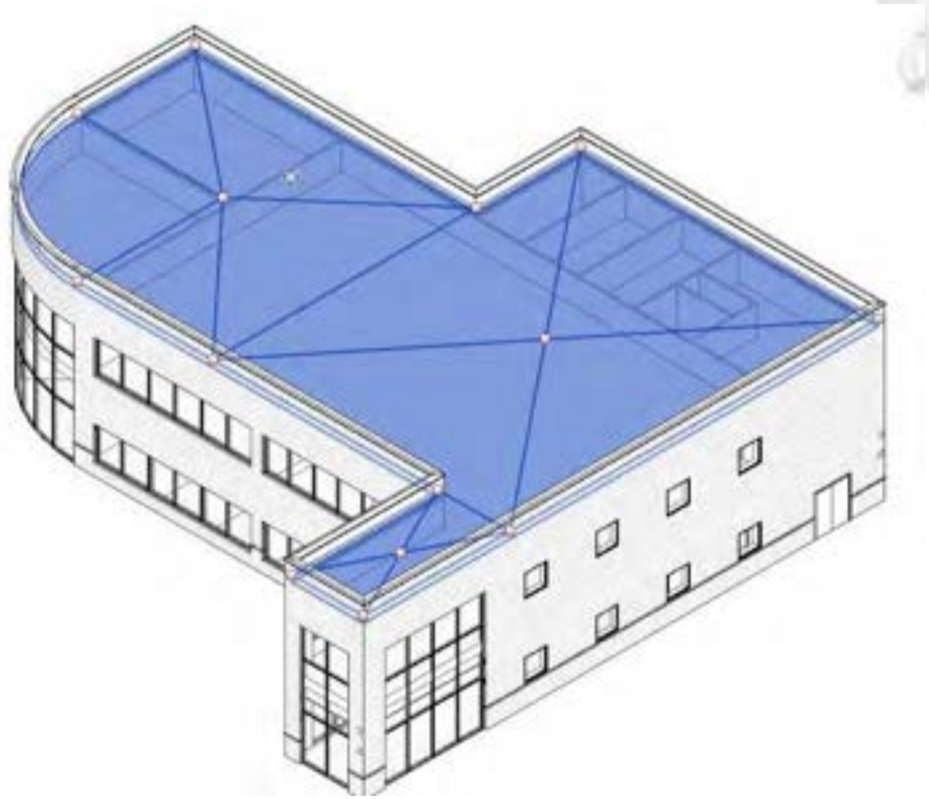
Scupper Drains



Proactive Roof Drainage Considerations

- Provide adequate slope to drain

- Slope structural deck



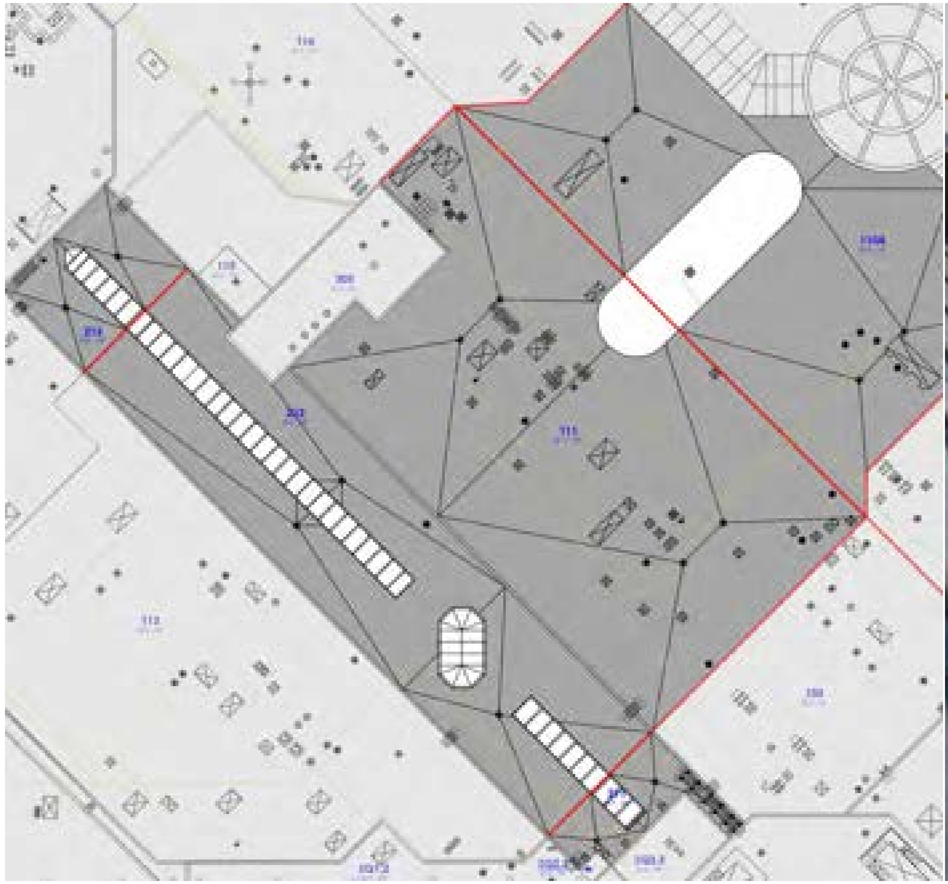
Proactive Roof Drainage Considerations

- Provide adequate slope to drain
- Slope concrete or Concrete topping

Proactive Roof Drainage Considerations

