A Pool with a View

RDH Technical Symposium

DELIVERED
JUNE 16, 2023

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BSc of Indoor Pools

- Many of the same principles still apply:
  - Ensure **continuity** of control layers
  - Keep **structure warm** with exterior insulation
  - Use **rainscreen** assemblies to allow for drying of incidental moisture
  - Minimize **glazed areas**
- Some new challenges
  - Water on the inside
  - Chlorines & water chemistry
  - Extreme vapour drive to exterior
  - Stainless-steel isn't stainless
  - HVAC and more…

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Environmental Conditions (Typical)

Typical Wintertime
(Vancouver, BC)

10 °C

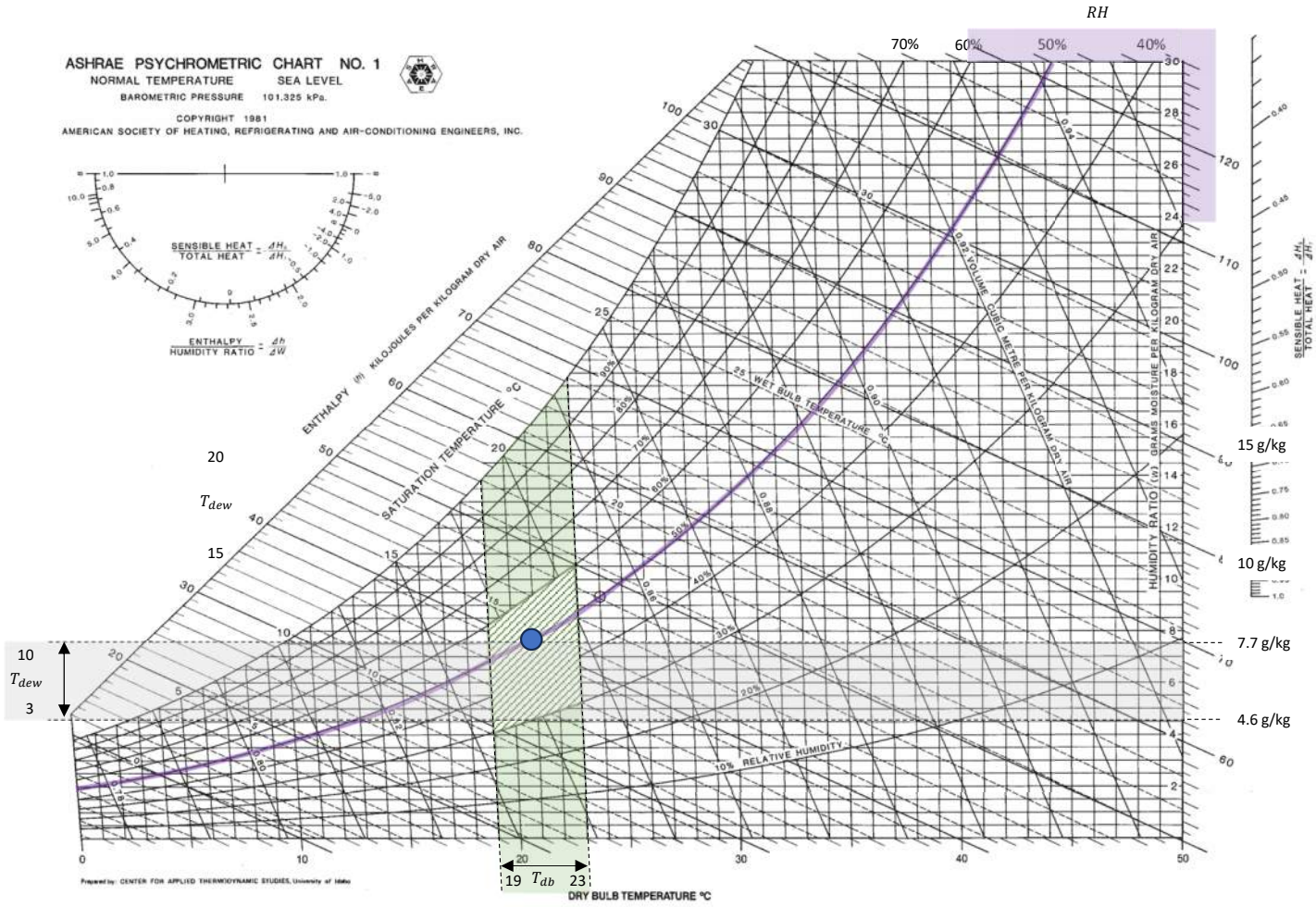
T_{dew}

21 °C/50%

0.9 kPa

ΔP_{vapour}

21 °C/50% (1244 Pa)
vs.
-7 °C/90% (304 Pa)



