MS 1525

Chapter 4
Architecture and Passive Design Strategy

by

Ar Von Kok Leong

Chapter 4 WG Member

Director, Arkitek MAA Sdn Bhd

6 July 2021

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Clause 4 Architecture & Passive Design Strategy

Retained

1) DF equation and table
2) Sun path diagram
3) Air movement air speed impact on occupants

Amendments and Omissions

1) Amended : descriptions of Natural Ventilation, Cross Ventilation and Stack Ventilation;
2) Amended : “bulk” insulation becomes “mass” insulation;
3) Omitted fr 2017 : emissivity levels (low $\leq$ 0.1, and high $\geq$ 0.9)

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Clause 4 Architecture & Passive Design Strategy

Additions

1) Added : new diagrams showing different types of Cross Ventilation and Stack Ventilation.
2) Added : design considerations for Cross Ventilation and Stack Ventilation.
3) Added : descriptions for Mass Insulation technology (bulk or resistive); and for Reflective Insulation technology.
4) Added : a combination of both technologies is recommended
5) Added : strategic landscaping : planting strategy
6) Added : expansion on the descriptions and design strategies for RE

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Clause 4.4.1 : Daylight Factor

$$DF = \frac{E_{internal}}{E_{external}} \times 100\%$$

- DF is expressed in percentage and counting only <u>diffused</u> light.
- DF can thus only be measured during overcast conditions.
- Direct solar radiation is not suitable for daylighting of workspaces due to its intense, glare and fluctuating nature, which is why daylighting design customarily only encompasses diffuse daylight from the sky.

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Clause 4.4.1 : Table 1

DF (%)	Lighting	Glare	Thermal comfort	Appearance and energy implication
> 6.0	Intolerable	Intolerable	Uncomfortable	Room appears strongly day lit. At daytime artificial lighting is rarely needed, but potential for thermal problems due to solar heat gain and glare problem.
3.5 - 6.0	Tolerable	Uncomfortable	Tolerable	
1.0 - 3.5	Acceptable	Acceptable	Acceptable	Room appears moderately day lit. Good balance between lighting and thermal aspects. Supplementary artificial lighting is needed at dark areas due to effect of layout or furniture arrangement
< 1.0	Perceptible	Imperceptible	Acceptable	Room look gloomy, artificial lighting is needed most of the time.

NOTE: In Malaysia, DF between 1.0 and 3.5 is recommended.

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Clause 4.6 : Natural Ventilation

ADDED

The purpose of ventilation is to provide:

a) thermal comfort; and
b) health.

Ventilation is the movement of air. Ventilation has three useful functions in the building sector. It is used to:

a) maintain thermal comfort of occupants by increasing the rate of evaporative and sensible heat loss from the body;
b) satisfy the fresh air needs of the occupants; and
c) cool the building mass and interior space by an exchange of warm indoor air by cooler outdoor air, when appropriate.

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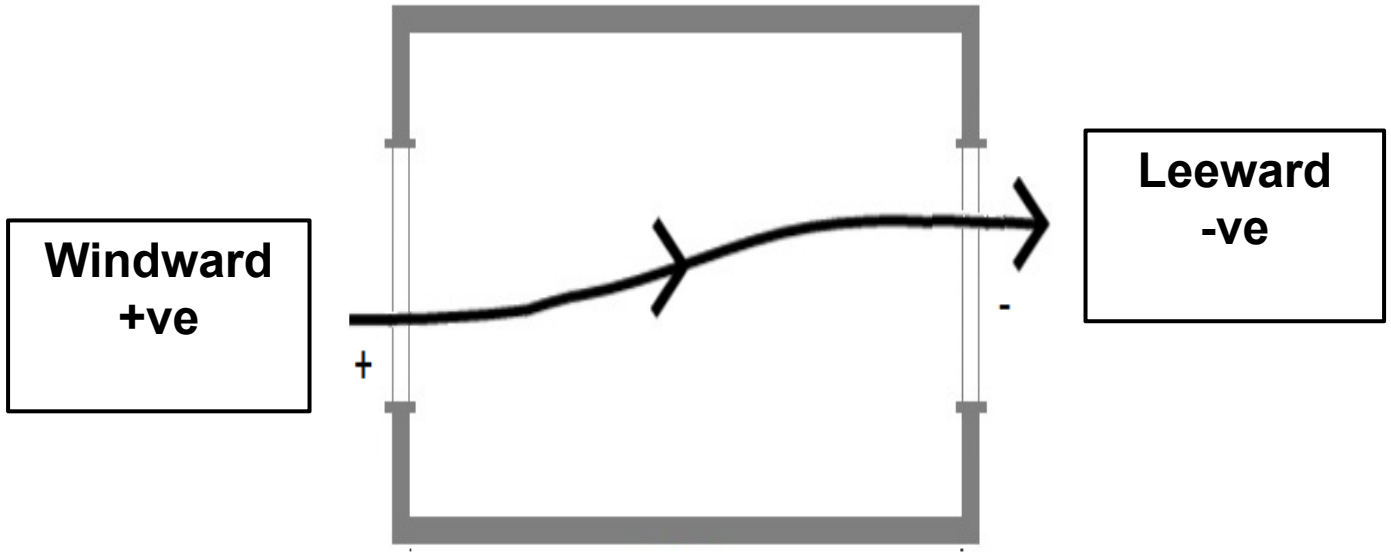
Clause 4.6.1 : Cross Ventilation



Clause 4.6.1
Orientate the building to maximise opportunities for cross ventilation

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Clause 4.6.1 : Cross Ventilation

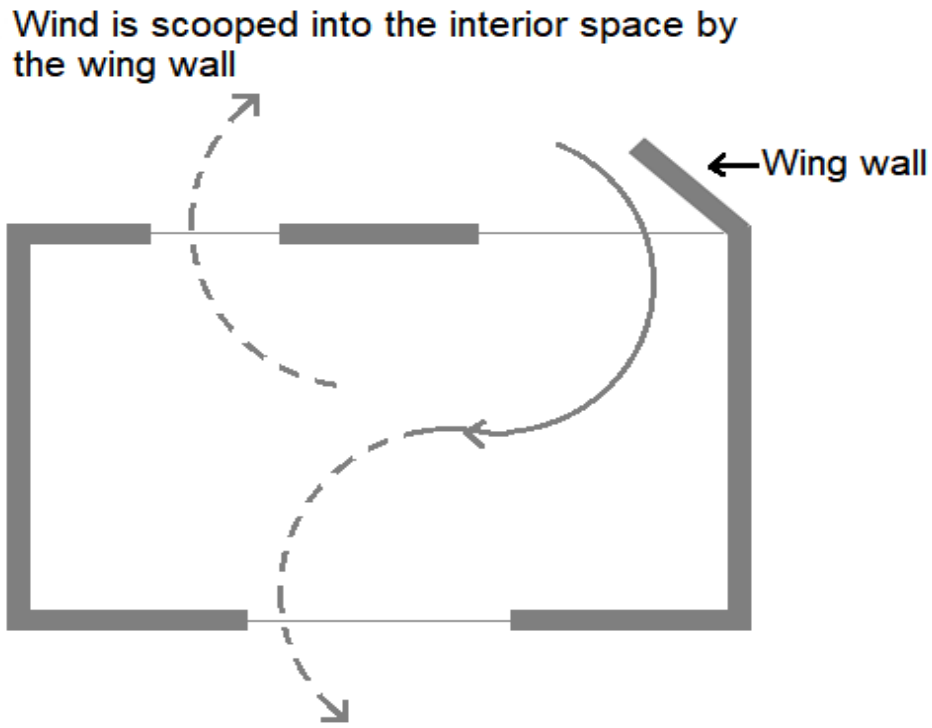

Figure 7

Use architectural features eg wing walls to create positive and negative pressure zones to induce cross ventilation

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Clause 4.6.1 : Cross Ventilation

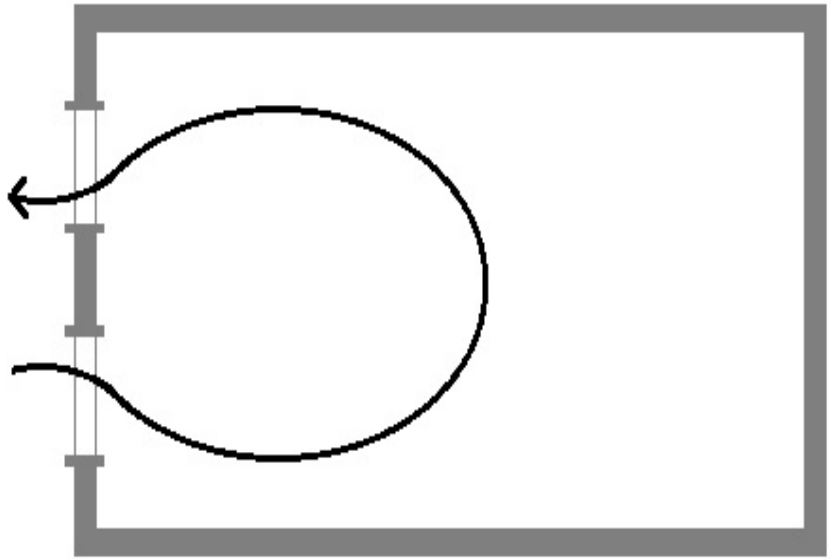

Figure 12
Two ventilation openings provide better cross ventilation.
Applicable to plan or section.

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Clause 4.6 : Natural Ventilation

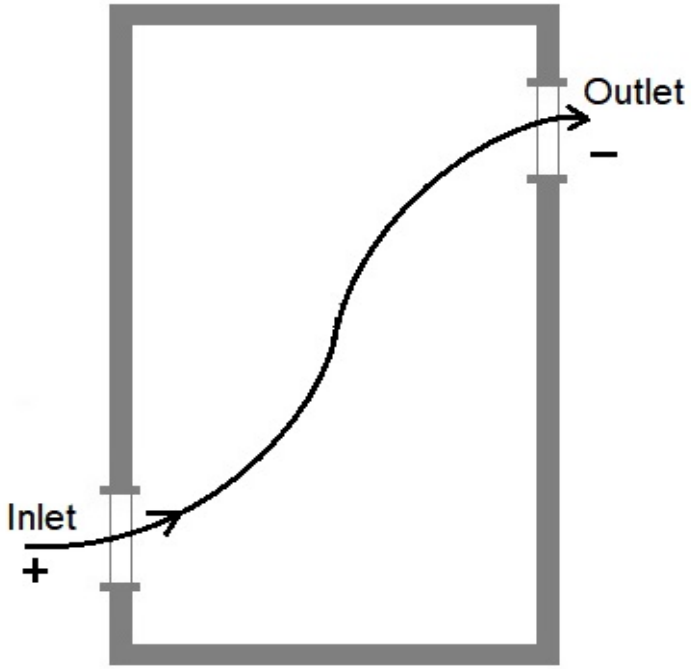

Figure 13 Stack Ventilation

where the vertical distance between inlet and outlet openings is maximized

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Clause 4.7 : Thermal Insulation

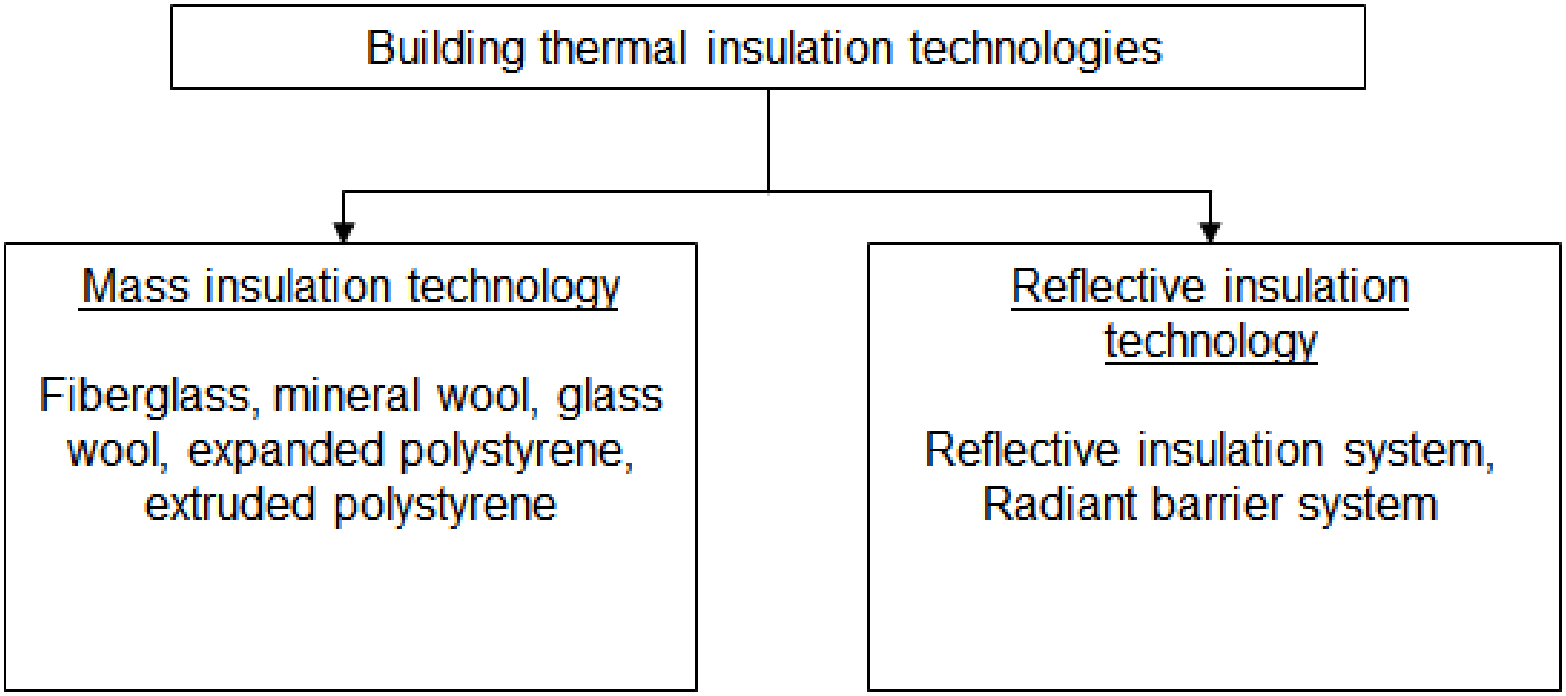

Figure 14

A combination of both technologies is recommended

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Clause 4.7 : Thermal Insulation

Summary

1) use of both mass and reflective technologies is encouraged;
2) simple explanation on the relationships between thermal conductivity (k), thermal transmittance (U-value) and thermal resistance (R-value);
3) description of the differences between Mass Insulation technology and Reflective Insulation technology;
4) air space required for Reflective Insulation as part of its overall system or assembly R-value which relies on the low thermal conductivity of air;
5) description of the Reflective Insulation technology's principles of reflecting and re-emitting radiant heat due to the properties of high reflectivity and low emissivity.

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Clause 4.8 : Strategic Landscaping

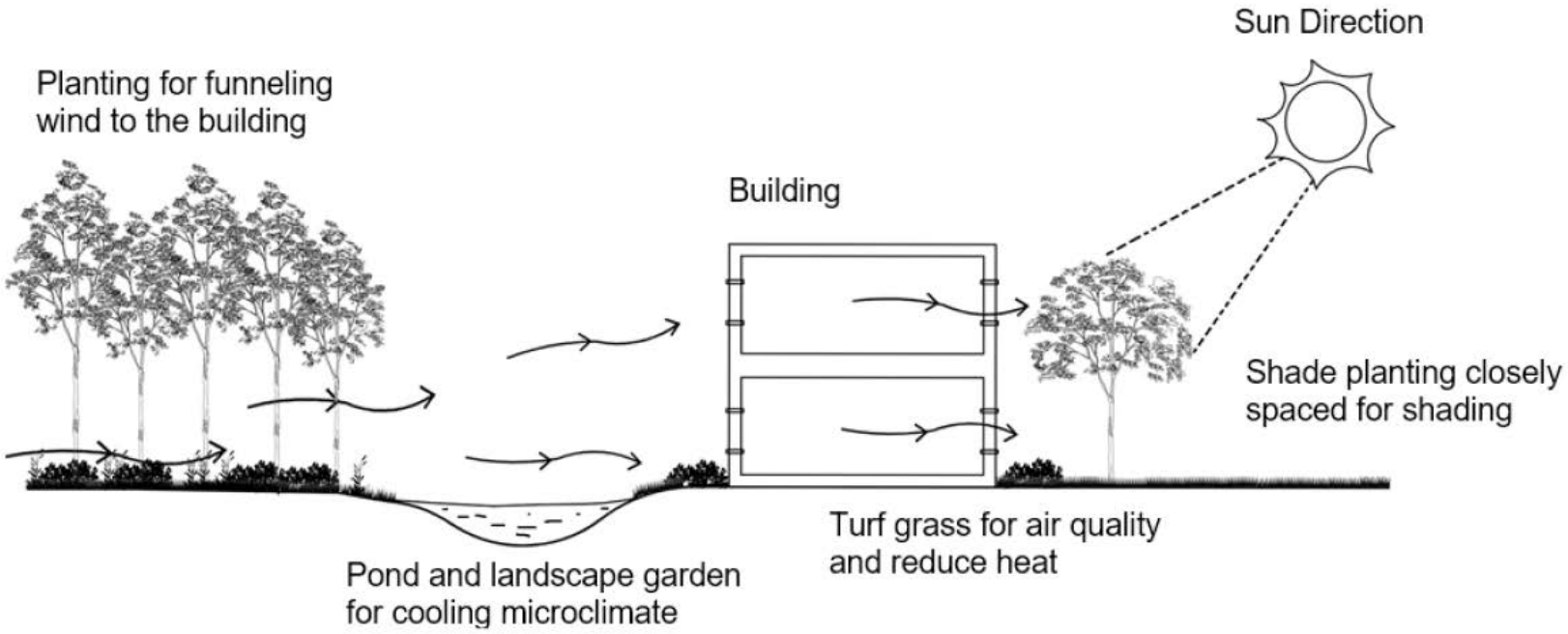

Figure 15 Sample of planting strategies.