- Provide adequate slope to drain

- Full Tapered Insulation

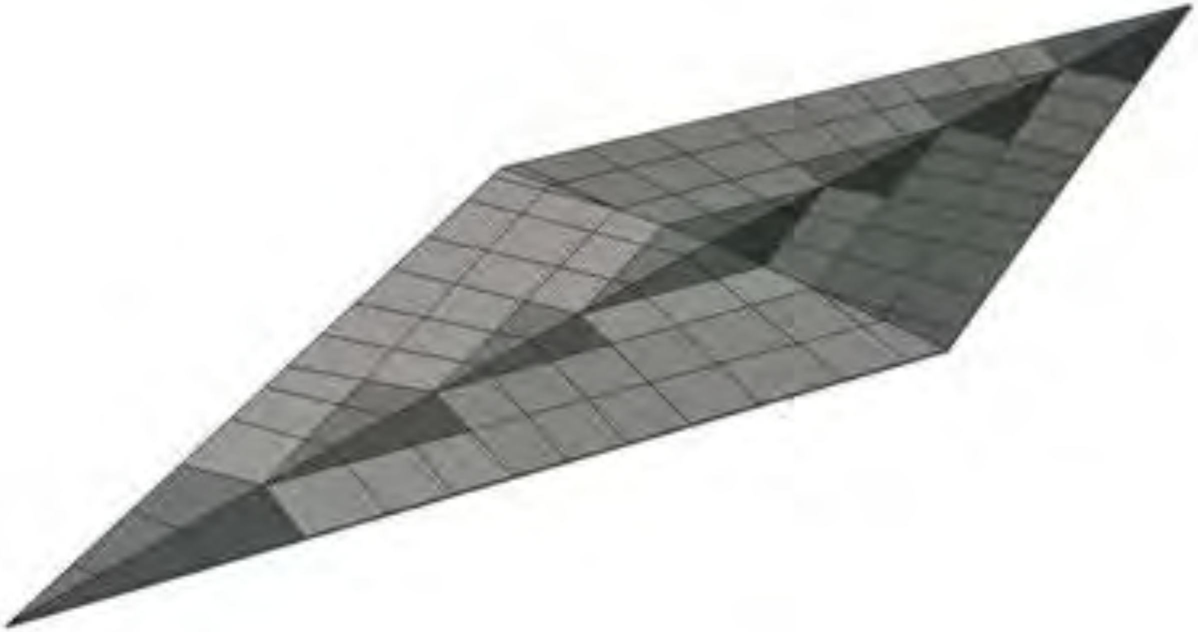


Proactive Roof Drainage Considerations

- Provide adequate slope to drain
- Tapered insulation

Proactive Roof Drainage Considerations

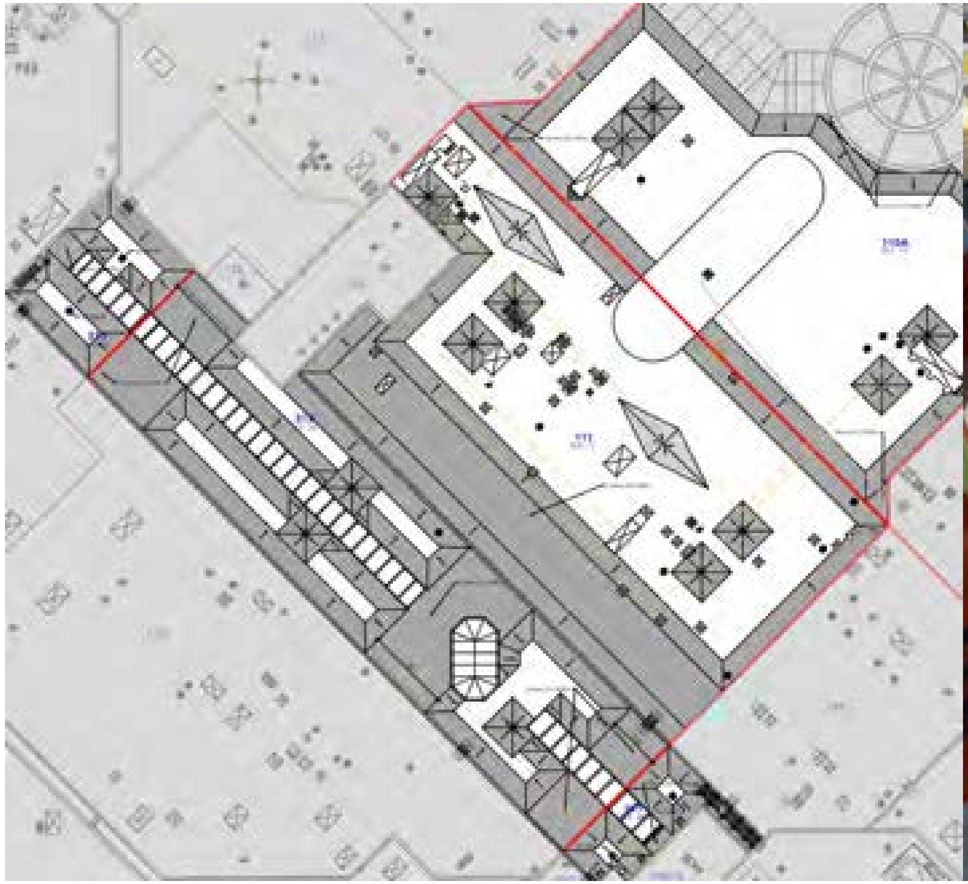
- Provide adequate slope to drain
- Crickets