Environmental Conditions (Pool)

Typical Pool

17 °C

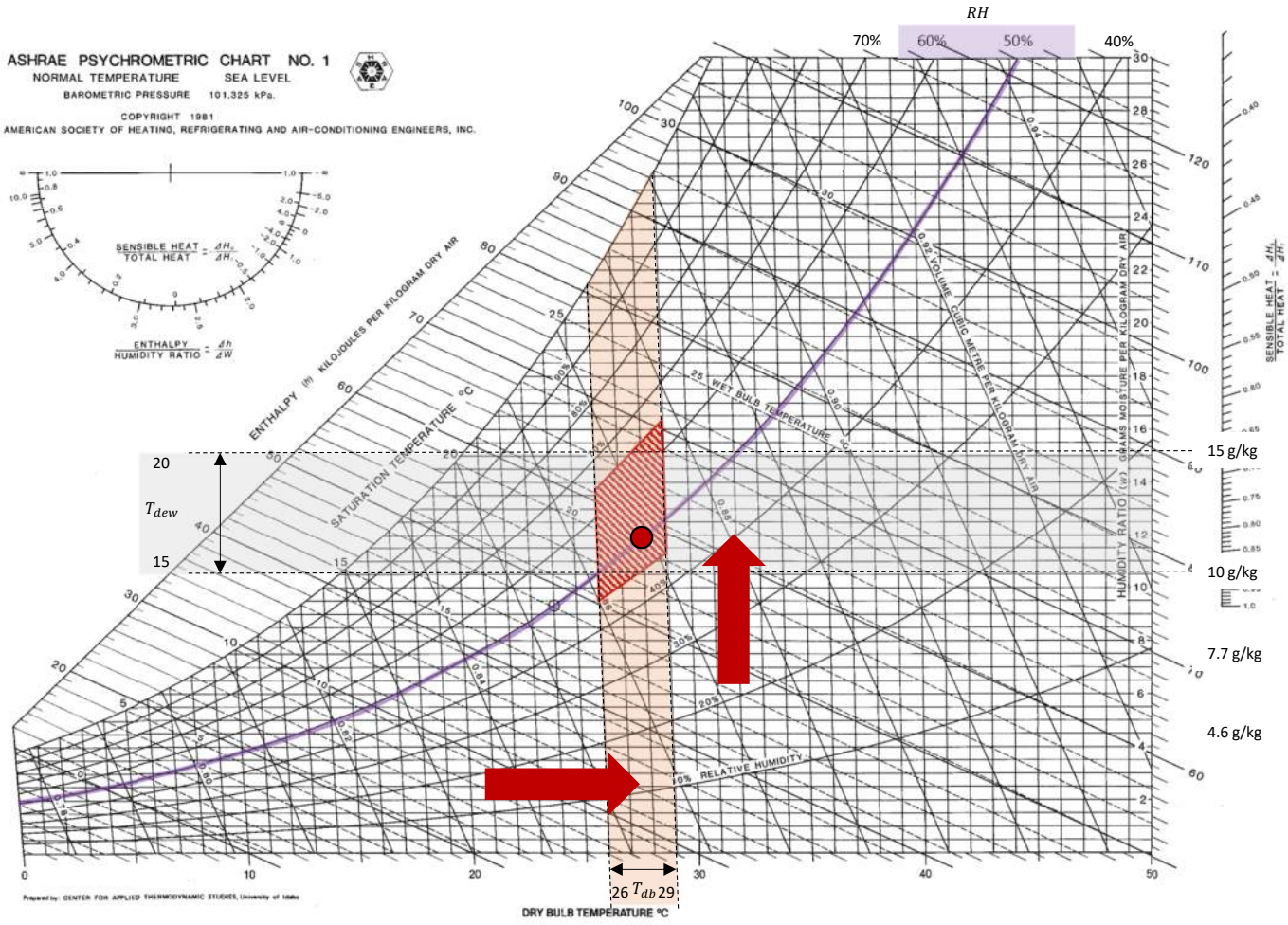
T_{dew}

28 °C/50%