SRI is mentioned

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Clause 4.9 : Renewable Energy

RE applications to complement passive design

1) Use of RE is encouraged
2) Consider topography, accessibility and site selection
3) Availability and sustainability of the resources
4) Design considerations, integration into building
5) Consider the by-products and emissions
6) Safety requirements
7) Wider elaboration of the different types of RE
8) Referenced to other codes eg MS 1837

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Chapter 5
Building Envelope
OTTV

by

Ar Von Kok Leong

Chapter 5 WG Chair

Director, Arkitek MAA Sdn Bhd

6 July 2021

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Clause 5 Building Envelope

1	OTTV shall apply to all external walls.	Clause 5.2
2	Each different wall type or wall finishes or different shading devices shall be calculated individually for any given orientation	Clause 5.2.2
3	New solar absorptivity table with revised range	Table 8
4	Non-permanent shading devices (such as curtains or blinds, or films applied on the surfaces of glass, or green walls) shall not be considered	Clause 5.3.3
5	Self shading, and complex shading devices	Clause 5.2.3
6	New graphs for R1 and R2 complete with equations for each	Figure 16
7	Definition of R1 and R2 and their limits	Figure 16 Notes

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Clause 5 Building Envelope

Amendments and Omissions

1) Omitted : total air-cond area > 1,000 sm, in line with UBBL Cl 38A
2) Amended : new graphs for SC2 for horizontal, vertical shading devices
3) Amended : roof weight definition amended, where
   Lightweight Roof = non-concrete construction, and
   Heavyweight Roof = concrete roof construction
4) Omitted : 50kg/m2
5) Omitted : equation for the calculation of the average weight of roof.
6) Amended : PSP is mentioned in line with UBBL Cl 38A, instead of "professional architect or professional engineer".
7) Amended : Section on Vestibules simplified, "exceptions" omitted, and local terminology introduced.

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Clause 5 Building Envelope

	2014	New
Colour	Suggested value of α	Suggested value of α
Light	< 0.40	0.20 to 0.40
Medium	0.40 to 0.70	0.41 to 0.70
Dark	> 0.70	0.71 to 0.95

Table 8 Solar Absorptivity, α

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Clause 5 Building Envelope

Retained unchanged

$$OTTV = \frac{(A_1 \text{ x } OTTV_1) + (A_2 \text{ x } OTTV_2) + \ldots + (A_n \text{ x } OTTV_n)}{A_1 + A_2 + \ldots + A_n}$$

$$OTTV_i = 15\,\alpha\,(1 - WWR)\,U_w + 6\,(WWR)\,U_f + (194 \text{ x } OF \text{ x } WWR \text{ x } SC)$$

$$RTTV = \frac{\left(A_r \text{ x } U_r \text{ x } T_{Deq}\right) + \left(A_s \text{ x } U_s \text{ x } \Delta T\right) + \left(A_s \text{ x } SC \text{ x } SF\right)}{A_0}$$

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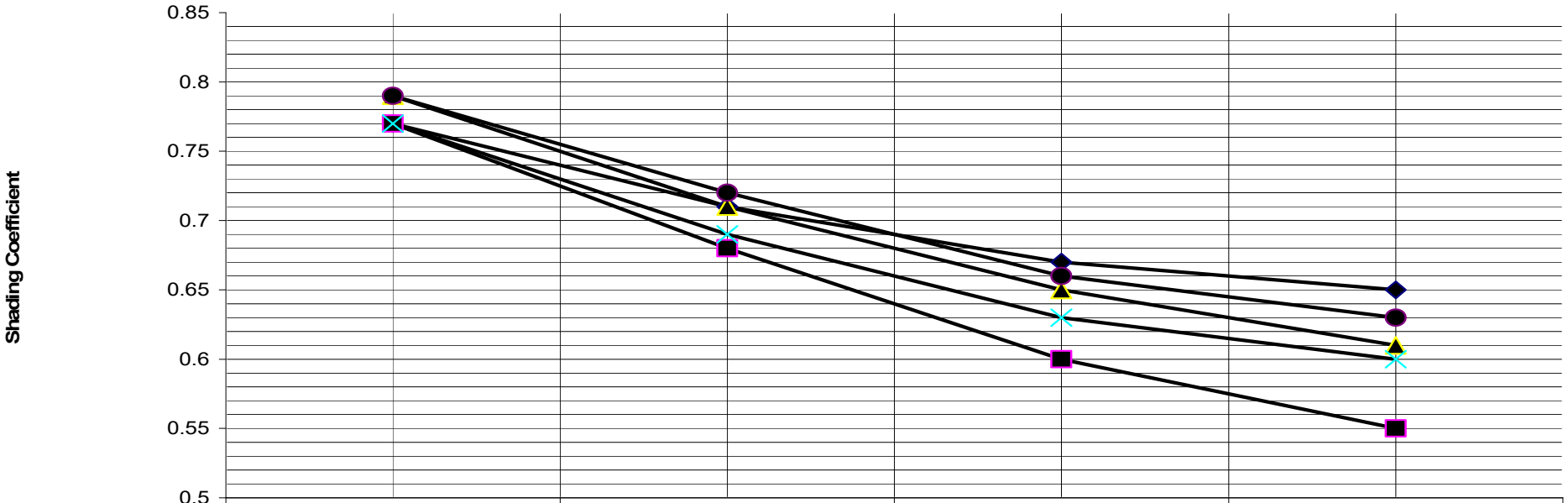
Clause 5 Building Envelope

2014

HORIZONTAL PROJECTION SHADING COFFICIENTS



	0,35	0.6	1	1.65
North/South	0.77	0.71	0.67	0.65
East	0.77	0.68	0.6	0.55
West	0.79	0.71	0.65	0.61
NE/SW	0.77	0.69	0.63	0.6
NW/SE	0.79	0.72	0.66	0.63

R1 (Projection / Window Height)

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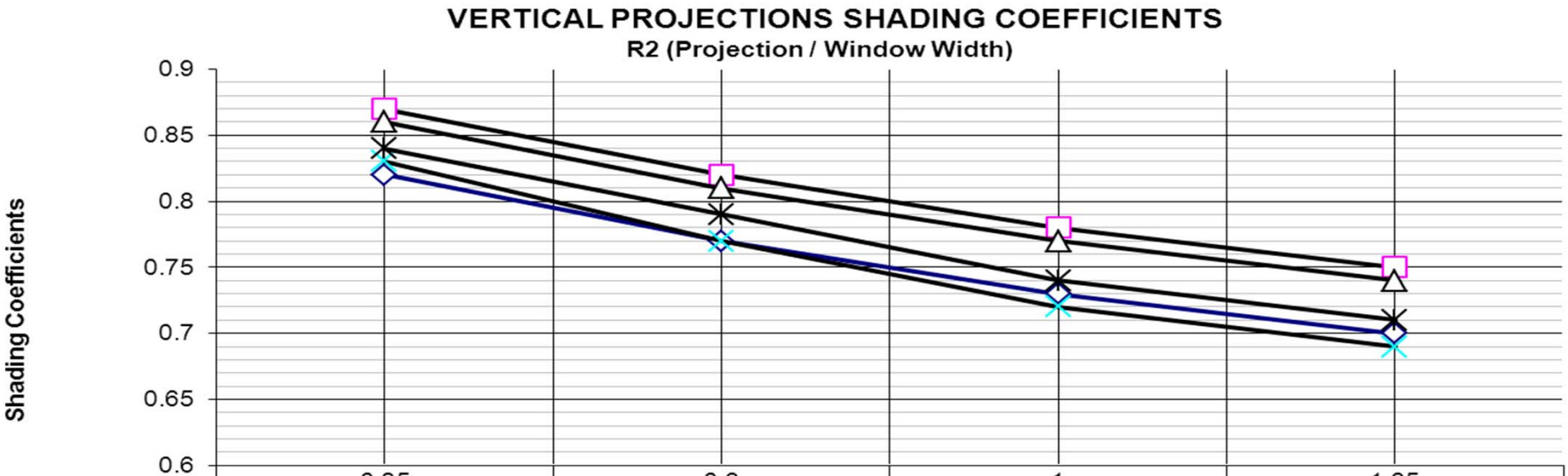
Clause 5 Building Envelope

2014



	0.35	0.6	1	1.65
North/South	0.82	0.77	0.73	0.7
East	0.87	0.82	0.78	0.75
West	0.86	0.81	0.77	0.74
NE/SW	0.83	0.77	0.72	0.69
NW/SE	0.84	0.79	0.74	0.71

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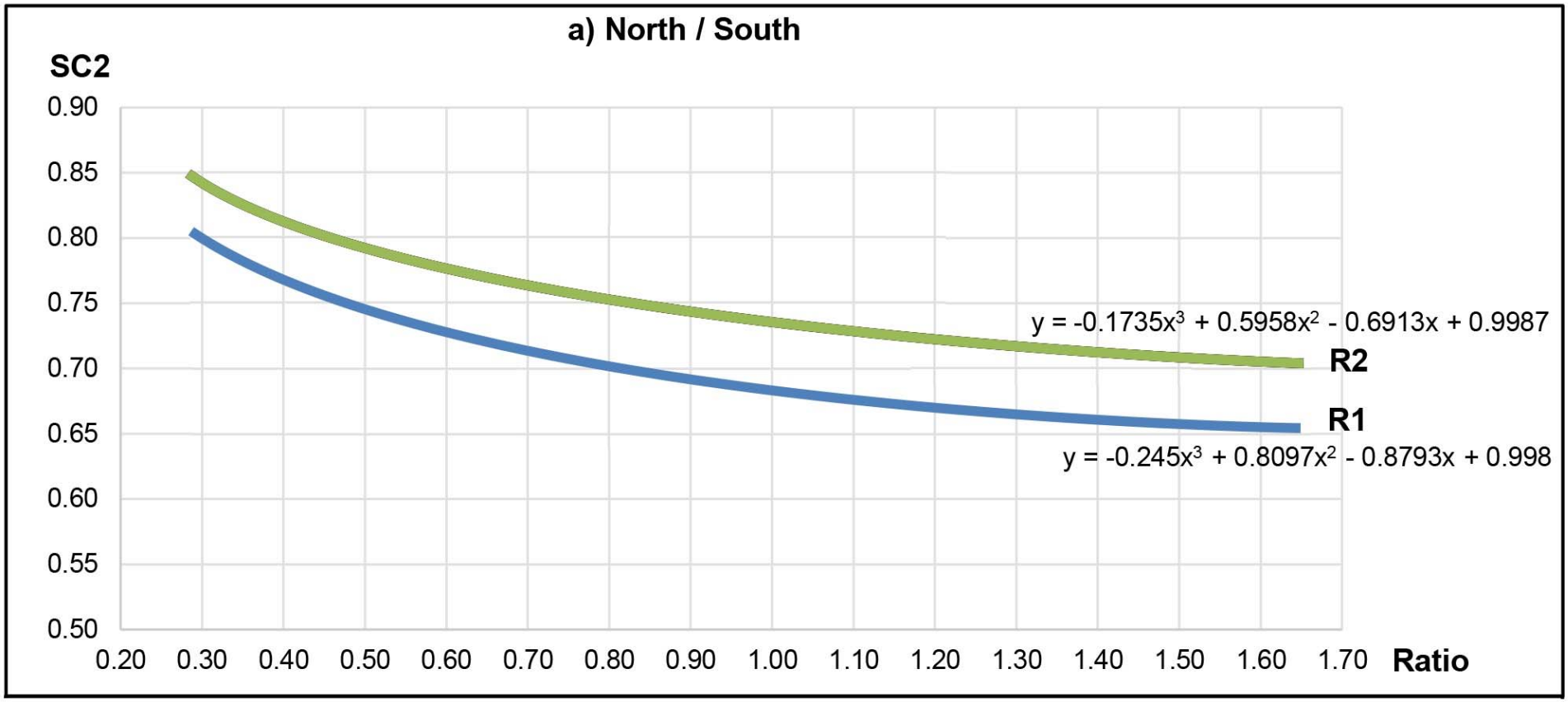
Clause 5.3.4 Figure 16



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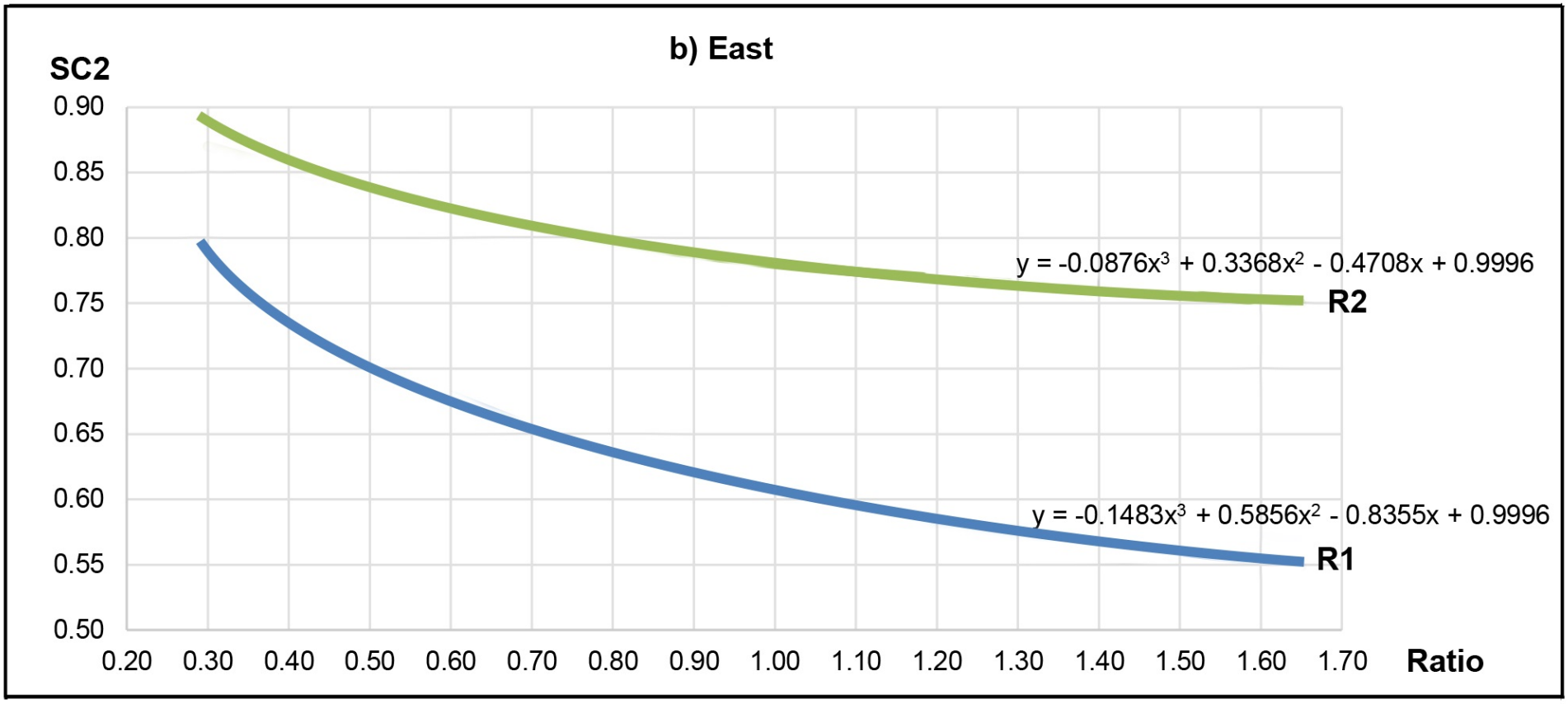
Clause 5.3.4 Figure 16