Proactive Roof Drainage Considerations

- Provide adequate slope to drain

- Localized tapered Insulation
- Fit low curbs
- 20-30% savings

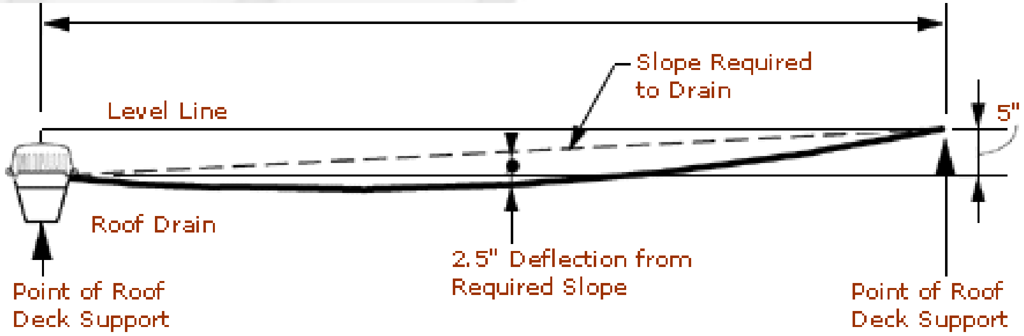


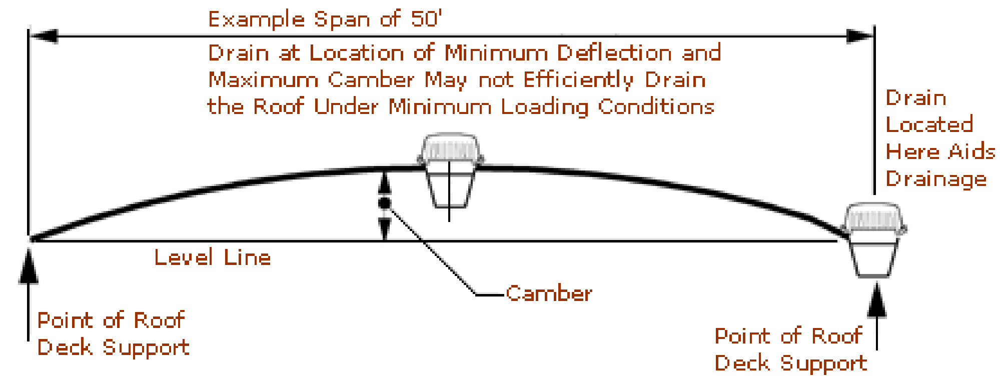
Common Pitfalls

- Drains located at high points
- Deck deflection
- Rooftop equipment blocking drainage path
- Blocked drains
- Mechanically impeded plumbing

Common Pitfalls

- Drains located at high points





Common Pitfalls

- Deck deflection

Common Pitfalls

- Rooftop equipment blocking drainage path

Common Pitfalls

- Blocked drains

Common Pitfalls

- Mechanically impeded plumbing

Retrofit Option

- Maintain drains and keep clear
- Prevent/Remove mechanical obstructions
- Relocate drains
- Add drains or scuppers
- Add sloped infill
  - Integrated during construction
  - Surface retrofit
- Mechanical Pump Drains (AC/Solar DC/Siphon)

Retrofit Option

- Maintain drains and keep clear

Retrofit Option

- Prevent/Remove mechanical obstructions
  - Avoid internal drain fittings
  - Provide proper drain screens and ballast guards where required