1.6 kPa

ΔP_{vapour}

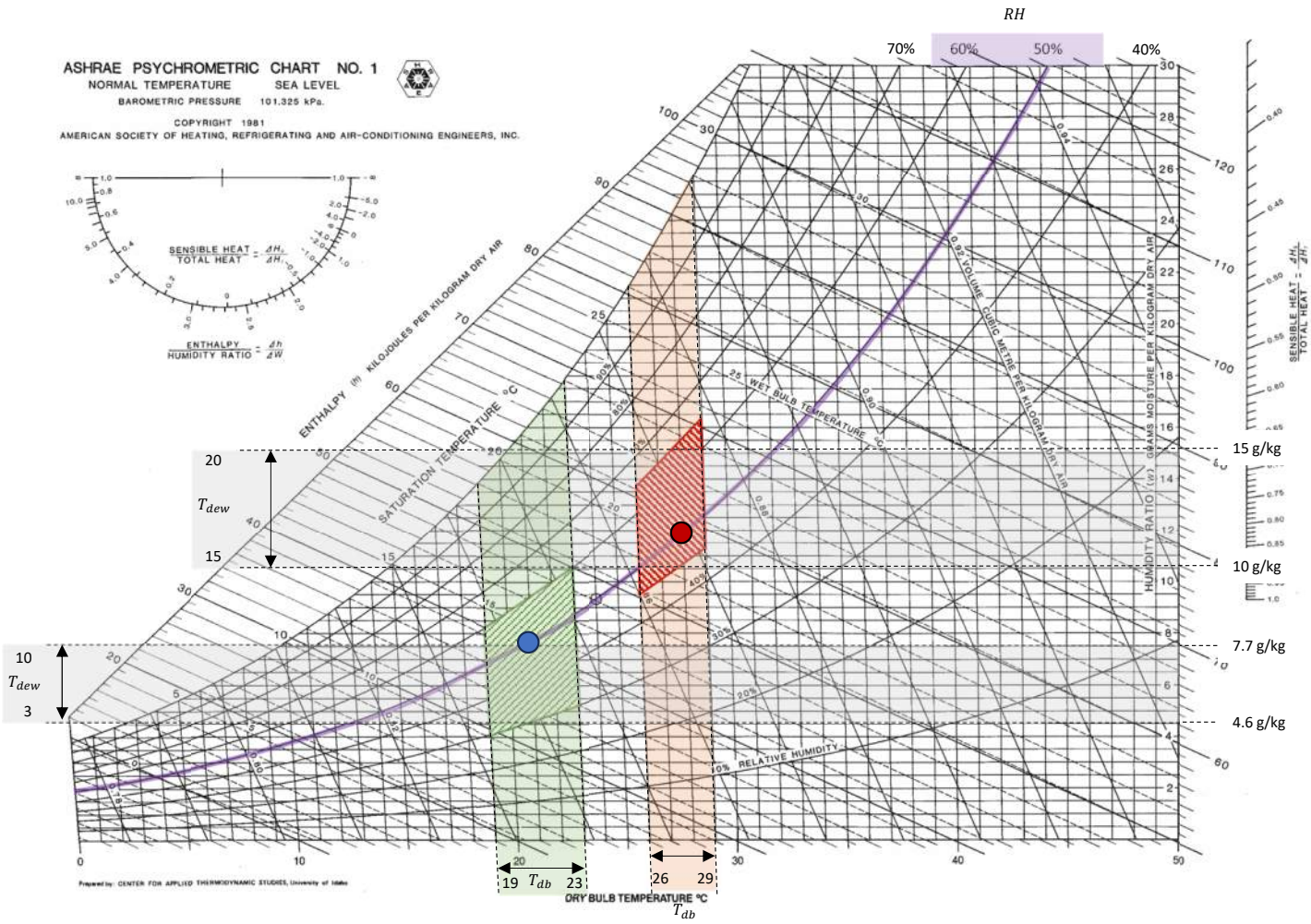
28 °C/50% (1891 Pa)
vs.
-7 °C/90% (304 Pa)