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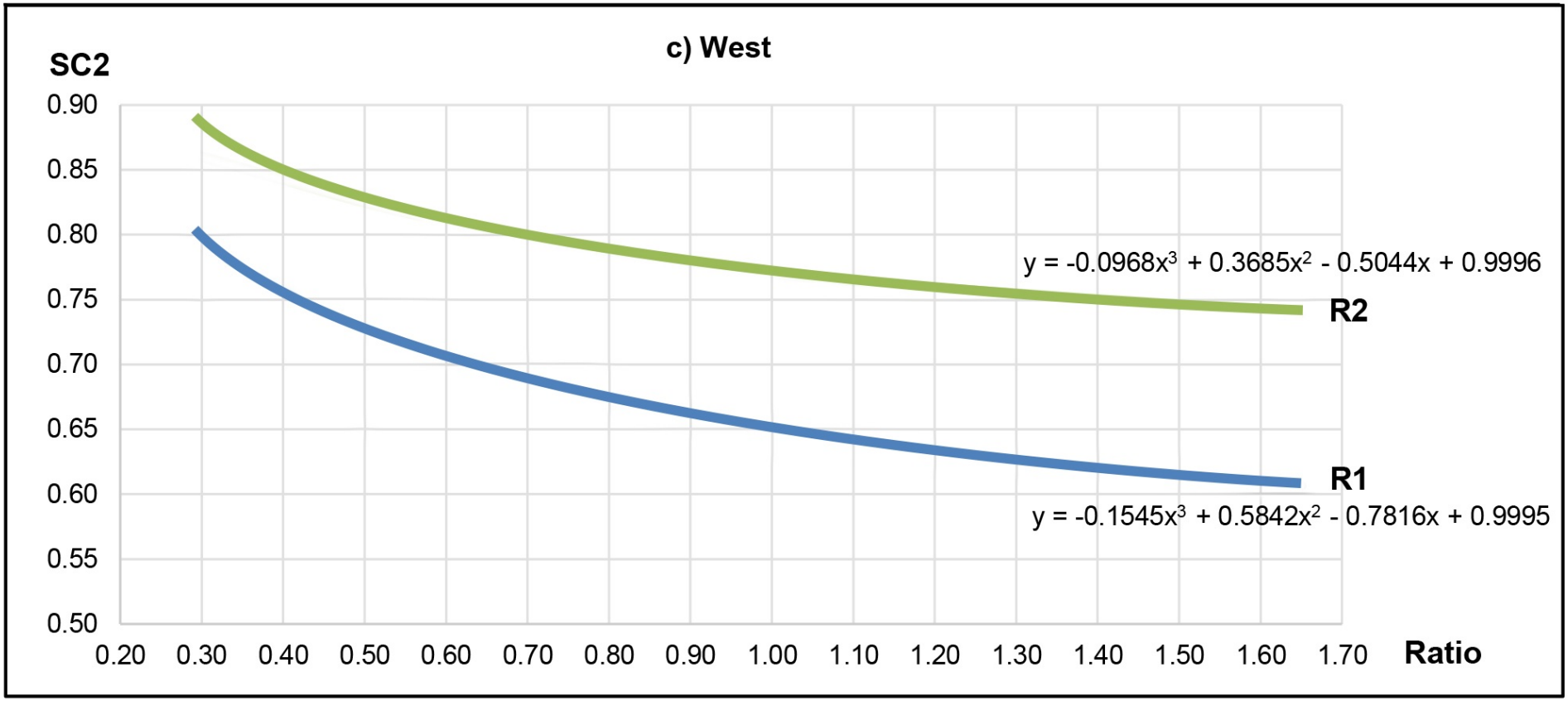
Clause 5.3.4 Figure 16



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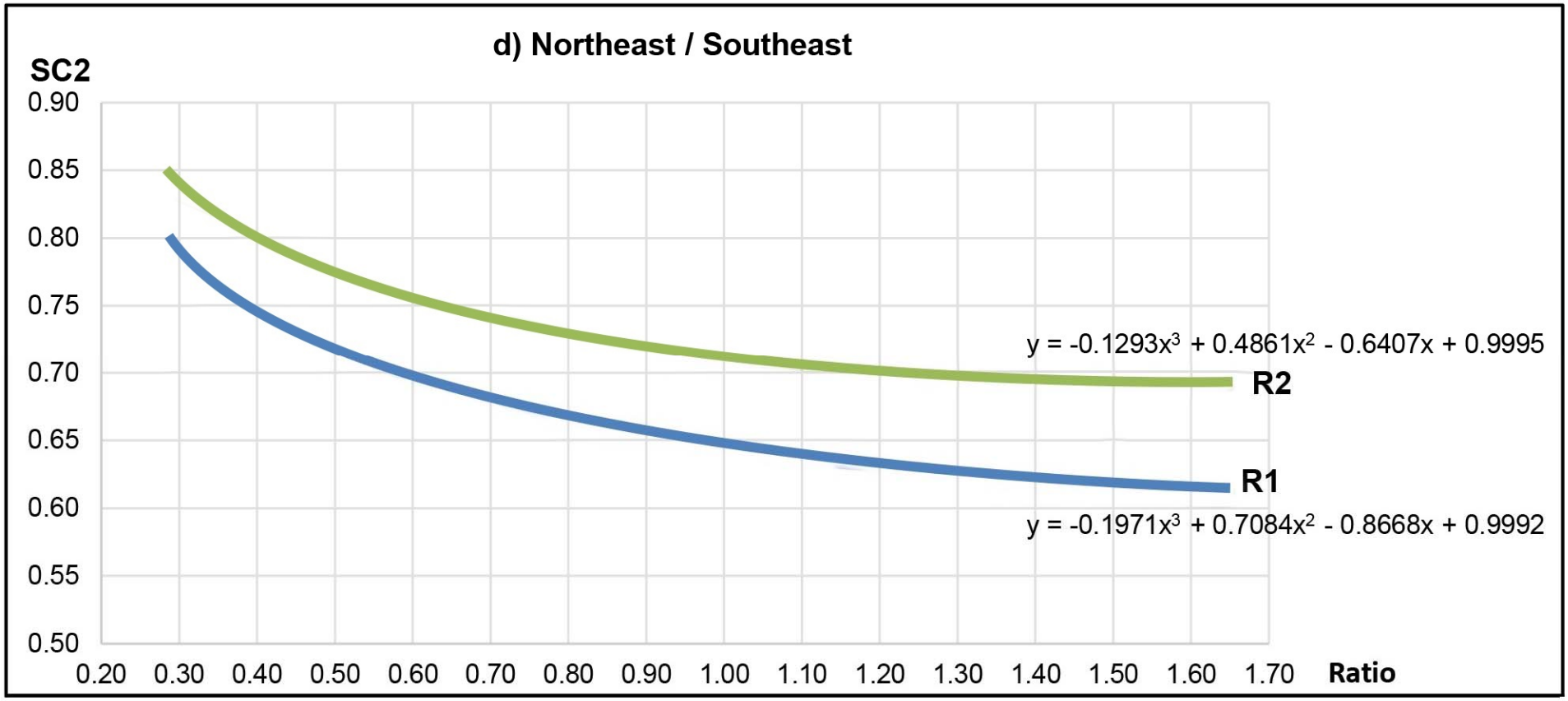
Clause 5.3.4 Figure 16



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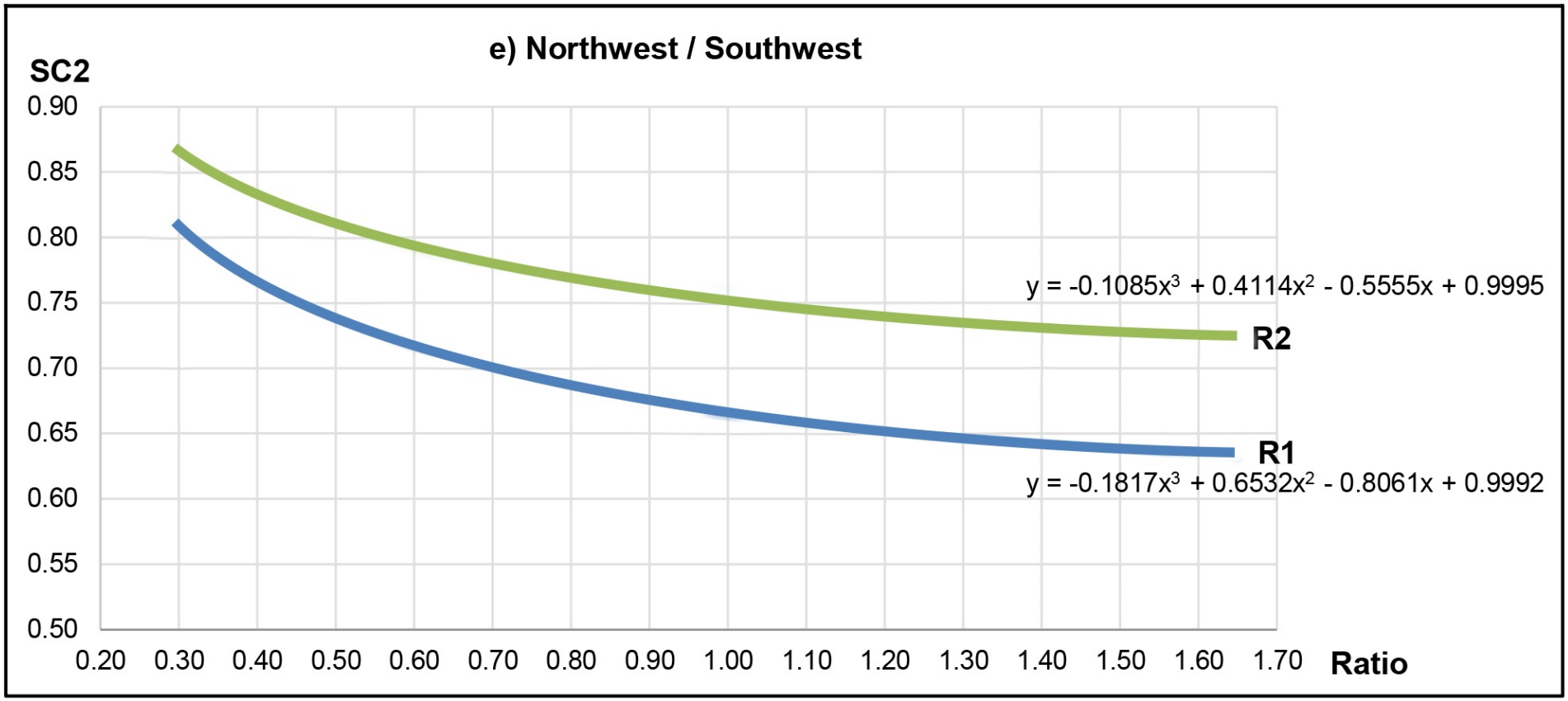
Clause 5.3.4 Figure 16



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OTTV for Complex Building Configurations

GBI submission requirements for Clause 5.2.3 self-shading:

Airwells
U-shaped buildings
Balconies and Yards

Self shading applies to the fenestration within the same development only

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OTTV for Complex Building Configurations

Airwells

Steps:

1) Determine plan area of airwell at topmost level;
2) Check UBBL Cl 40, Table 1;
3) Determine no roof over airwell, space below is not aircond, otherwise RTTV applies;
4) Pick an internal wall to start, say Wall A;
5) Determine the height of wall opposite Wall A that provides the shading;
6) Use RL of the last floor, not parapet height;
7) Determine dimensions X, Y, Z;
8) Find ratio Z/Y and indicate the cutoff point where Z/Y = 3 on Wall A;
9) Floors below the cutoff point where Z/Y ≥ 3 enjoy self shading from opposite wall, and do not require OTTV calculations;
10) Floors above it will require OTTV calculations.
11) OF does not apply.

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Complex Building Configurations

Airwells : UBBL

Building Height	Clause 40(1) min area of airwell for habitable rooms	Clause 40(2) min area of airwell for toilets etc
2 storeys	7.0 m2	3.5 m2
Up to 4 storeys	9.0 m2	4.0 m2
Up to 6 storeys	11.0 m2	4.5 m2
Up to 8 storeys	13.0 m2	5.0 m2
> 8 storeys	15.0 m2	5.5 m2

Minimum width in any direction shall be 2.0m.

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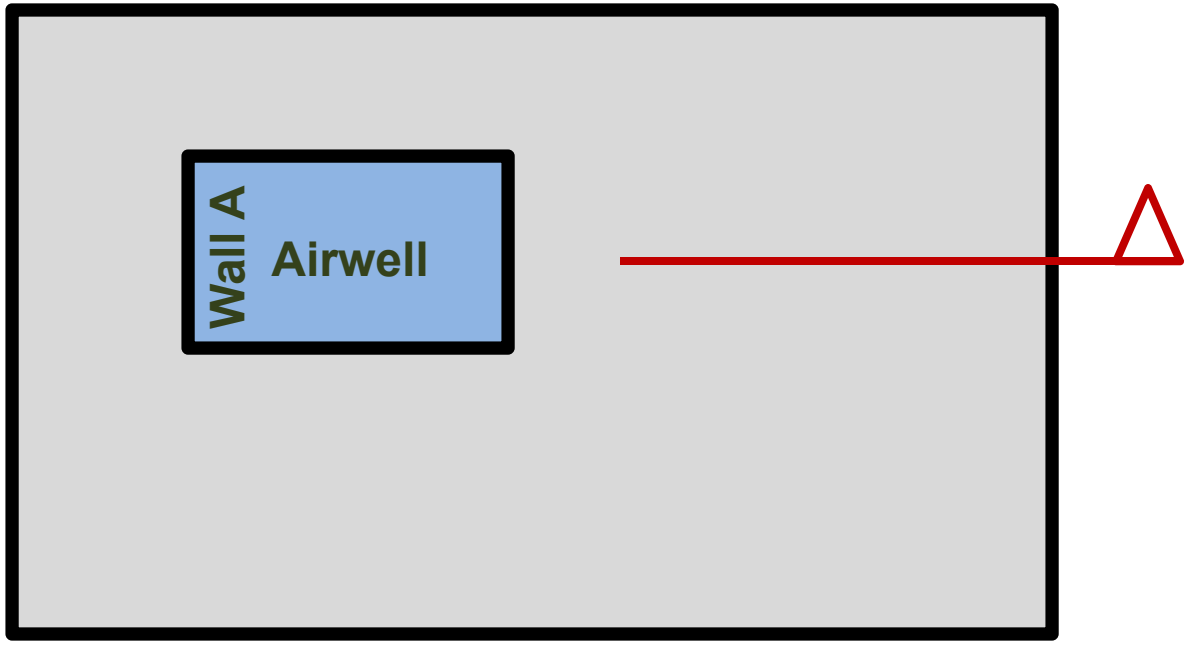
OTTV for Complex Building Configurations

Airwells



Roof Plan

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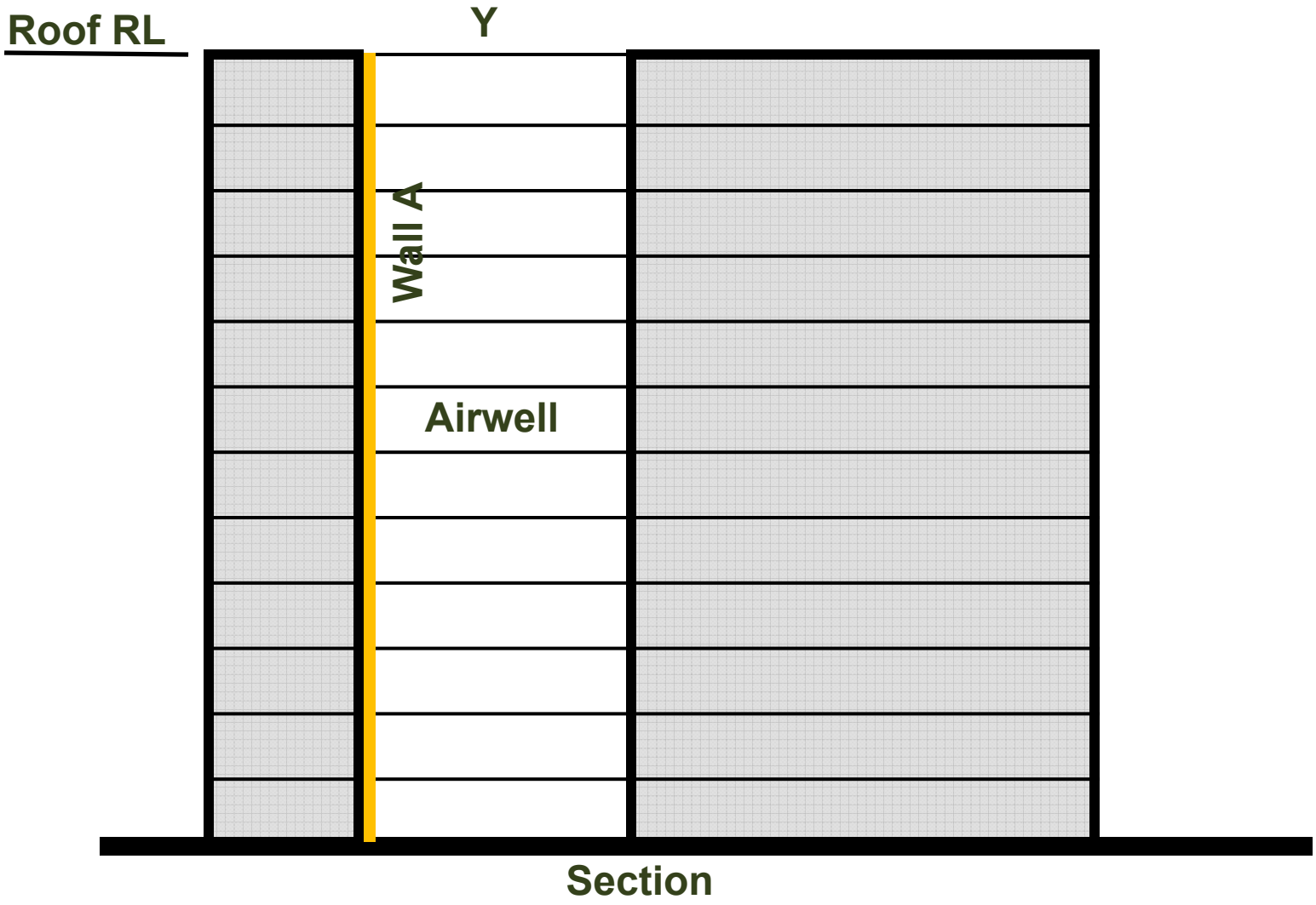
OTTV for Complex Building Configurations