- DON'T REMOVE FLOW CONTROL DEVICES

Retrofit Option

- Relocate drains

Retrofit Option

- Add drains or scuppers

Retrofit Option

- Add sloped infill
  - Integrated during construction
  - Surface retrofit

Retrofit Option

- Tapered Materials Integrated during construction

Retrofit Option

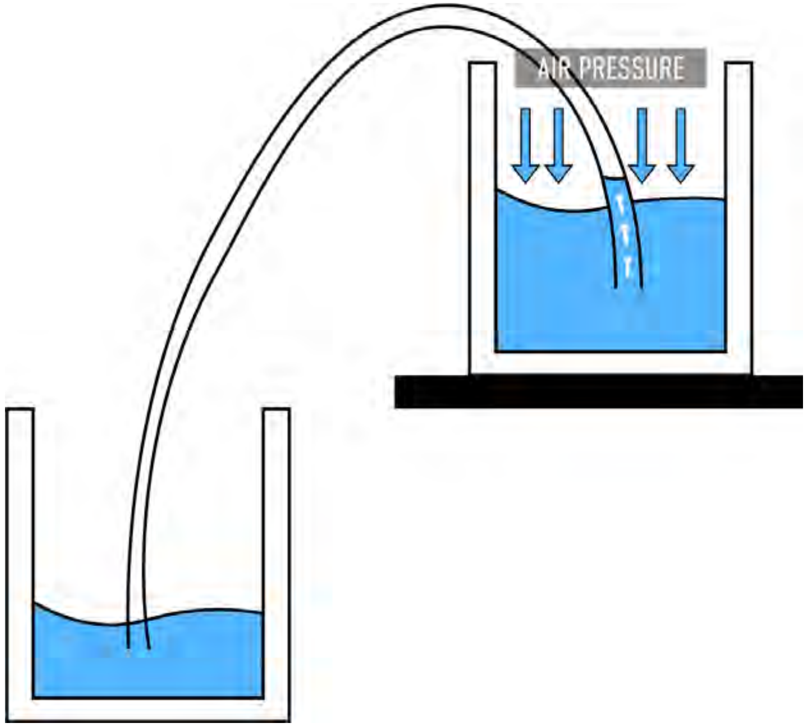
- Surface retrofit with material infill

Retrofit Option

- Surface retrofit with material infill

Retrofit Option

- Mechanical Pump Drains (AC/Solar DC/Siphon)

Case Study 1:

Existing Conventional Built-up Roof

- Secondary School
- 2-stories
- Autoclave Aerated Concrete (Siporex) structure

Case Study 1:
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- Secondary School
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Case Study 1:

Existing Conventional Built-up Roof

- Roof reaching end of serviceable life
- Siporex deflection mid-span over classrooms

Case Study 1:

Existing Conventional Built-up Roof

- Original Roof Assembly (top down):
  - Pea Gravel Surfacing;
  - Built-up Felt and Asphalt Roof;
  - Semi-Rigid Fibreglass Insulation;
  - Felt and Asphalt Vapour Retarder; and
  - Siporex Deck

Case Study 1:
Existing Conventional Built-up Roof

- New Roof Assembly (top down):
  - Pea Gravel Surfacing;
  - Built-up Felt and Asphalt Roof;
  - Fibreboard Insulation;
  - Rigid Polyisocyanurate (Foam) Insulation;
  - Felt and Asphalt Vapour Retarder; and
  - Siporex Deck