Environmental Conditions (Compared)

- Dew point temperature 17 °C (63 °F)
- ~700 Pa increased vapour pressure
- 2x the weight of latent water in the air

Typical Wintertime (Vancouver, BC)	**Typical Pool**
10 °C T_{dew} 21 °C/50%	17 °C T_{dew} 28 °C/50%
0.9 kPa ΔP_{vapour} 21 °C/50% (1244 Pa) vs. -7 °C/90% (304 Pa)	1.6 kPa ΔP_{vapour} 28 °C/50% (1891 Pa) vs. -7 °C/90% (304 Pa)



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What is 1.6 kPa?

Table C-1 *(continued)*
Wind Speeds

q	V	q	V	q	V	q	V
kPa	m/s	kPa	m/s	kPa	m/s	kPa	m/s
0.38	24.2	0.76	34.3	1.14	42.0	1.52	48.5
0.39	24.6	0.77	34.5	1.15	42.2	1.53	48.6
0.40	24.9	0.78	34.7	1.16	42.4	1.54	48.8
0.41	25.2	0.79	35.0	1.17	42.5	1.55	49.0
0.42	25.5	0.80	35.2	1.18	42.7	1.56	49.1
0.43	25.8	0.81	35.4	1.19	42.9	1.57	49.3
0.44	26.1	0.82	35.6	1.20	43.1	1.58	49.4
0.45	26.4	0.83	35.8	1.21	43.3	1.59	49.6
0.46	26.7	0.84	36.0	1.22	43.4	1.60	49.7
0.47	27.0	0.85	36.3	1.23	43.6	1.61	49.9
0.48	27.2	0.86	36.5	1.24	43.8	1.62	50.1
0.49	27.5	0.87	36.7	1.25	44.0	1.63	50.2
0.50	27.8	0.88	36.9	1.26	44.1	1.64	50.4
0.51	28.1	0.89	37.1	1.27	44.3	1.65	50.5
0.52	28.4	0.90	37.3	1.28	44.5	1.66	50.7

→ >180 km/h

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Moisture Loads

Ventilation

Evaporation

Air Leakage

People

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Moisture Loads

Ventilation

50 to 100 kg/hr

- 4 – 6 ACH
- Can contribute to drying during the coldest periods
- Significant energy use

Evaporation

30 – 80 kg/hr

- Evaporation decreased by
  - Reduce air velocity over the water
  - Increase interior RH
  - Use a pool cover
  - Decrease water temp.
  - Less activity

Air Leakage

30 – 60 kg/hr

People

0.1 – 0.5 kg/(hr·person)