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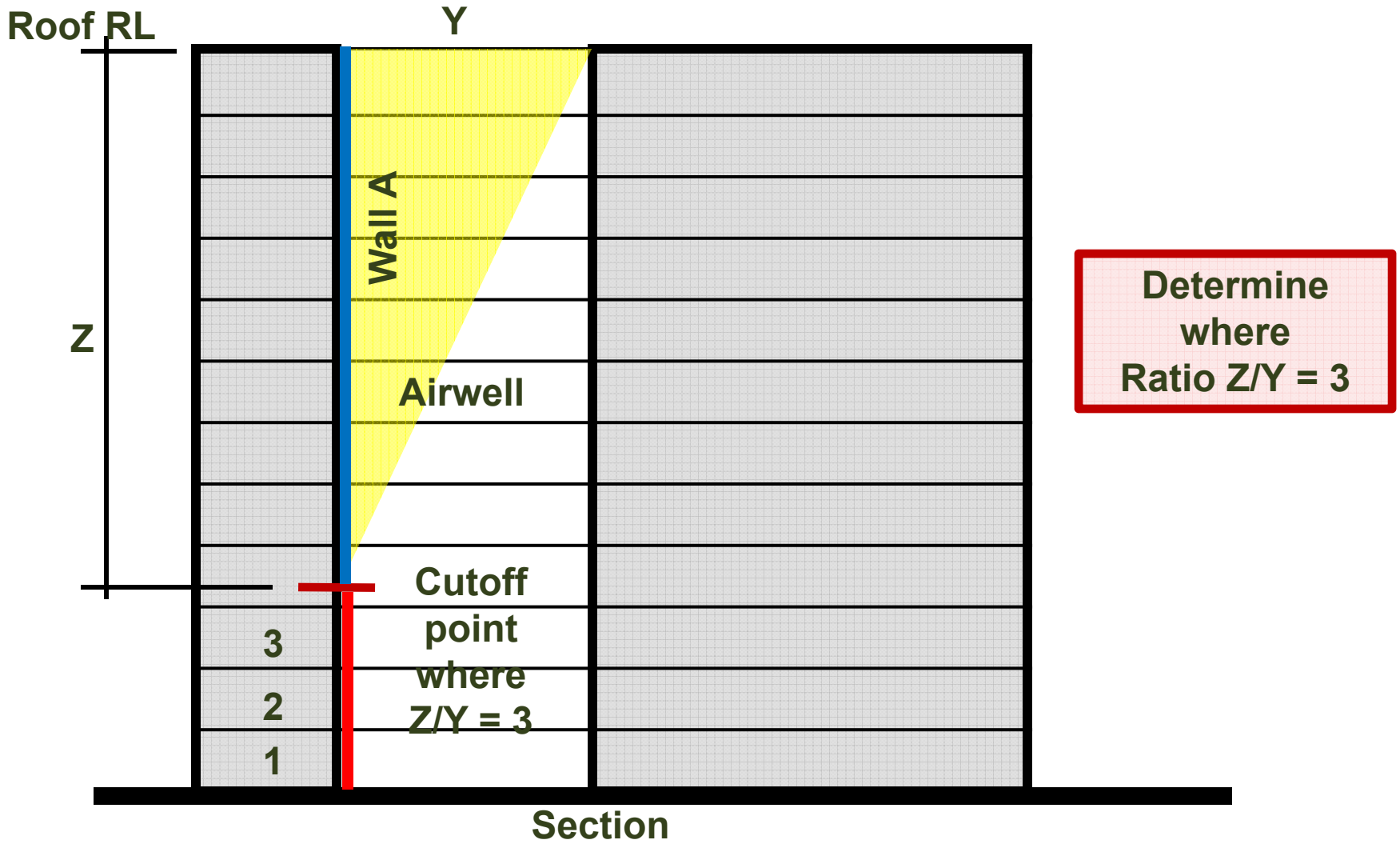

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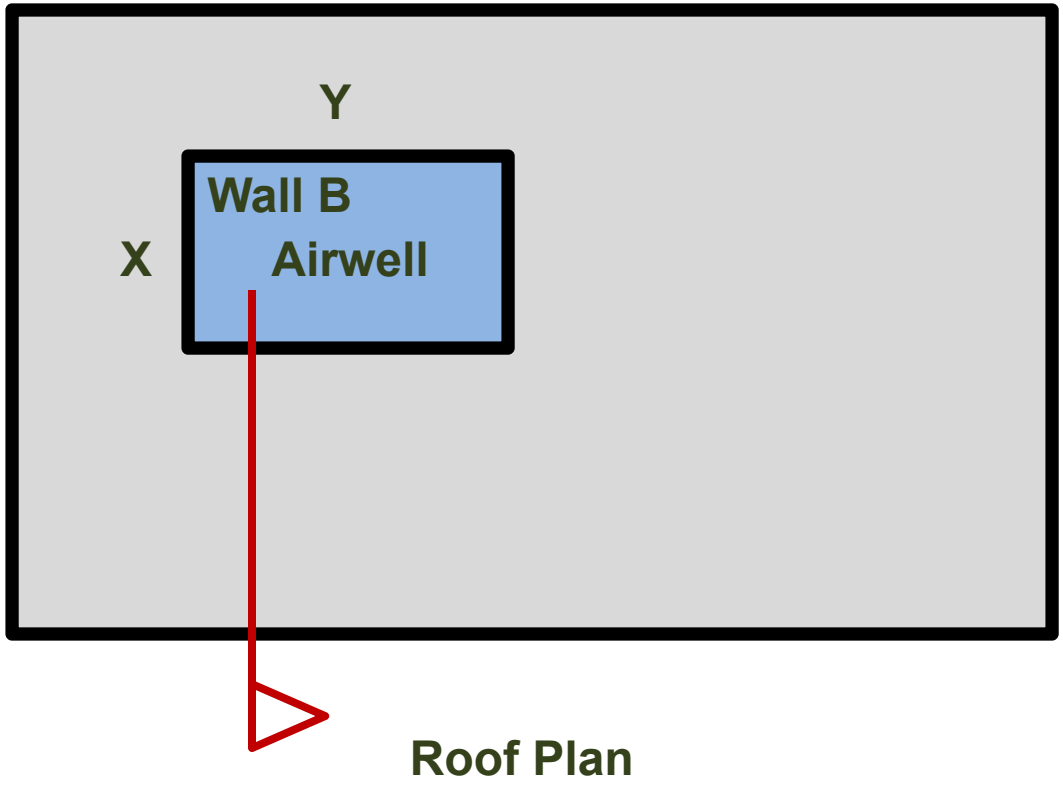
OTTV for Complex Building Configurations

Airwells



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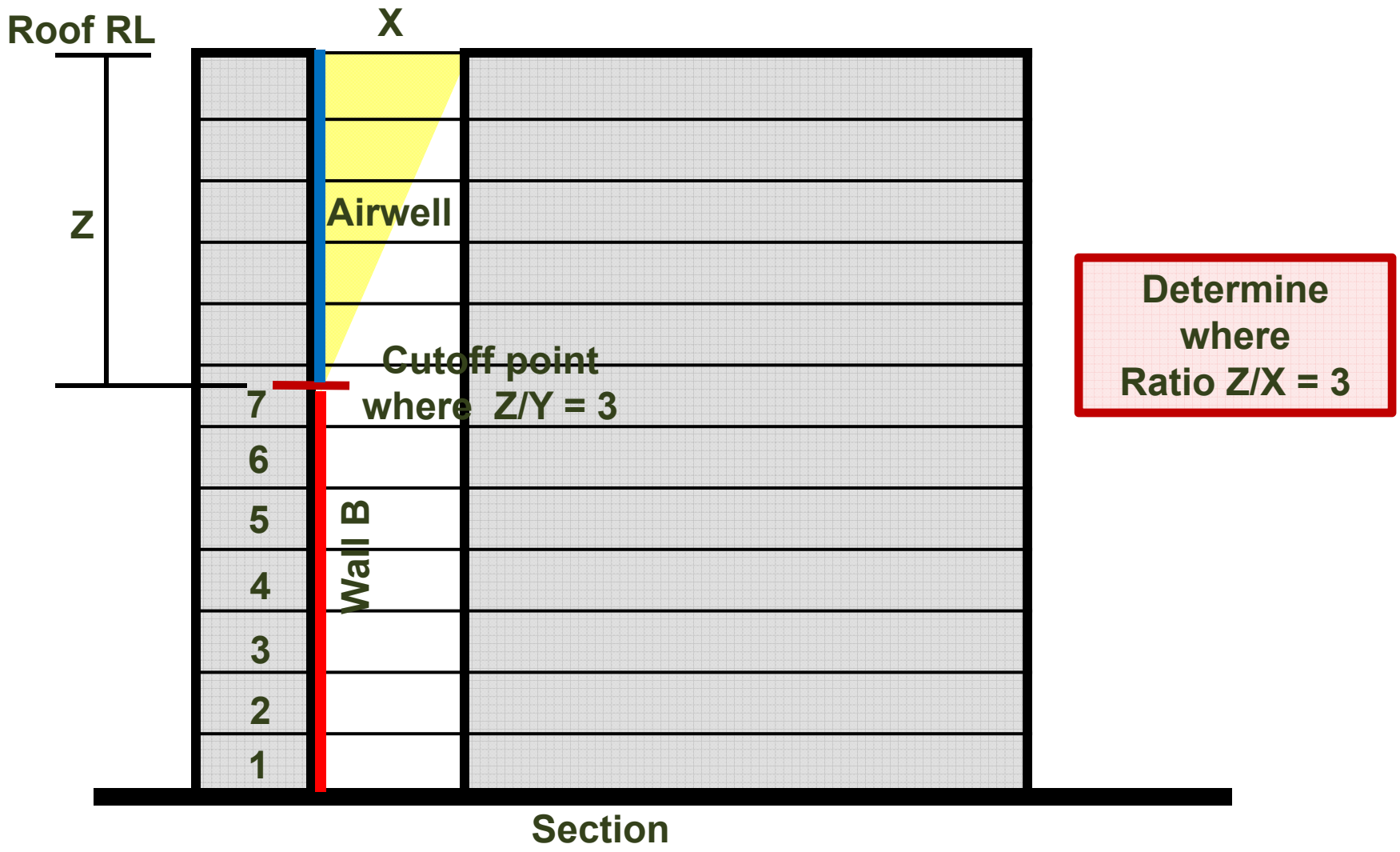

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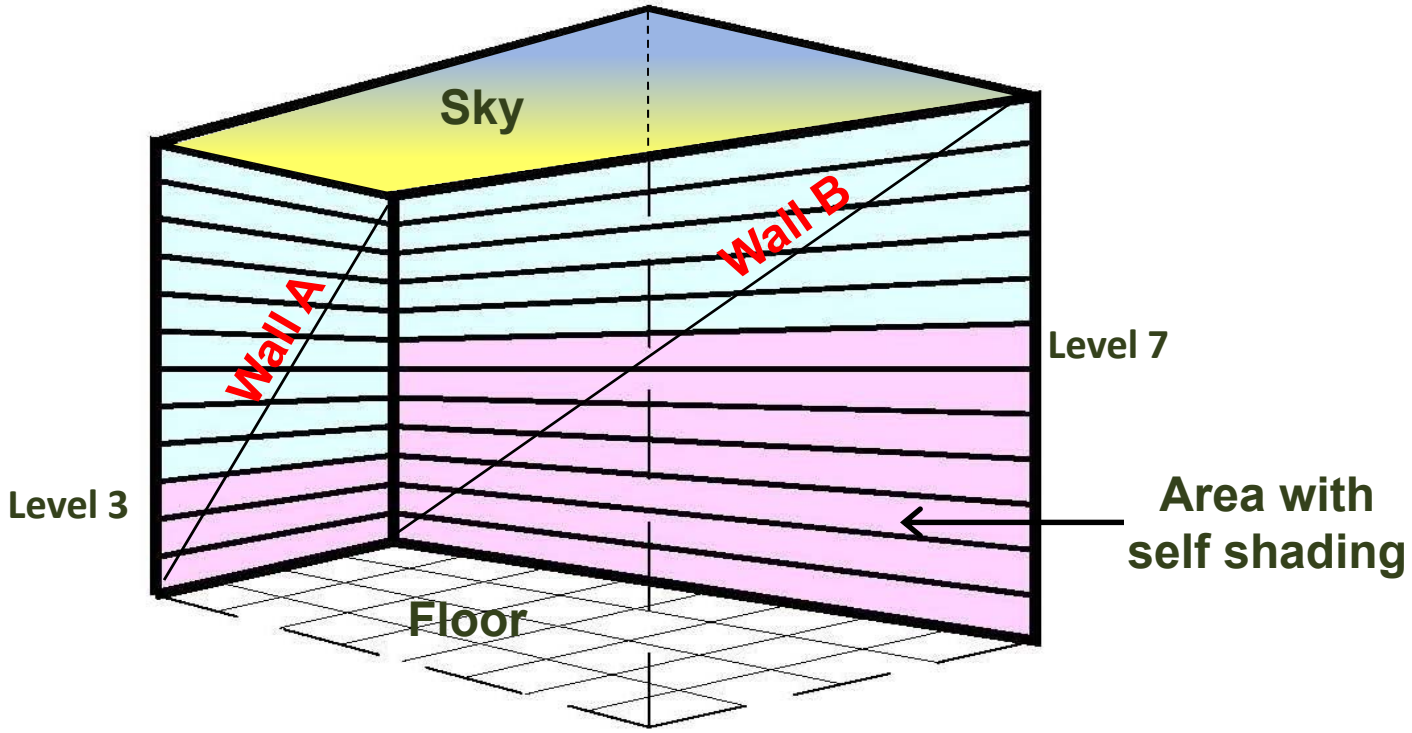

Inside view of internal walls

Parts with self shading do not require OTTV calculations

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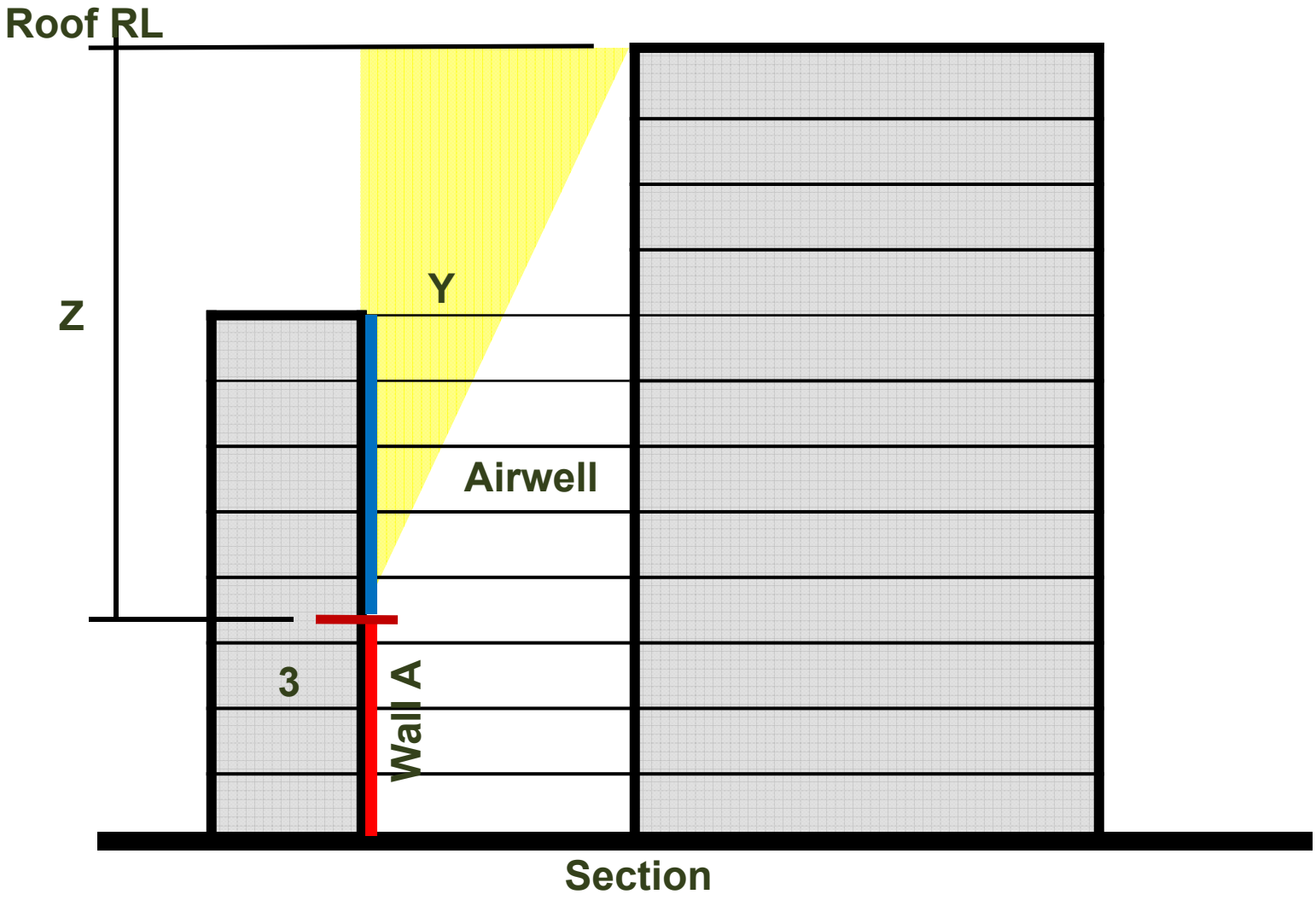