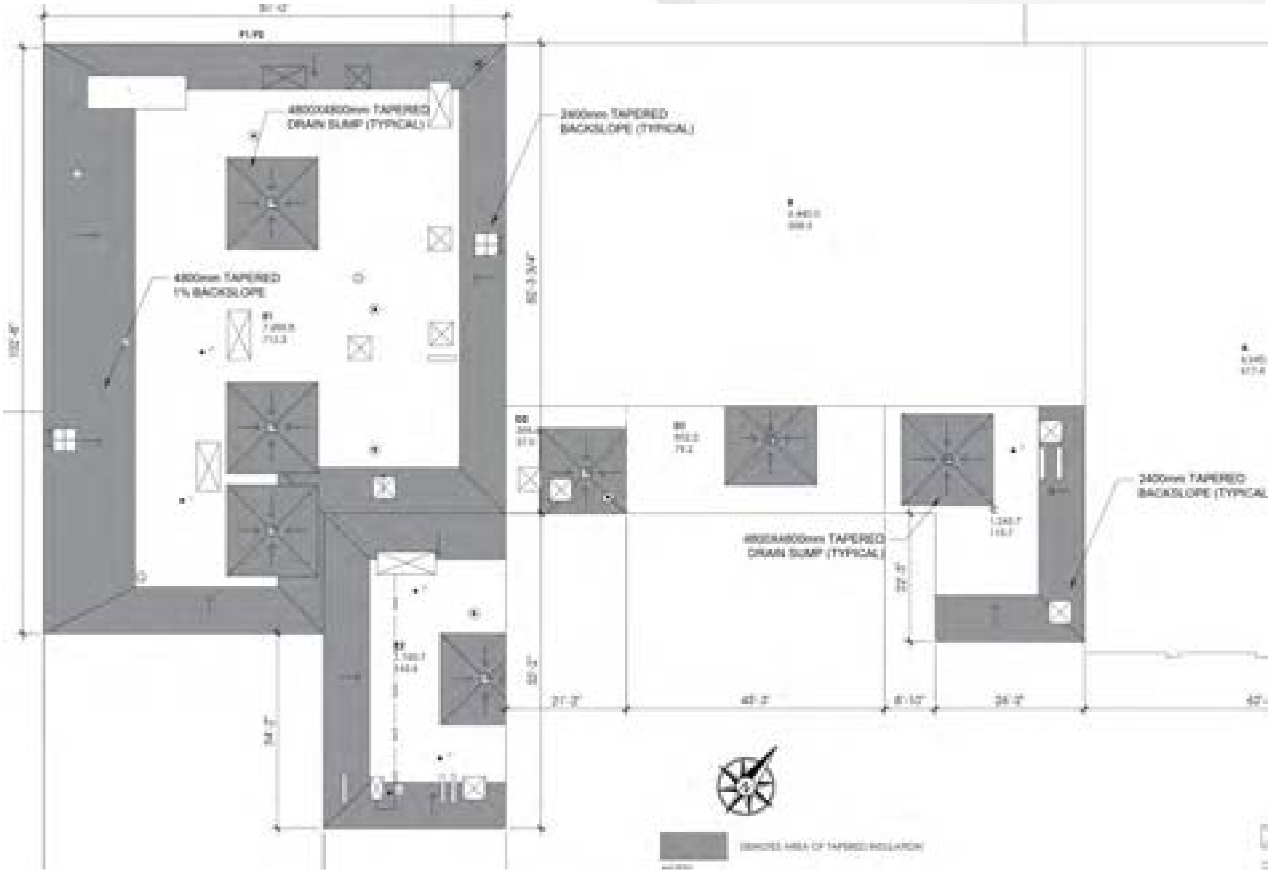
Case Study 1:

Existing Conventional Built-Up Roof

Original Assembly	New Roof Assembly	Changes
Pea Gravel Surfacing	Pea Gravel Surfacing	No Change
Built-up Felt and Asphalt Roof;	Built-up Felt and Asphalt Roof;	No Change
	Fibreboard Insulation;	Solid substrate
Semi-Rigid Fibreglass Insulation;	Rigid Polyisocyanurate (foam plastic) Insulation;	Less acoustic properties, with higher thermal value
Felt & Asphalt VB	Felt & Asphalt VB	No Change
Siporex Deck	Siporex Deck	No Change

Case Study 1:
Existing Conventional Built-up Roof

- Design approach:
  - Localized tapered insulation
  - Double flood coat and gravel where required



Case Study 1:

Existing Conventional Built-up Roof

- Localized tapered insulation

Case Study 1:

Existing Conventional Built-up Roof

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Case Study 1:

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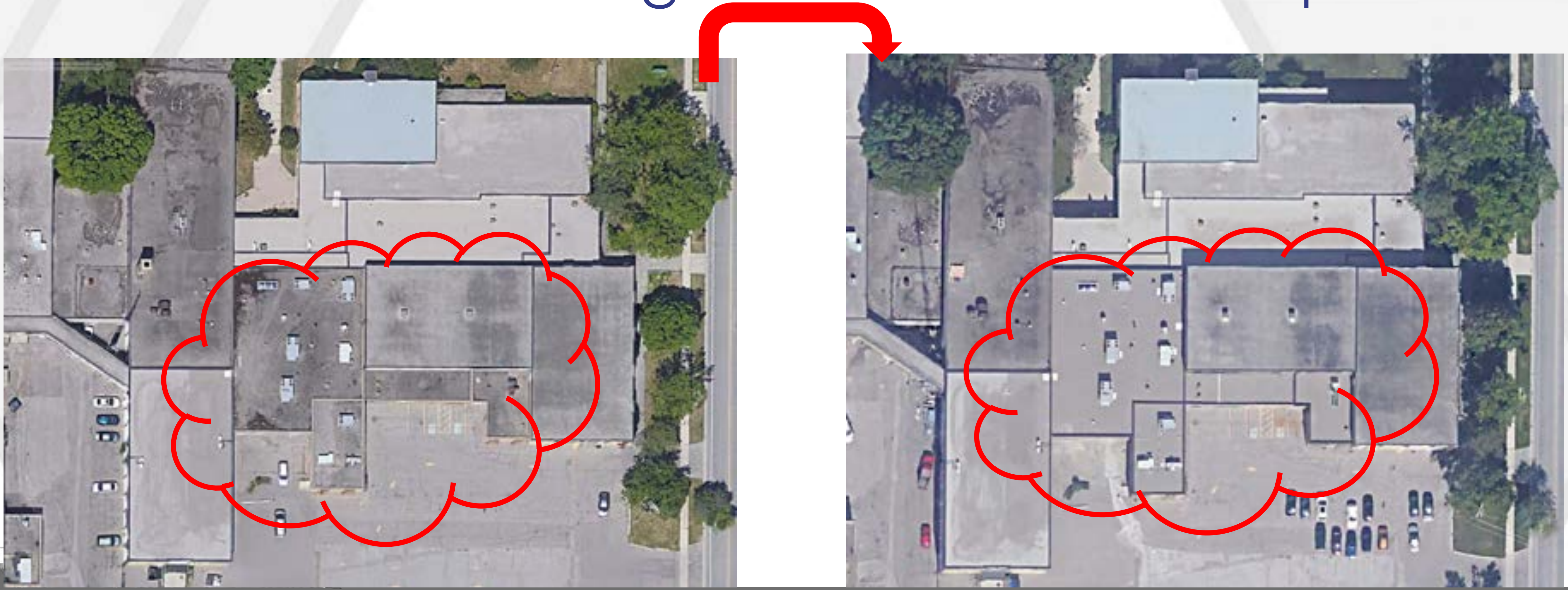