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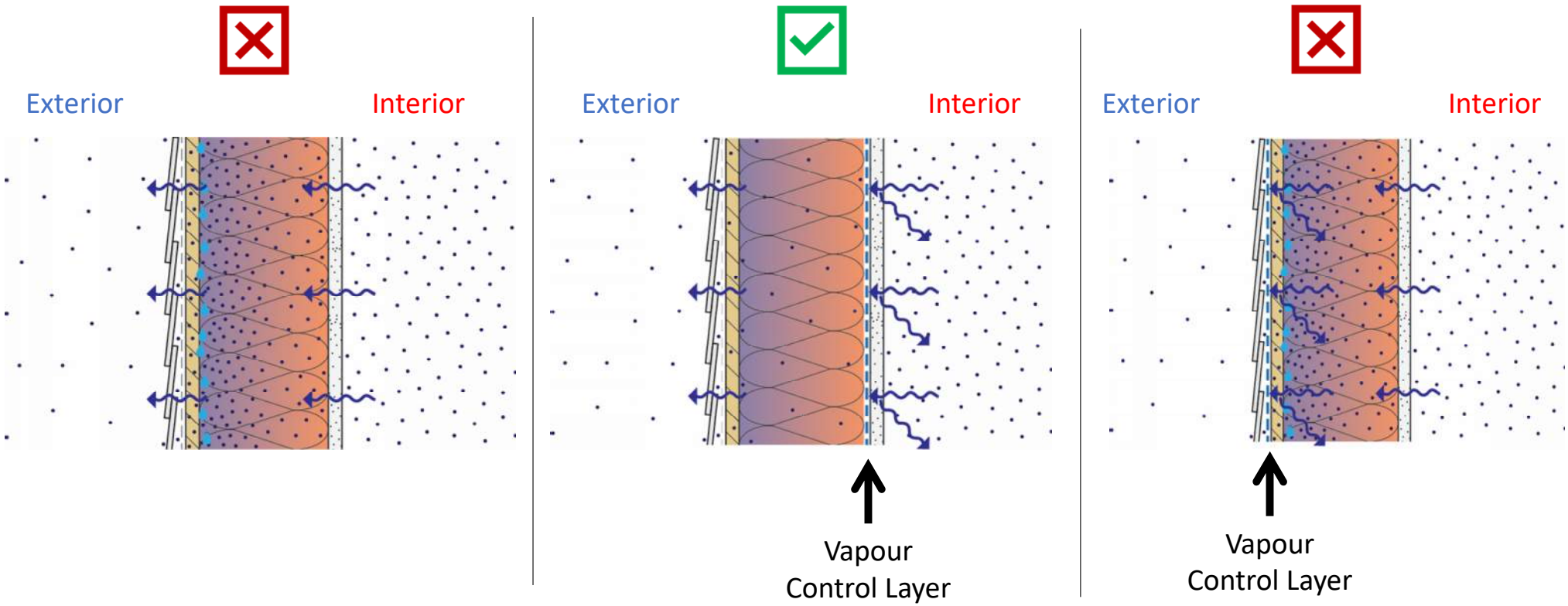
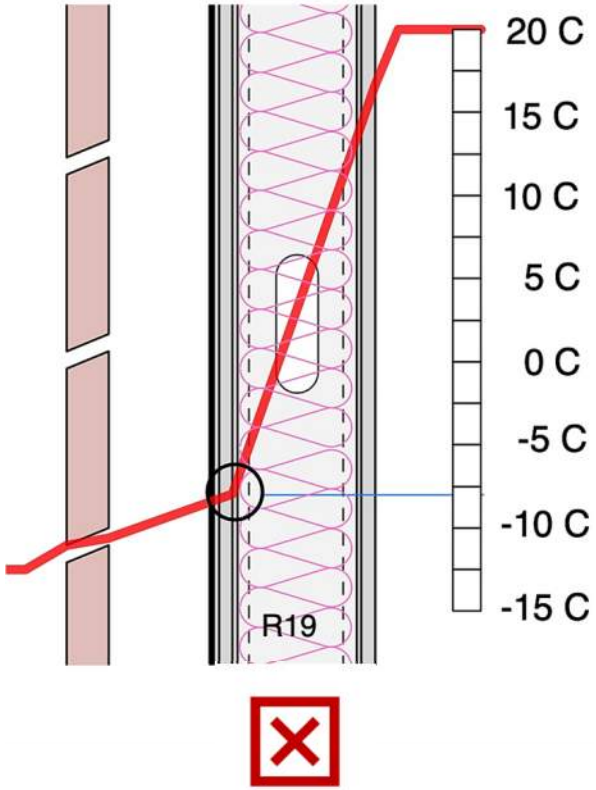
Assumptions: Wintertime conditions (21 °C/-7 ° C). Air leakage rate 2 L/s·m^2 @ 75 Pa (0.7 L/s·m^2 @15 Pa), Pool Surface: 150 m^2