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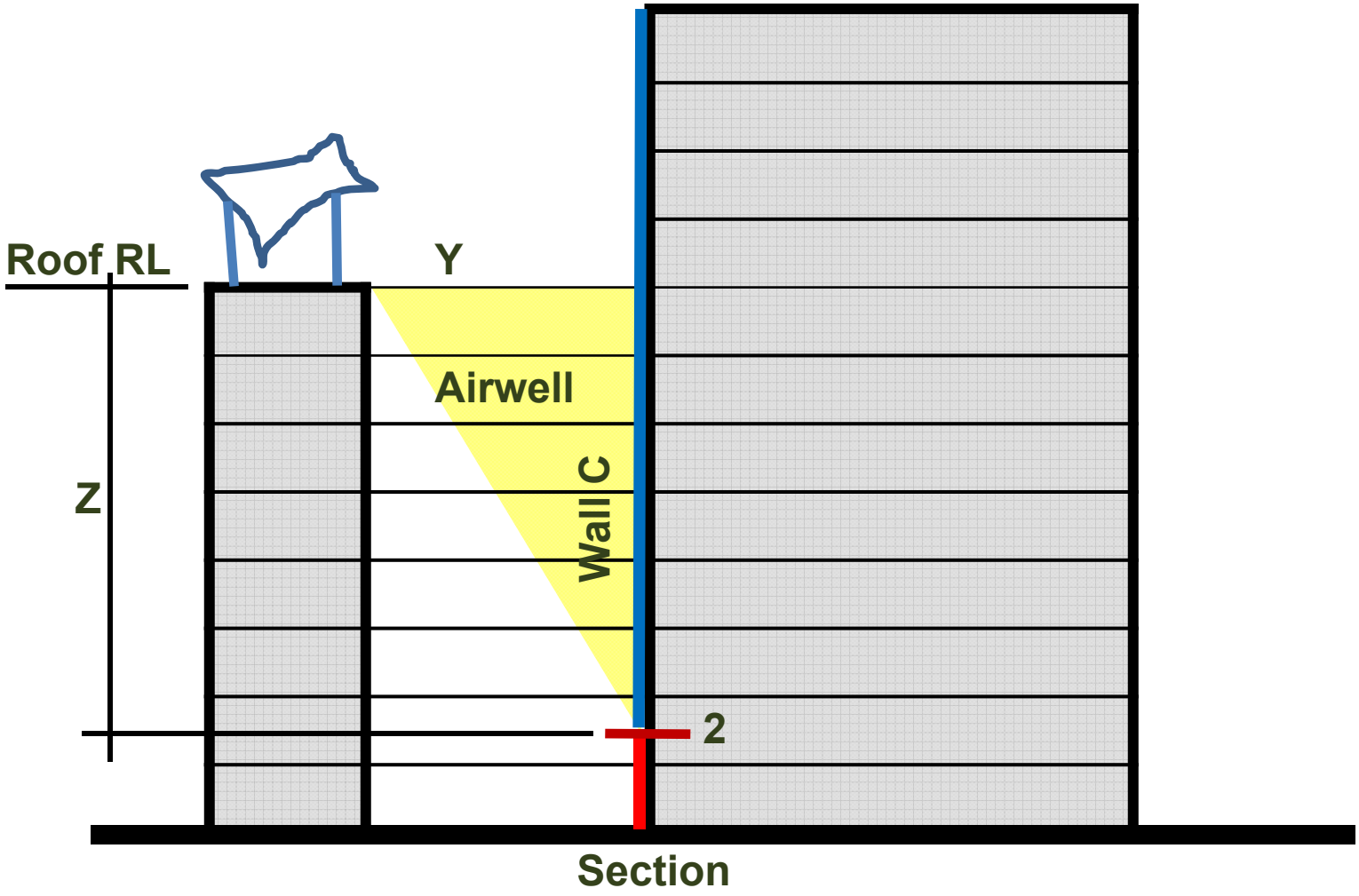

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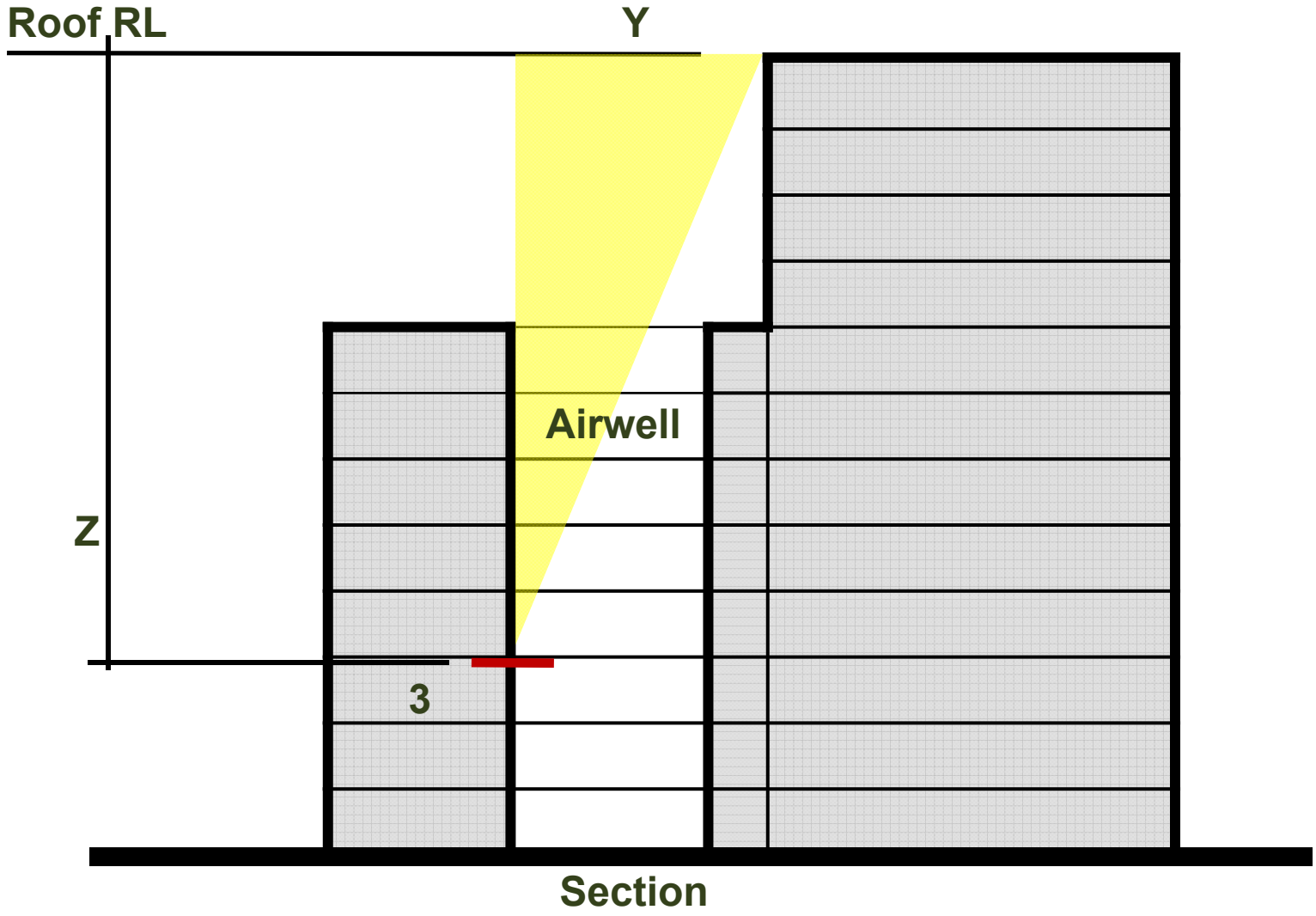

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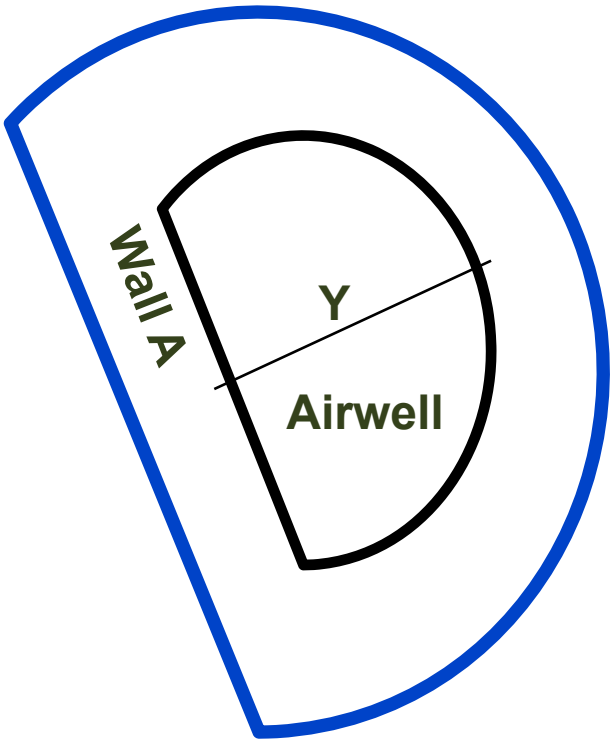
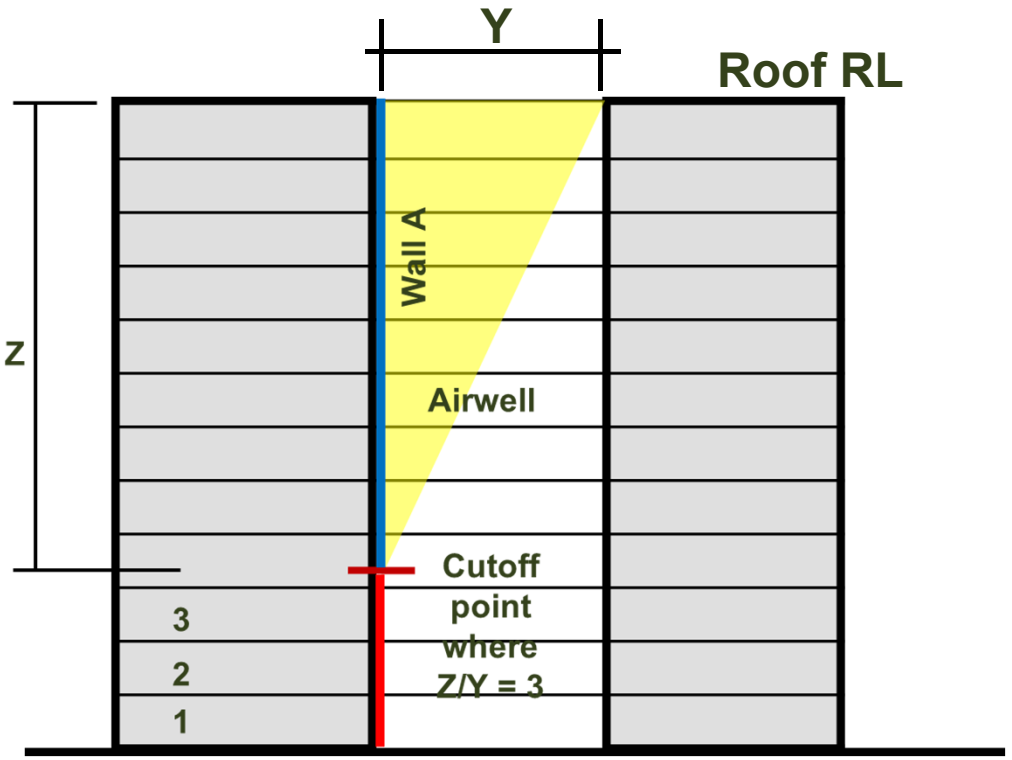
OTTV for Complex Building Configurations

Airwells



Plan



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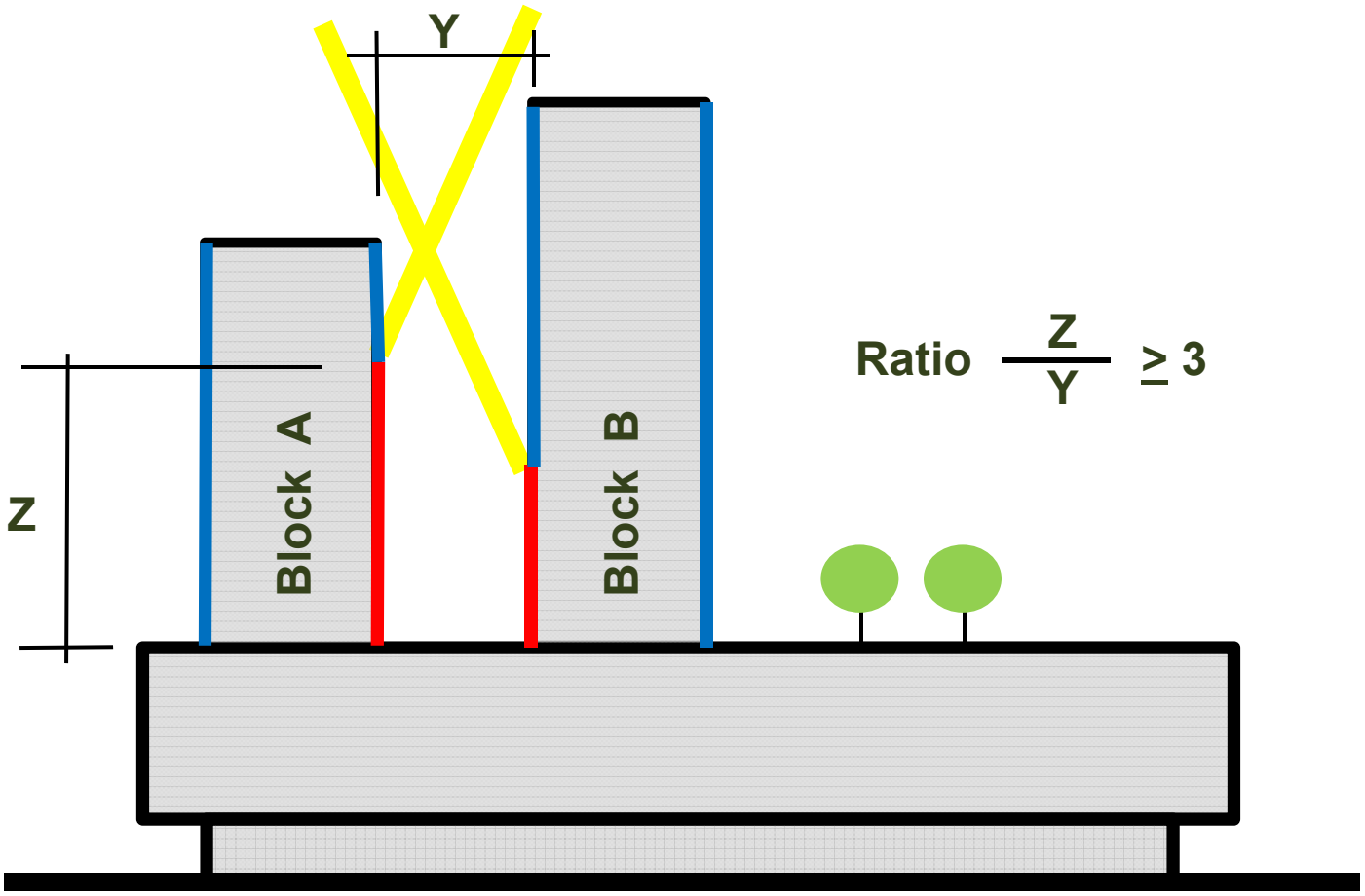
OTTV for Complex Building Configurations