Case Study 2:

Existing Conventional Modified Bitumen

- Residential Condominium
- 2-stories
- Wood structure

Case Study 2:

Existing Conventional Modified Bitumen

- Issue: Ice quakes
- Cause: Excessive ponding freezing and shifting

Case Study 2:

Existing Conventional Modified Bitumen

- Always been drainage issues.
- Why ice quakes after roof replacement?

Case Study 2:

Existing Conventional Modified Bitumen

- Original Roof Assembly (top down):
  - Pea Gravel Surfacing;
  - Built-up Felt and Asphalt Roof;
  - Fibreboard Insulation;
  - Semi-Rigid Fibreglass Insulation;
  - Kraft Vapour Retarder; and
  - Wood Deck

Case Study 2:

Existing Conventional Modified Bitumen

- New Roof Assembly (top down):
  - Granular surfaced modified bitumen roof membrane;
  - Asphalt core cover board;
  - Rigid Polyisocyanurate (foam) Insulation;
  - Kraft Vapour Retarder; and
  - Wood Deck

Case Study 2:

Existing Conventional Modified Bitumen

Original Assembly	New Roof Assembly	Changes
Pea Gravel Surfacing	Granular Surfacing	Thinner and lighter
Built-up Felt and Asphalt Roof;	Modified bitumen roof membrane	Thinner and lighter
Fibreboard Insulation	Asphalt core cover board	Thinner and denser
Semi-Rigid Fibreglass Insulation;	Rigid Polyisocyanurate (foam plastic) Insulation	Less acoustic properties
Kraft Vapour Retarder	Kraft Vapour Retarder	No Change
Wood Deck	Wood Deck	No Change

Case Study 2:

Existing Conventional Modified Bitumen

- Solutions:
  - Full tapered
  - Retrofit fill
  - New internal drains

  - Localized tapered insulation
  - New scupper drains

Case Study 2:

Existing Conventional Modified Bitumen

- Approved strategy to control ponding water:
  - Localized tapered insulation
  - New scupper drains

Case Study 2:

Existing Conventional Modified Bitumen

- Oversized sumps around existing drains

Case Study 2:

Existing Conventional Modified Bitumen

- Add scuppers with oversized sumps

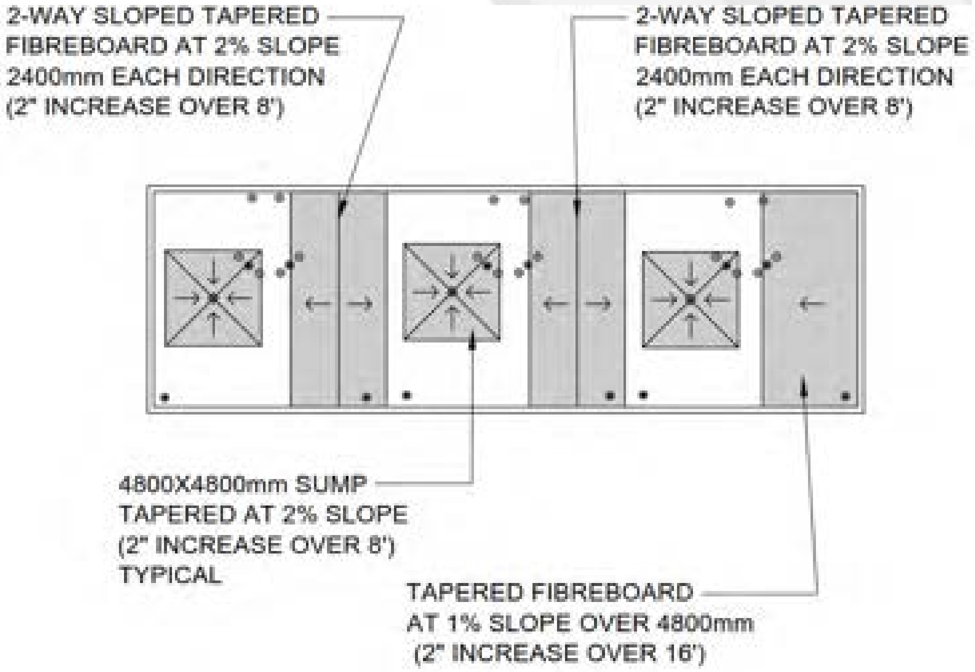
Case Study 2:

Existing Conventional Modified Bitumen

Case Study 2b:

Second Phase – Replace Built-Up Roof with Hybrid BUR/MB

- Full replacement drainage design included:
  - Infill areas of deflected deck
  - Add over sized drain sumps
  - Provide tapered backslope around the roof perimeter (and increase at end units)
  - Double pour asphalt and gravel at low areas



Case Study 2b:

Second Phase – Replace Built-Up Roof with Hybrid BUR/MB

Case Study 2b:

Second Phase – Replace Built-Up Roof with Hybrid BUR/MB

Case Study 3:

Existing Conventional Built-up Roof

- Residential Condominium
- 2-stories
- Wood structure

Case Study 3:

Existing Conventional Built-Up Roof

- Reaching end of serviceable life
- Previous phase of roofs changed the built-up roofs to modified bitumen
  - Similar to Case Study 2, the modified bitumen roofs had ponding and reports of ice quakes

Case Study 3:

Existing Conventional Built-Up Roof

- Always been drainage issues.
- Previous modified bitumen replacement did not address

Case Study 3:

Existing Conventional Built-Up Roof

- Original Roof Assembly (top down):
  - Pea Gravel Surfacing;
  - Built-up Felt and Asphalt Roof;
  - Fibreboard Insulation;
  - Rigid Polyisocyanurate (Foam) Insulation;
  - Kraft Vapour Retarder; and
  - Wood Deck

Case Study 3:

New Conventional Hybrid Built-Up MB Roof

- New Roof Assembly (top down):
  - Pea Gravel Surfacing;
  - Modified Bitumen Membrane and Asphalt;
  - Fibreboard Insulation;
  - Rigid Polyisocyanurate (Foam) Insulation;
  - Kraft Vapour Retarder; and
  - Wood Deck

Case Study 3:

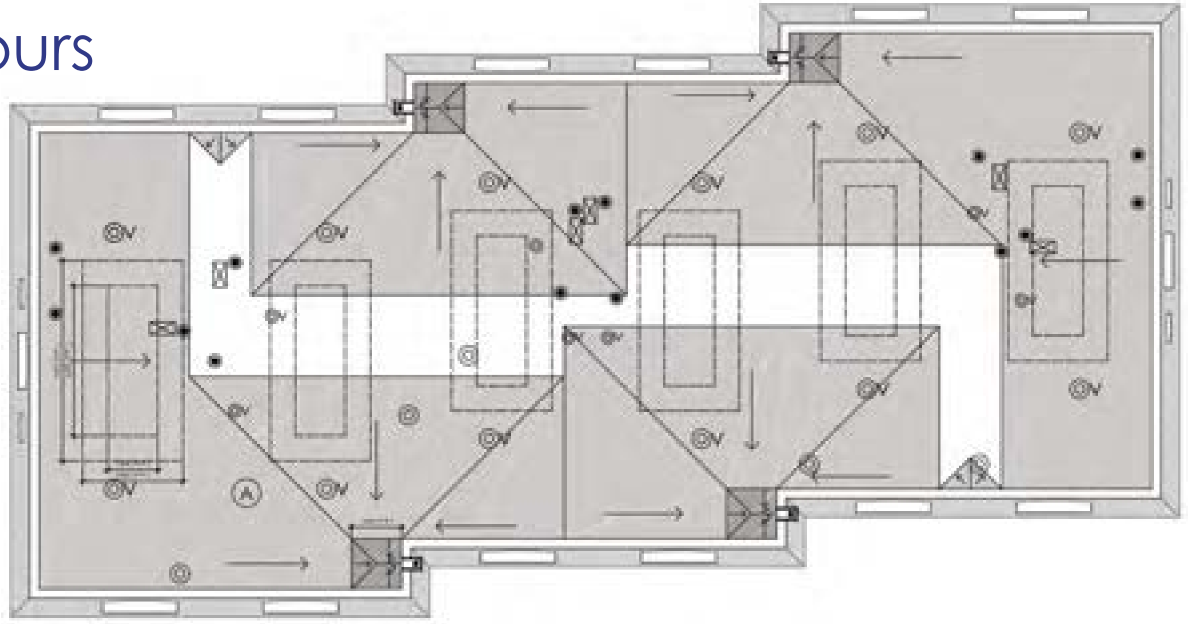
Existing Conventional Built-up Roof

Original Assembly	New Roof Assembly	Changes
Pea Gravel Surfacing	Pea Gravel Surfacing	No Change
Built-up Felt and Asphalt Roof;	Modified bitumen roof membrane	Thinner and lighter
Fibreboard Insulation	Fibreboard Insulation	No Change
Rigid Polyisocyanurate (foam plastic) Insulation	Rigid Polyisocyanurate (foam plastic) Insulation	No Change
Kraft Vapour Retarder	Kraft Vapour Retarder	No Change
Wood Deck	Wood Deck	No Change

Case Study 3:

Existing Conventional Built-Up Roof

- Design Approach:
  - Infill insulation at deflected deck
  - Approaching full tapered insulation
  - Flood coat and gravel double pours



Case Study 3:
Existing Conventional Built-Up Roof

- Design Approach:
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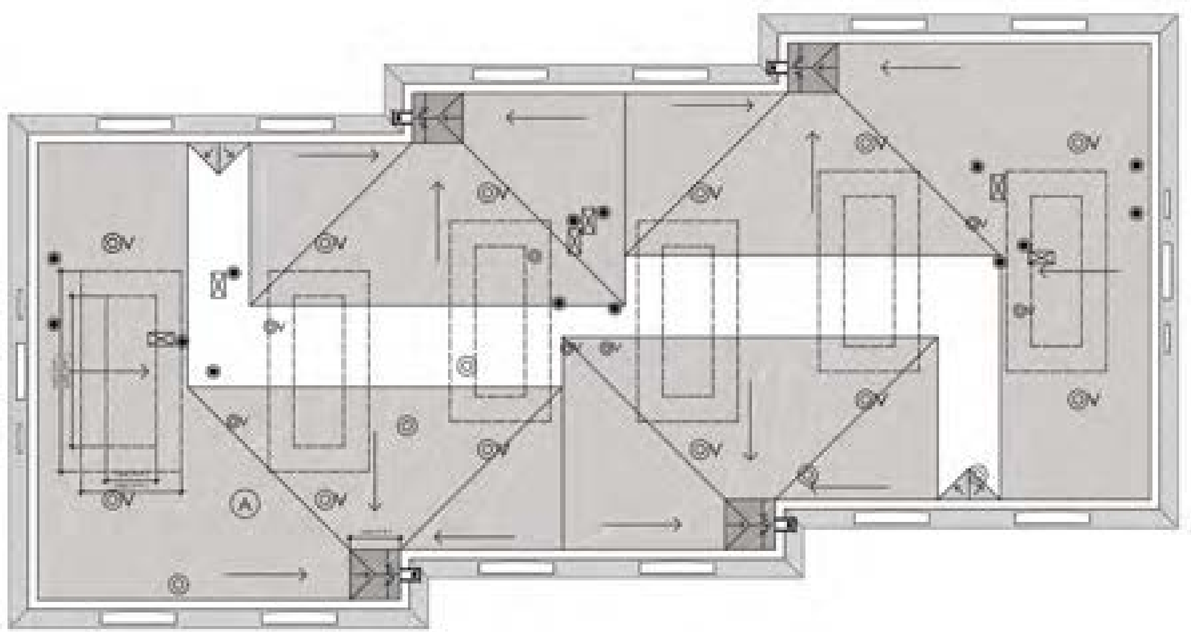
Case Study 3:

Existing Conventional Built-Up Roof

- Design Approach:
  - Tapered insulation



Case Study 3:
Existing Conventional Built-Up Roof

- Design Approach:
  - Flood coat and gravel double pours

Case Study 3a:

Existing Conventional Modified Bitumen Roof

- Poor approach to drainage

Case Study 3a:

Existing Conventional Modified Bitumen Roof

- Retrofit Approach:
  - Flood coat and gravel double pours

Case Study 3/3a:

Existing Conventional Modified Bitumen

Closing

When is the water too much?

- Standing water remains 48-hours after rain during weather conducive to drying.
- Water depth exceeding flashing heights.
- Water pressure causing leaks due to increased hydrostatic pressure.

Closing

Best to design new roofs to slope to drain.

- Slope structure
- Provide adequate drain sizing and locations
- Add sloped infill where required during roofing

Closing

Control existing ponding water

- Add or relocate drains where possible
- Add localized top fill

Roof Drainage Design:

Pitfalls to Avoid and Retrofit Options

Thank You

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