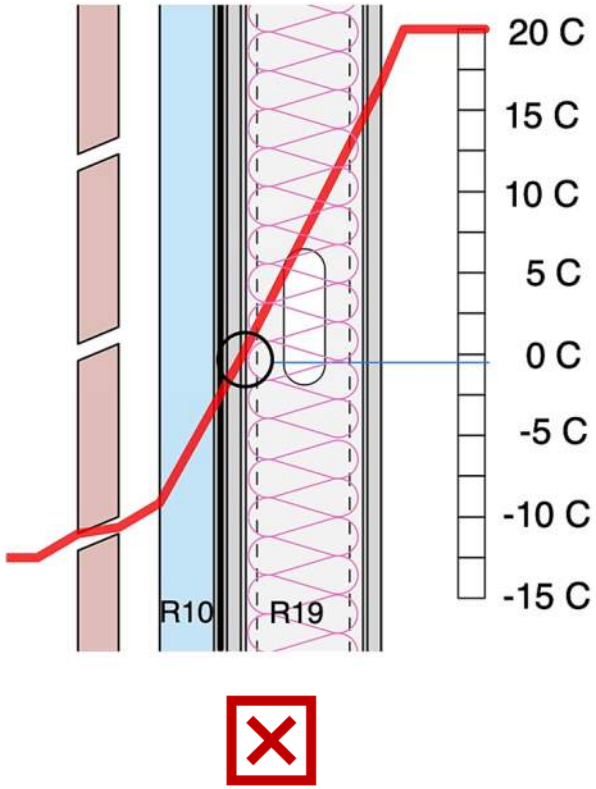
Wintertime Vapour Diffusion

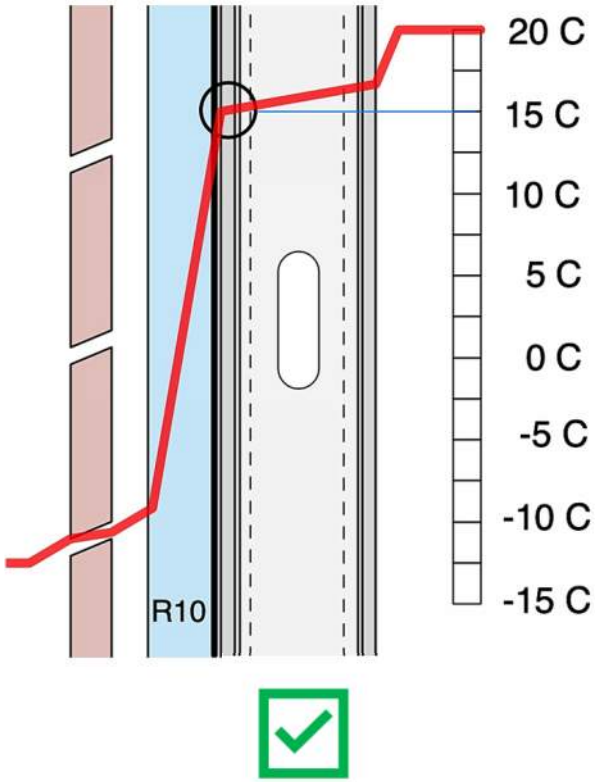


Where to insulate?

Split-insulation is often a good compromise. **NOT IN POOLS**







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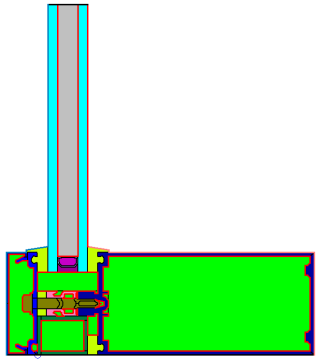
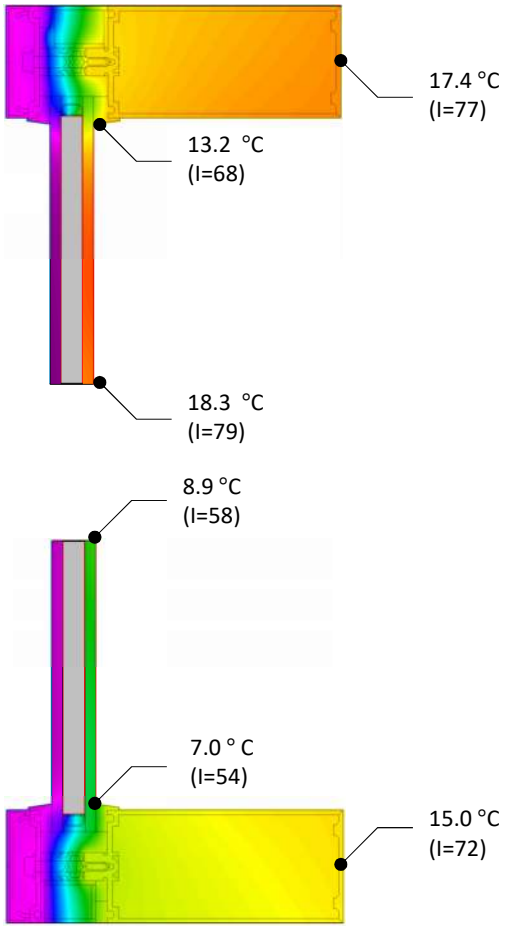
Thermal Control