U-shaped development

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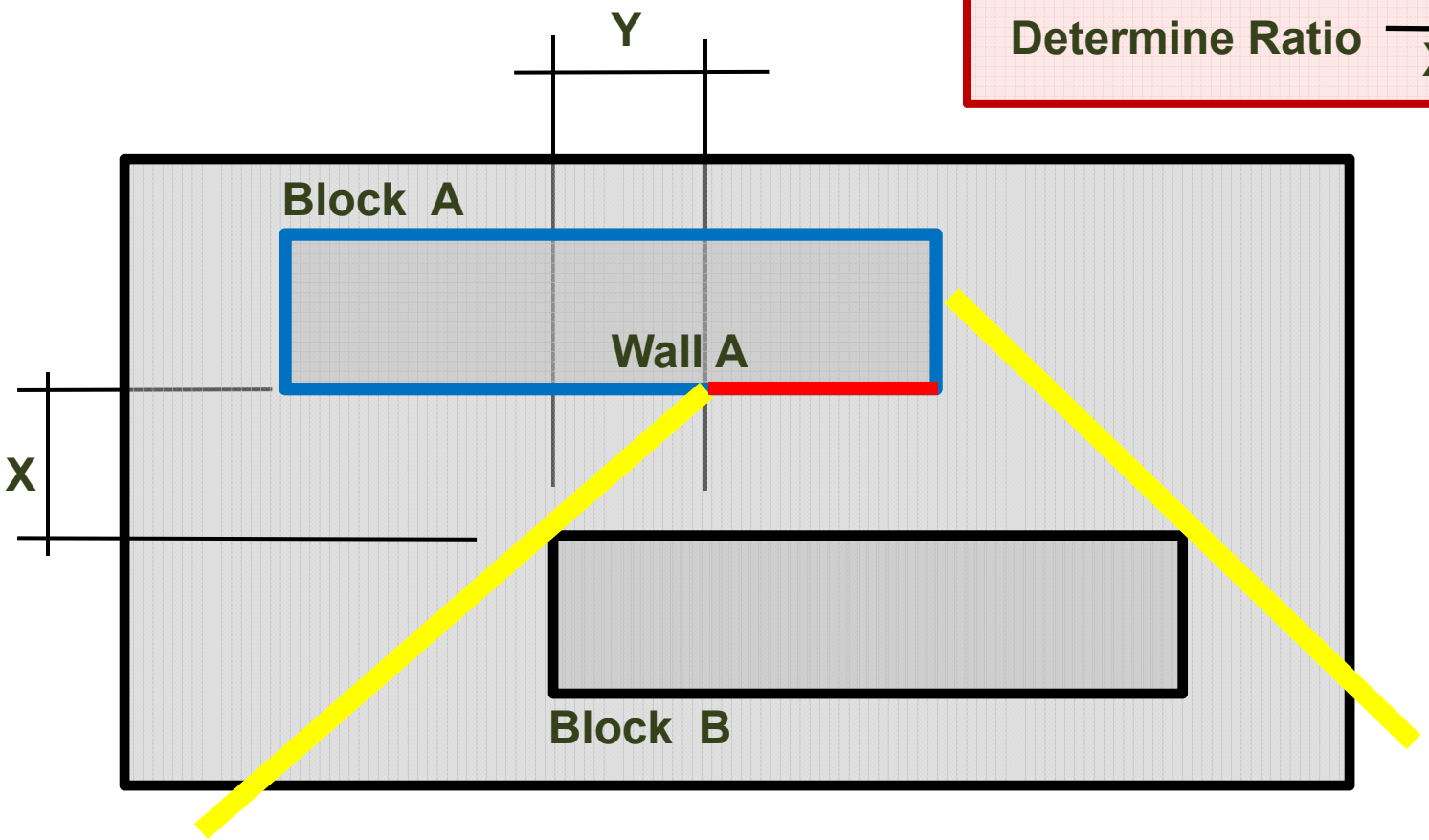
OTTV for Complex Building Configurations

Determine Ratio $\frac{Y}{X} = 1$



Plan

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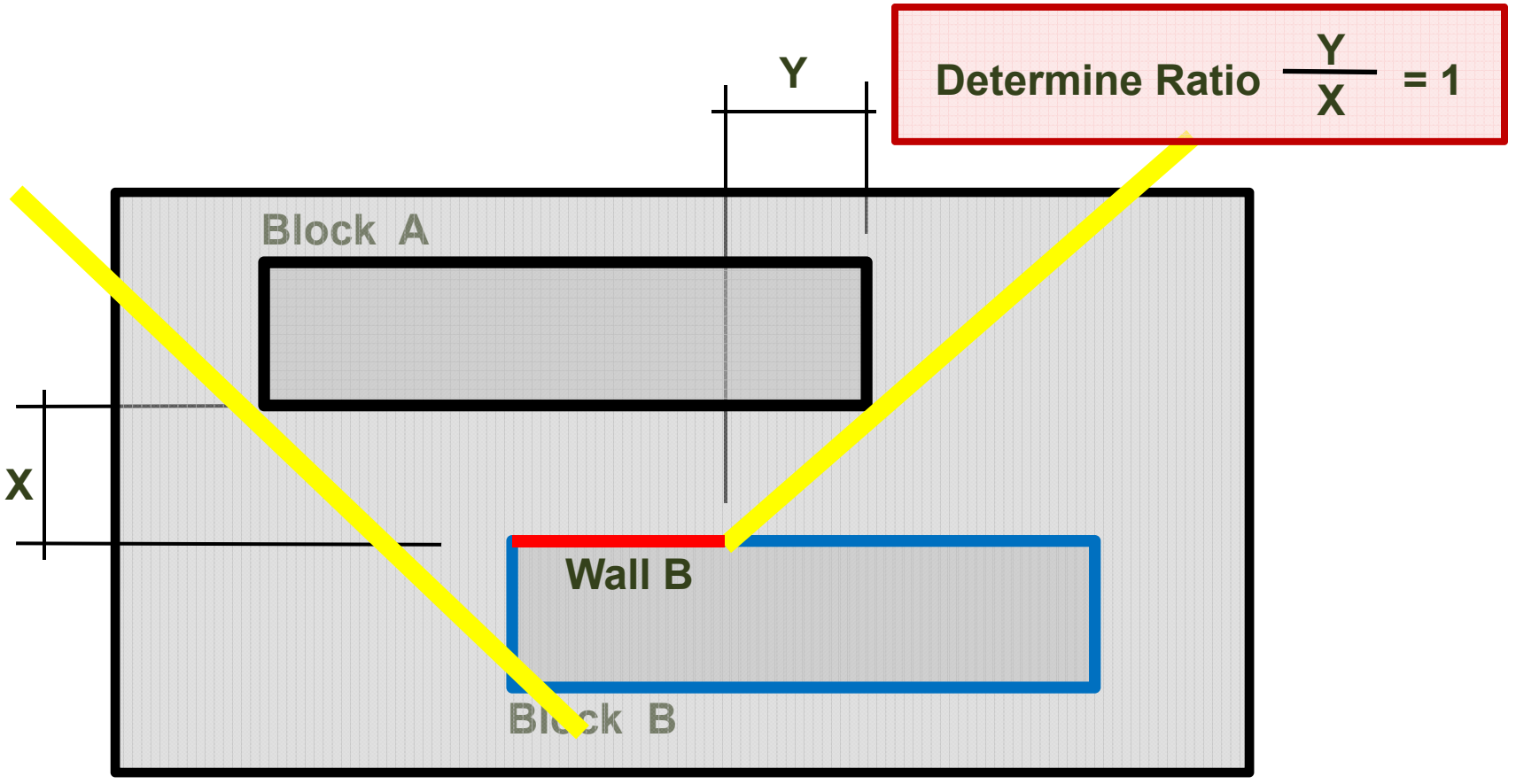

Plan

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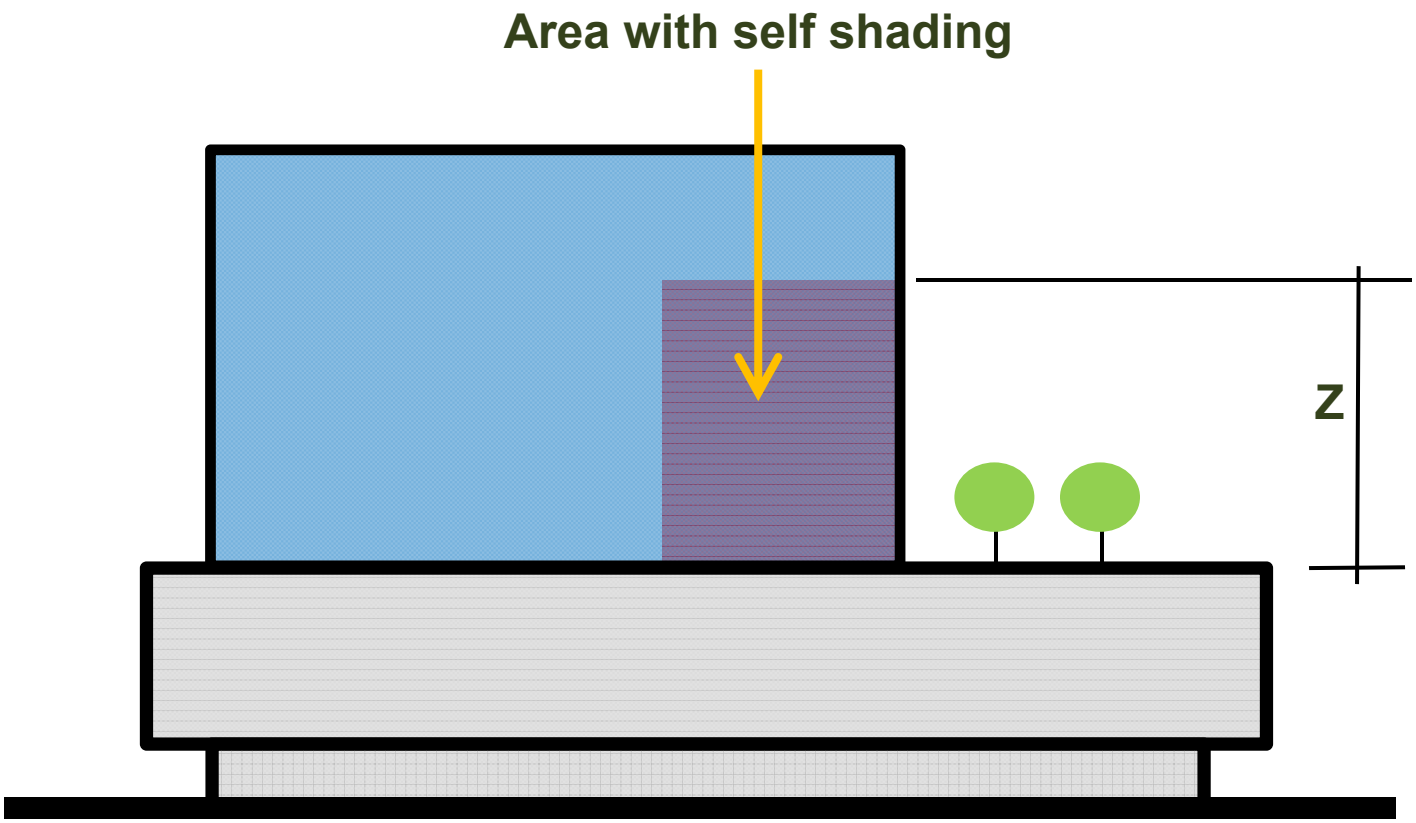

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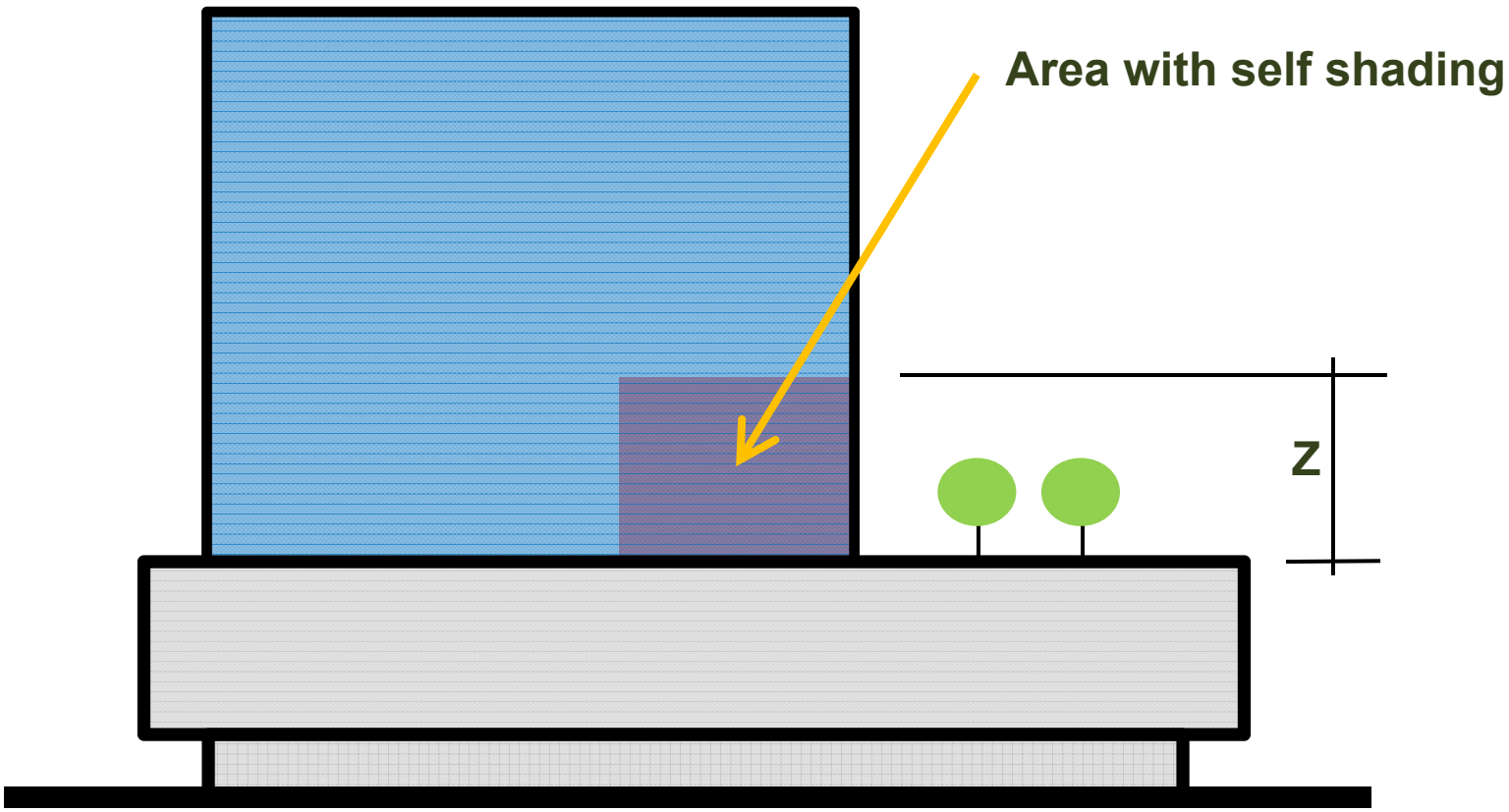

Block B Wall B

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Chapter 5
Building Envelope
Roof U-values

by

Ar Von Kok Leong

Chapter 5 WG Chair

Director, Arkitek MAA Sdn Bhd

6 July 2021

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Roof U-value major changes

1	Roof types : Lightweight (non-concrete roof) and heavyweight (concrete roof)	Table 10
2	Multiple roofs and definition of a primary roof	Clauses 5.5.2, 5.5.3
3	Equation for the calculation of the average weight of roof	Omitted
4	Daylight credits	Omitted
5	New clause on thermal insulation with definition of mass insulation, reflective insulation and relationship between U, k and R values	Clause 4.7

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Roof U-value major changes

2014	2019	
Roof Weight Group	**Roof Type**	**Max U-value**
Light (under 50kg/m2)	Lightweight (non concrete roof construction)	0.4
Heavy (above 50kg/m2)	Heavyweight (concrete roof construction)	0.6

Table 10

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Clause 5.5.3 : Multiple Roofs

Definition of a Primary and Secondary Roof

1) **Primary Roof sits directly above a habitable space;**
2) **Secondary Roof sits directly above the Primary Roof;**
3) **Area of Primary Roof that is directly covered does not need insulation, so long as the space between the two roofs are naturally or mechanically ventilated;**
4) **Ventilation will allow the removal of heat before it is transmitted down.**

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Clause 5.5.3 : Multiple Roofs

5) GBI recommends natural cross ventilation (ie open on minimum two sides), but accepts the following forced ventilation rates:

Height	RC secondary roof	Metal secondary roof
1.0m	1.5 ACH	2.25 ACH
2.0m	0.75 ACH	1.1 ACH
3.0m	0.5 ACH	0.75 ACH

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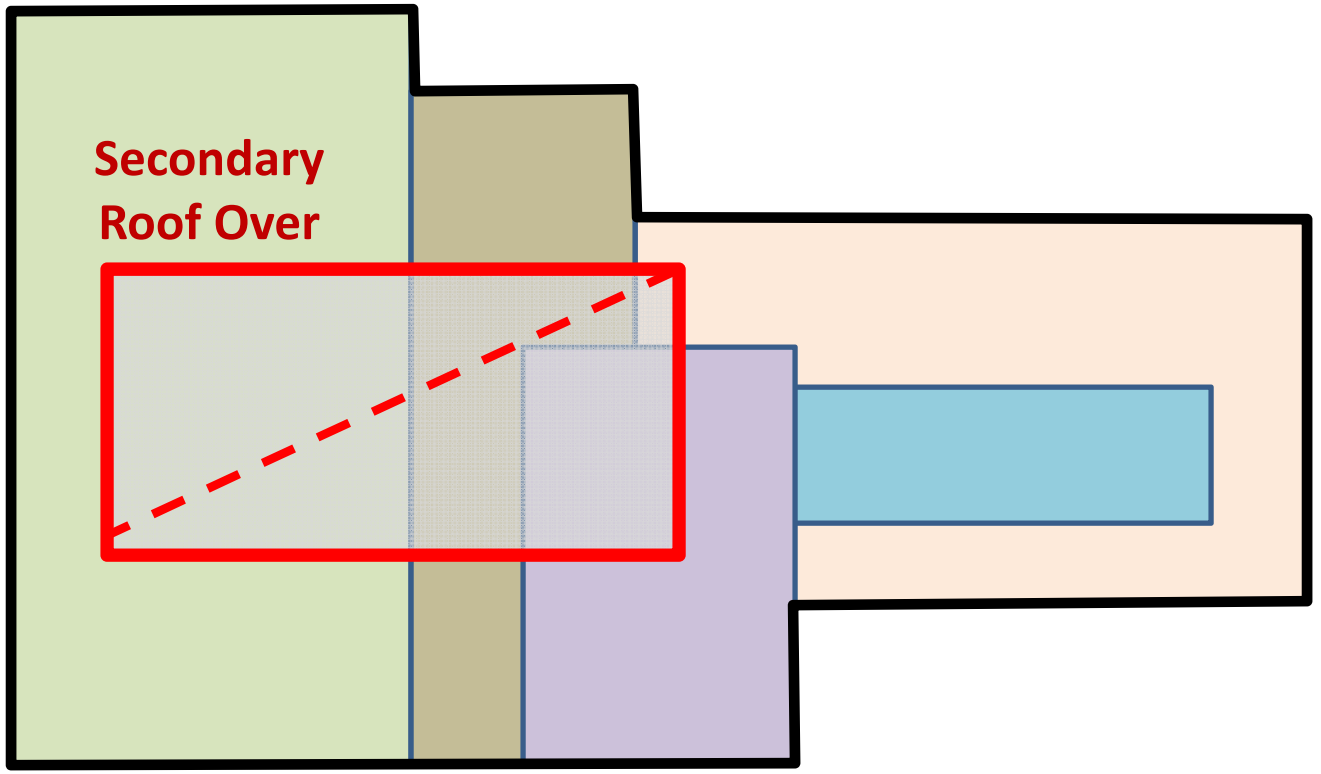
Clause 5.5.3 : Multiple Roofs



Plan View

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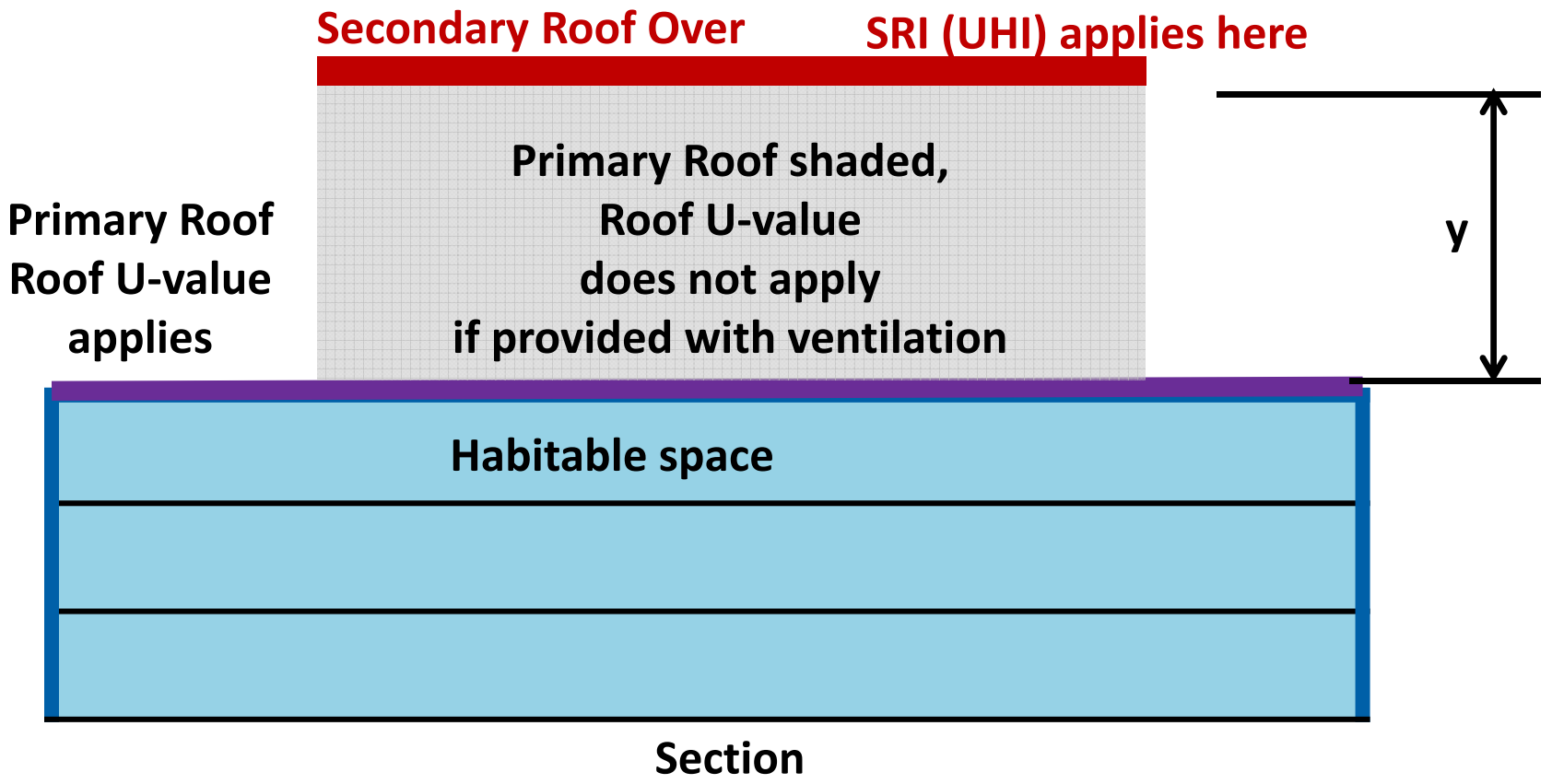
Clause 5.5.3 : Multiple Roofs



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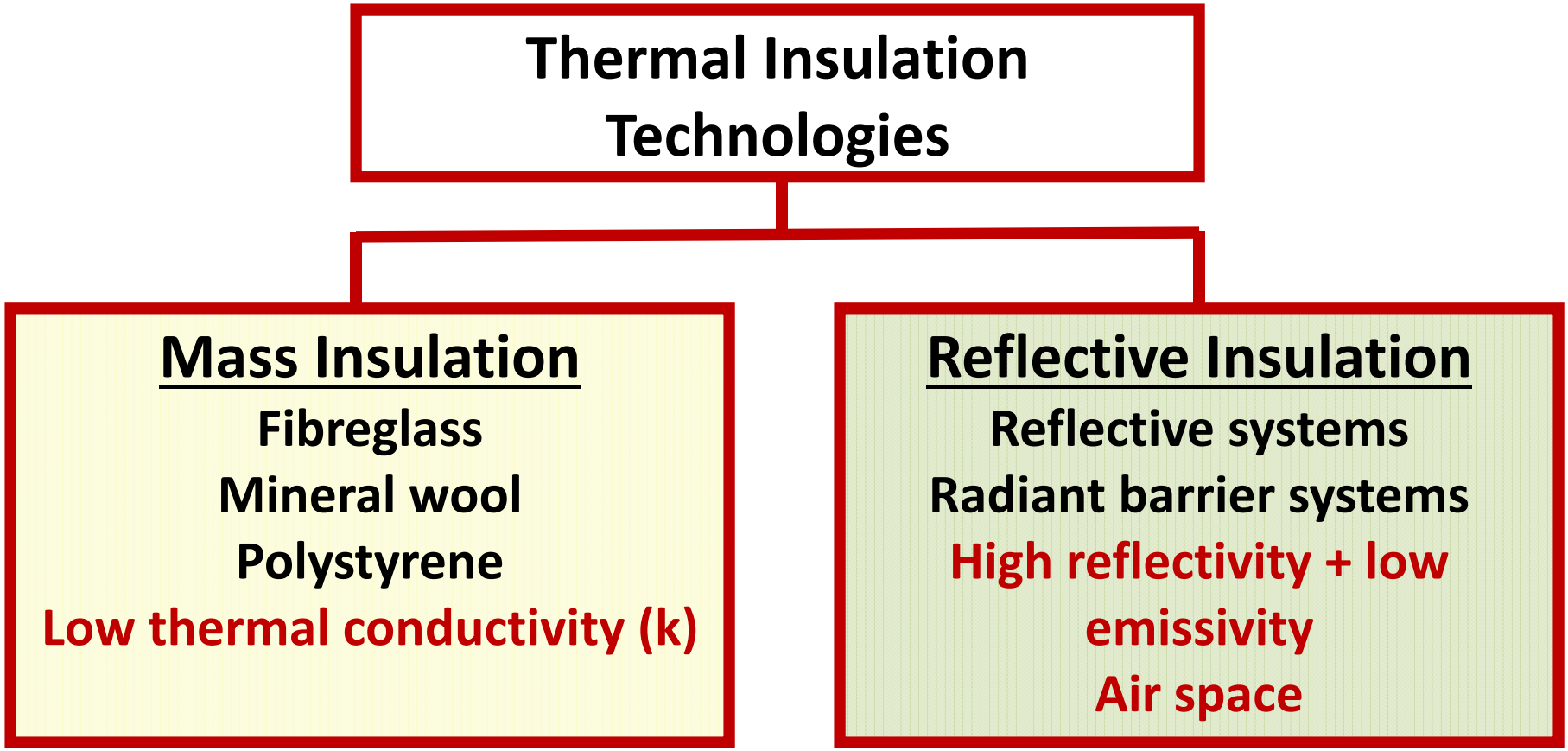
Clause 4.7 : Thermal Insulation



Clause 4.7 Figure 14

A combination of both technologies is recommended

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Clause 4.7 : Thermal Insulation

Relationship between thermal conductivity (k), thermal resistance (R) and thermal transmittance (U-value)

k = Thermal conductivity

$$R = \frac{\text{Material thickness, } d}{k}$$

$$U = \frac{1}{R} = \frac{k}{d}$$

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Clause 4.7 : Reflective Insulation

1) Based on a composite system or assembly to derive R;
2) Comprises of a low emissivity and high reflectance values;
3) Reflective insulation relies on the low conductivity of air space bounded and adjacent to the low-e surfaces;
4) Radiant barriers rely on large ventilated airspaces eg attics;
5) A combination of mass insulation and reflective insulation/radiant barrier is recommended.

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GBI Pro-Series

20 Nov 2019

Worked Examples

Roof U-values

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Category	Type
Roof Type	Lightweight (non concrete roof)
	Heavyweight (concrete roof)
Material	Metal
	Tiled
Insulation	Reflective Insulation Single Sided
	Reflective Insulation Double Sided
	Radiant Barrier Single Sided
	Radiant Barrier Double Sided
	Mass Insulation
Ceiling	Inclined
	Horizontal
Attic	Ventilated
	Non ventilated

MS 1525

Roof U-values Worked Examples

2014 2019

Roof Weight Group	Roof Type	Max U-value
Light (under 50kg/m2)	Lightweight (non concrete roof construction)	0.4
Heavy (above 50kg/m2)	Heavyweight (concrete roof construction)	0.6

Table 10

EXAMPLE 1

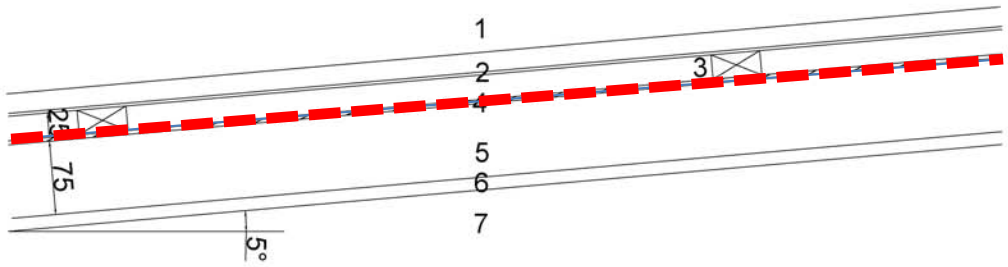
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 Metal Deck	47.6	0.000
3 25mm Purlin+ Air Gap	-	0.766
4 Reflective Insulation Double Sided	-	0.150
5 75mm Rafter + Air Gap	-	1.319
6 Plasterboard, 13mm thk	0.250	0.048
7 Internal surface	-	0.160

Total R = 2.487

U-Value = 1 / R

U-Value = 0.40

Non-concrete roof
With reflective insulation only

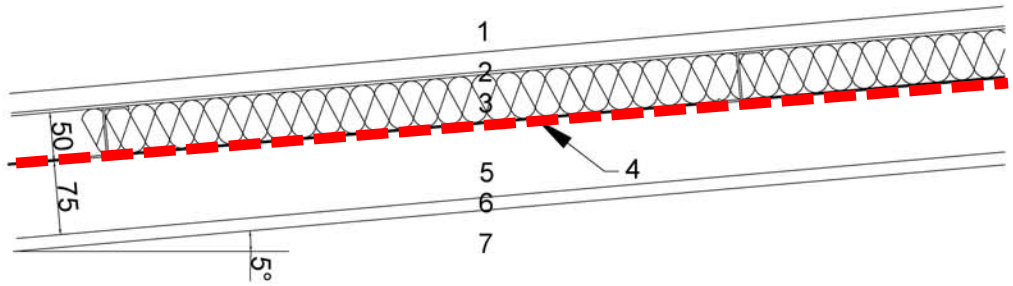


Roof	Lightweight (rLW)
Material	Metal (mM)
Insulation	Reflective Insulation Double Sided (iRIDS)
Ceiling	Inclined (cl)
Attic	No (aNO)
Code	rLW_mM_iRIDS_cl_aNO

EXAMPLE 2

	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 Metal Deck	47.600	0.000
3 50mm 40kg/m3 Mass Insulation	0.036	1.388
4 Radiant Barrier Single Sided (facing down)	-	0.000
5 75mm Rafter + Air Gap	-	1.319
6 Plasterboard, 13mm thk	0.250	0.048
7 Internal surface	-	0.160
	Total R =	2.959
	U-Value =	1 / R
	U-Value =	0.34

Non-concrete roof
With reflective insulation and mass insulation



Roof	Lightweight (rLW)
Material	Metal (mM)
Insulation	Mass (IM) + Radiant Barrier Single Sided (iRBSS) facing down
Ceiling	Inclined (cl)
Attic	No (aNO)
Code	rLW_mM_iM+iRBSS_cl_aNO

EXAMPLE 7

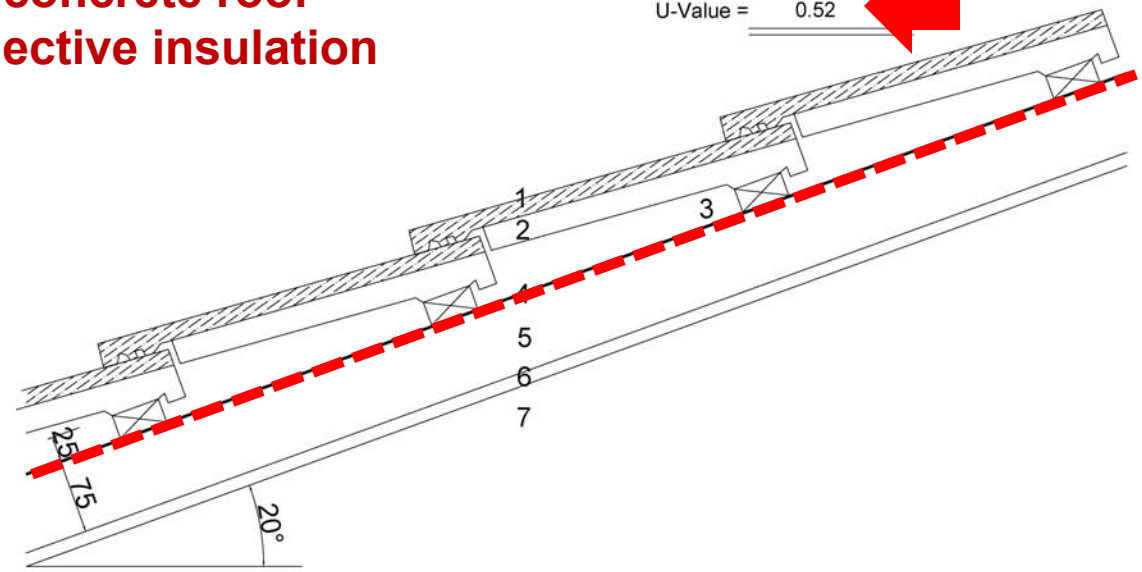
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 25mm Purlin+ Air Gap	-	0.725
4 Radiant Barrier Double Sided	-	0.000
5 75mm Rafter + Air Gap	-	0.943
6 Plasterboard, 13mm thk	0.250	0.048
7 Internal surface	-	0.160

Total R = 1.934

U-Value = 1 / R

U-Value = 0.52

Non-concrete roof
With reflective insulation



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Radiant Barrier Double Sided (iRBDS)
Ceiling	Inclined (cl)
Attic	No (aNO)
Code	rLW_mT_iRBDS_cl_aNO

EXAMPLE 8

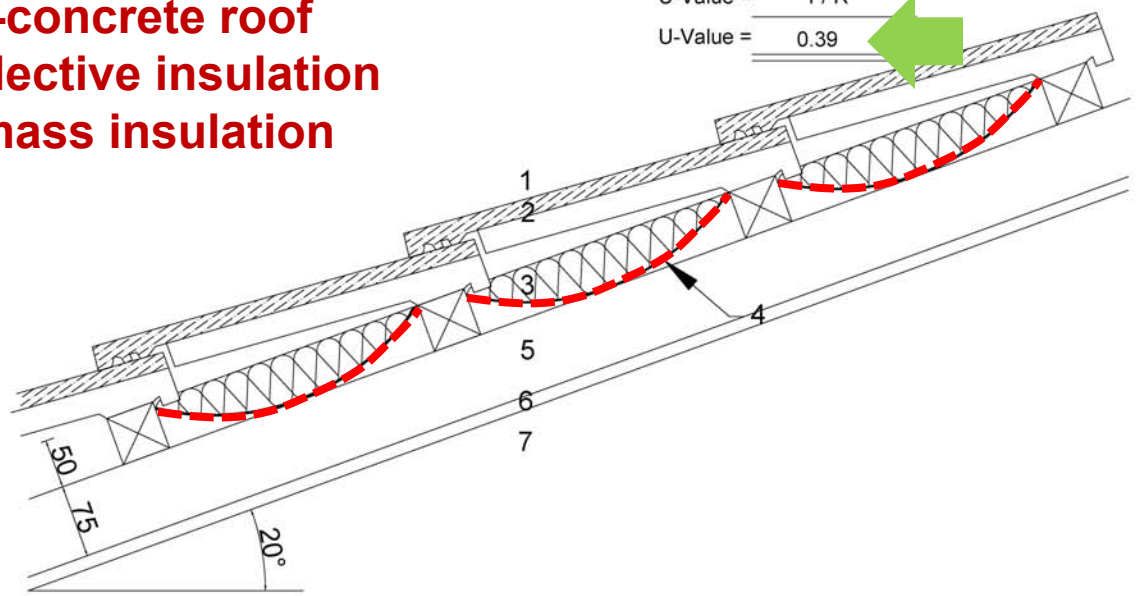
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 50mm 40kg/m3 Mass Insulation	0.036	1.388
4 Radiant Barrier Single Sided (facing down)	-	0.000
5 75mm Rafter + Air Gap	-	0.943
6 Plasterboard, 13mm thk	0.250	0.048
7 Internal surface	-	0.160

Total R = 2.597

U-Value = 1 / R

U-Value = 0.39

Non-concrete roof
With reflective insulation and mass insulation



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Mass (iM) + Radiant Barrier Single Sided (iRBSS) facing down
Ceiling	Inclined (cl)
Attic	No (aNO)
Code	rLW_mT_iM+iRBSS_cl_aNO

EXAMPLE 9

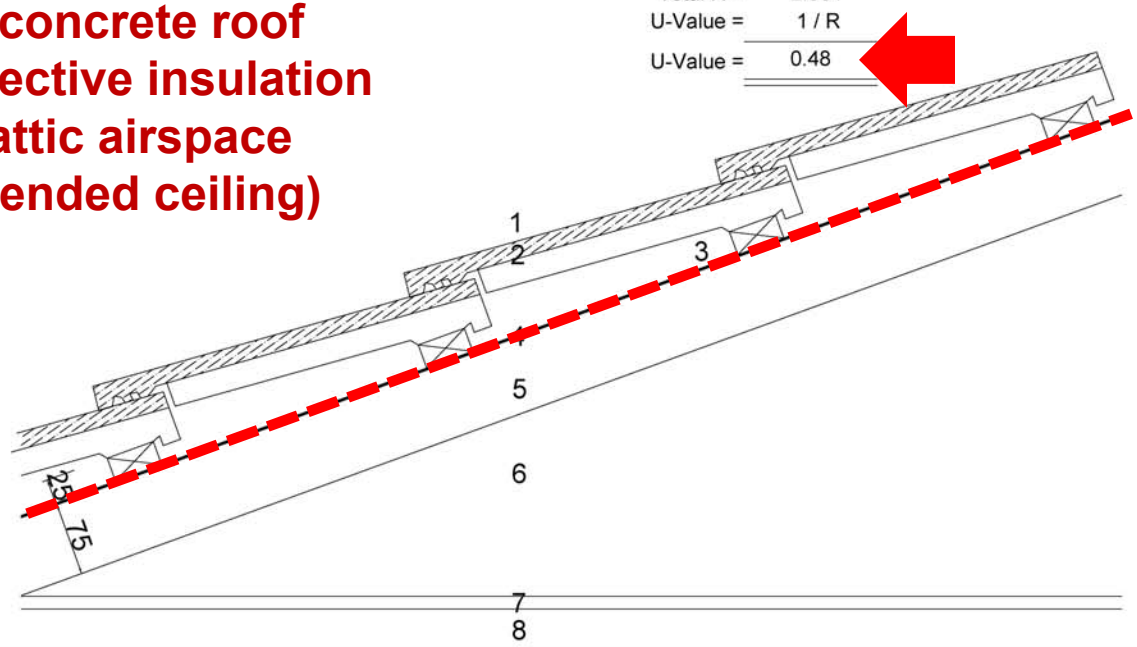
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 25mm Purlin+ Air Gap	-	0.725
4 Radiant Barrier Double Sided	-	0.000
5 75mm Rafter + Air Gap	-	0.000
6 Attic Space (unventilated)	-	1.090
7 Plasterboard, 13mm thk	0.250	0.048
8 Internal surface	-	0.160

Total R = 2.081

U-Value = 1 / R

U-Value = 0.48

Non-concrete roof
With reflective insulation
and attic airspace
(suspended ceiling)



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Radiant Barrier Double Sided (iRBDS)
Ceiling	Horizontal (cH)
Attic	Unventilated (aUV)
Code	rLW_mT_iRBDS_cH_aUV

EXAMPLE 10

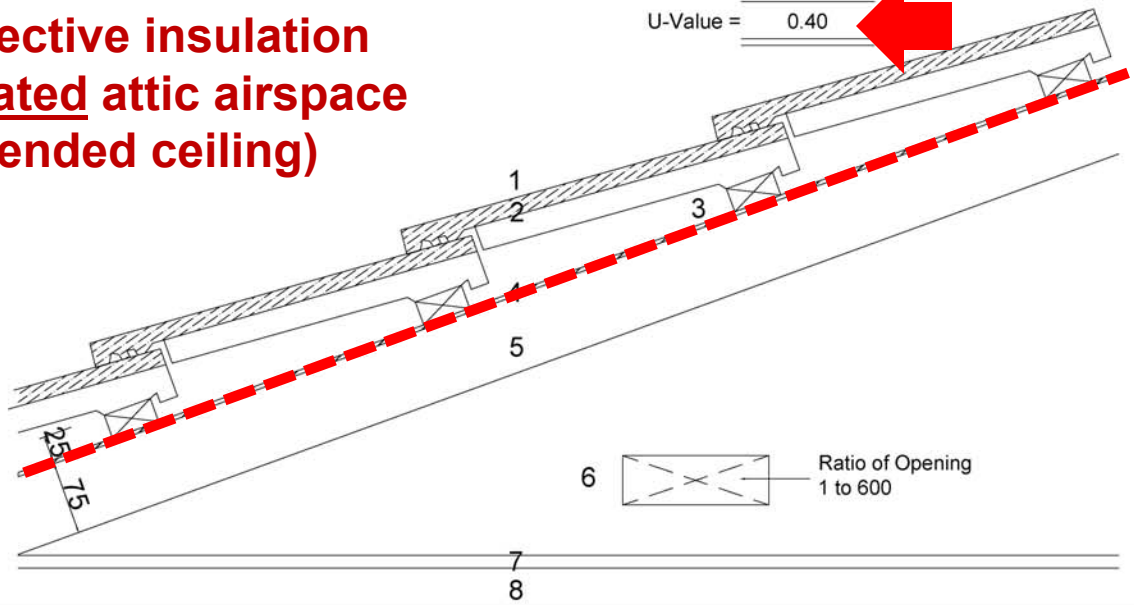
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 25mm Purlin+ Air Gap	-	0.725
4 Reflective Insulation Double Sided	-	0.150
5 75mm Rafter + Air Gap	-	0.000
6 Attic Space (ventilated)	-	1.360
7 Plasterboard, 13mm thk	0.250	0.048
8 Internal surface	-	0.160

Total R = 2.501

U-Value = 1 / R

U-Value = 0.40

Non-concrete roof
With reflective insulation
and ventilated attic airspace
(suspended ceiling)



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Reflective Insulation Double Sided (iRIDS)
Ceiling	Horizontal (cH)
Attic	Ventilated (aV)
Code	rLW_mT_iRDS_cH_aV

EXAMPLE 11

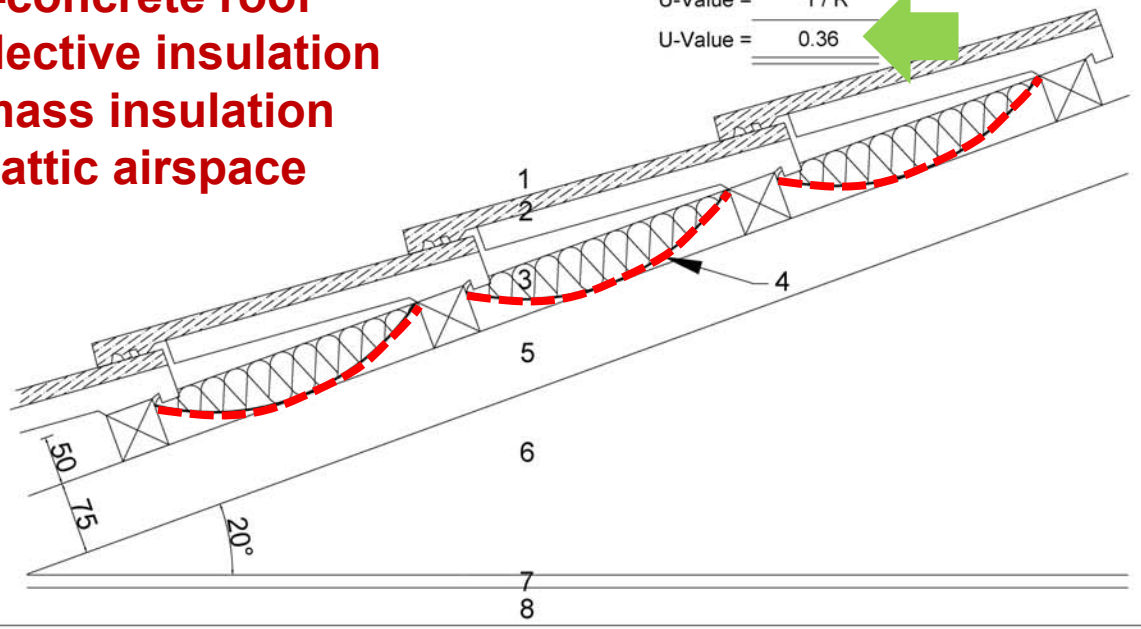
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 50mm 40kg/m3 Mass Insulation	0.036	1.388
4 Radiant Barrier Single Sided (facing down)	-	0.000
5 75mm Rafter + Air Gap	-	0.000
6 Attic Space (unventilated)	-	1.090
7 Plasterboard, 13mm thk	0.250	0.048
8 Internal surface	-	0.160

Total R = 2.744

U-Value = 1 / R

U-Value = 0.36

Non-concrete roof
With reflective insulation
and mass insulation
and attic airspace



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Mass (iM) + Radiant Barrier Single Sided (iRBSS) facing down
Ceiling	Horizontal (cH)
Attic	Unventilated (aUV)
Code	rLW_mT_iM + iRBSS_cH_aUV

EXAMPLE 12

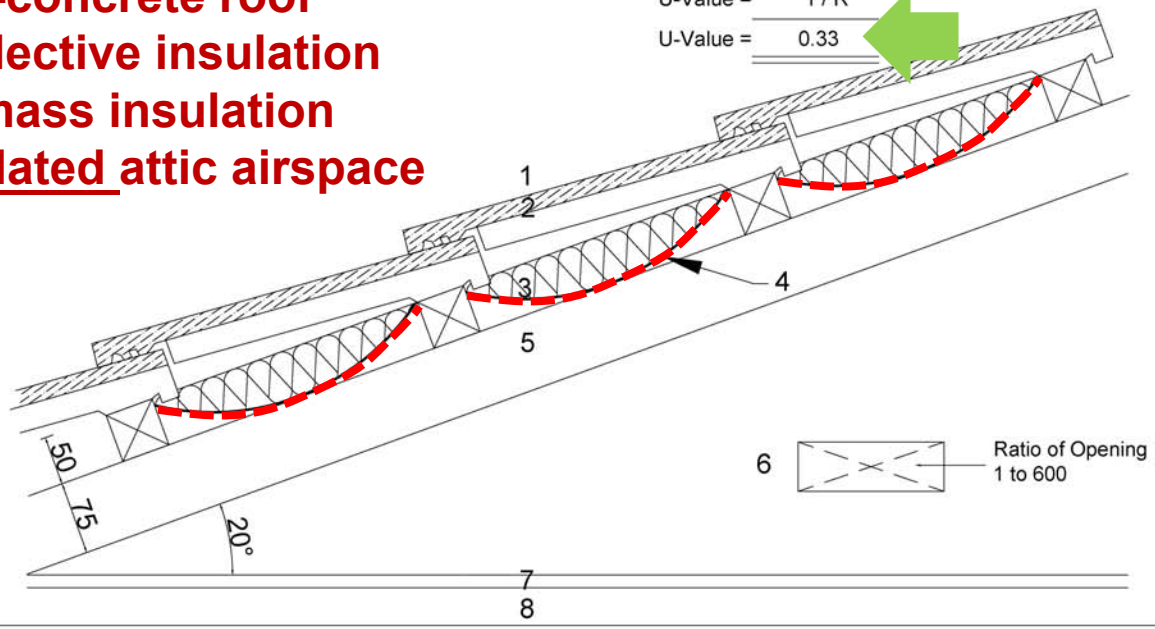
	Thermal Conductivity (W/mk)	Thermal Resistance (m^2k/W)
1 External surface	-	0.044
2 12mm Roof Tile	0.836	0.014
3 50mm 40kg/m3 Mass Insulation	0.036	1.388
4 Radiant Barrier Single Sided (facing down)	-	0.000
5 75mm Rafter + Air Gap	-	0.000
6 Attic Space (ventilated)	-	1.360
7 Plasterboard, 13mm thk	0.250	0.048
8 Internal surface	-	0.160

Total R = 3.014

U-Value = 1 / R

U-Value = 0.33

Non-concrete roof
With reflective insulation
and mass insulation
and ventilated attic airspace



Roof	Lightweight (rLW)
Material	Tile (mT)
Insulation	Mass (iM) + Radiant Barrier Single Sided (iRBSS) facing down
Ceiling	Horizontal (cH)
Attic	Ventilated (aV)
Code	rLW_mT_iM + iRBSS_cH_aV

MS 1525

thank you

by

Ar Von Kok Leong

Director, Arkitek MAA Sdn Bhd

MS 1525

Clause 5 Building Envelope

Recommendations for the next revision

to initiate new studies into Urban Heat island effect specifically for Malaysia

a) by conducting experiments in different parts of the country

b) by conducting research on Solar Absorption Index, Solar Reflectivity Index, and Solar Emissivity Index of the range of most commonly used building materials in the country.

c) this will form a part of Strategic Landscaping in Chapter 4.

MS 1525

Clause 5 Building Envelope

Recommendations for the next revision

to review the existing OTTV equation

a) to conduct experiments over a year (new Test Reference Year) to update the Orientation Factor (OF), and the Value of the constants;

b) to conduct research on other similar OTTV in the tropical regions to determine if OTTV $\leq$ 50 W/m2 is still suitable in Malaysia;

c) to analyze values of R1 and R2 for non-standard types of shading devices such as dynamic shading devices, complex or free-form shading devices, perforated shading devices, self-shading;

d) to study the effects of shading from natural plants.

MS 1525

Clause 5 Building Envelope

Recommendations for the next revision

to review Roof U-values and RTTV equations

a) to conduct experiments over a year (new Test Reference Year) to determine Orientation Factor (OF) for roofs, and to update the Value of the constants;

b) to conduct experiments on the impact of multiple roofs on the Roof U value;

c) to conduct research on other similar Roof U-values and RTTV (or similar) in the tropical regions to determine if Lightweight Roof < 0.4 W/m2; Heavyweight Roof < 0.6 W/m2; and RTTV $\leq$ 25 W/m2 are still relevant.

d) to collaborate with the industry to finalise data for reflective insulation performance and its limitations.