- Directing airflow over the interior surface of a window will increase surface temperatures
- Example is a Kawneer 1600 UT with a Ug-1.4 W/m^{2}K



Natural Convection
(Standard NFRC)



Note: Boundary Conditions 28 °C (82.4 ° F) and -18 °C (-0.4 ° F), NFRC h_c = 3.0 W/m^{2}K, 1 m/s h_c = 8.0 W/m^{2}K

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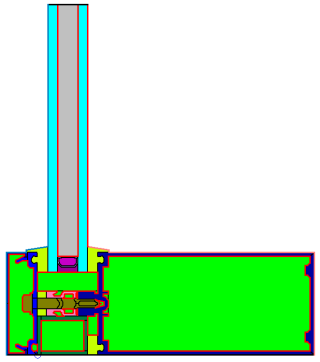

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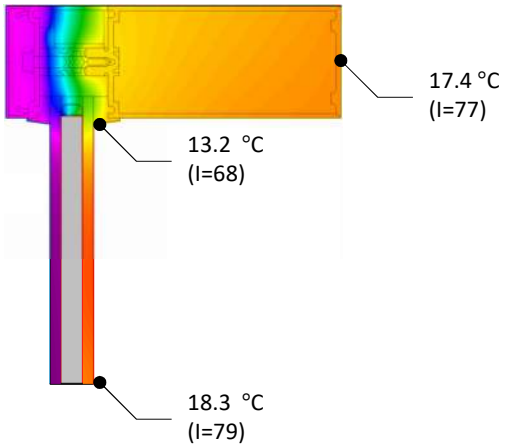
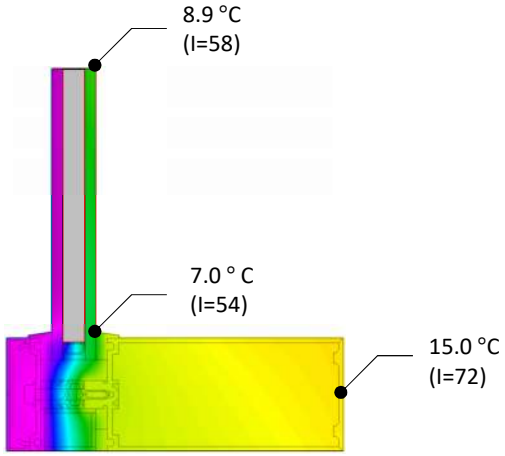
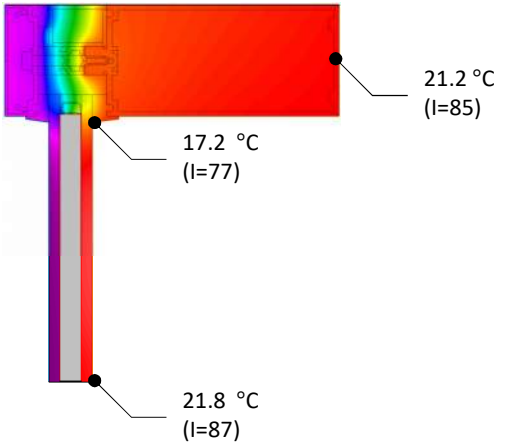
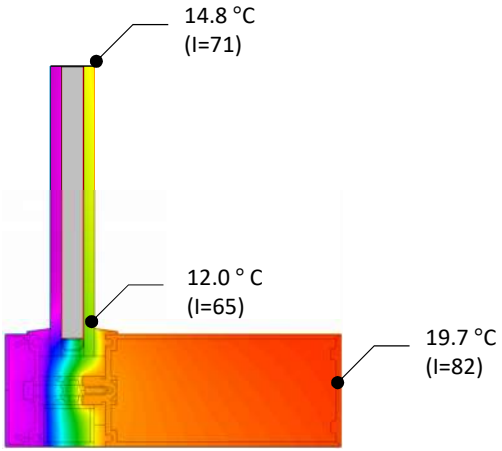




Forced Convection
(1 m/s)





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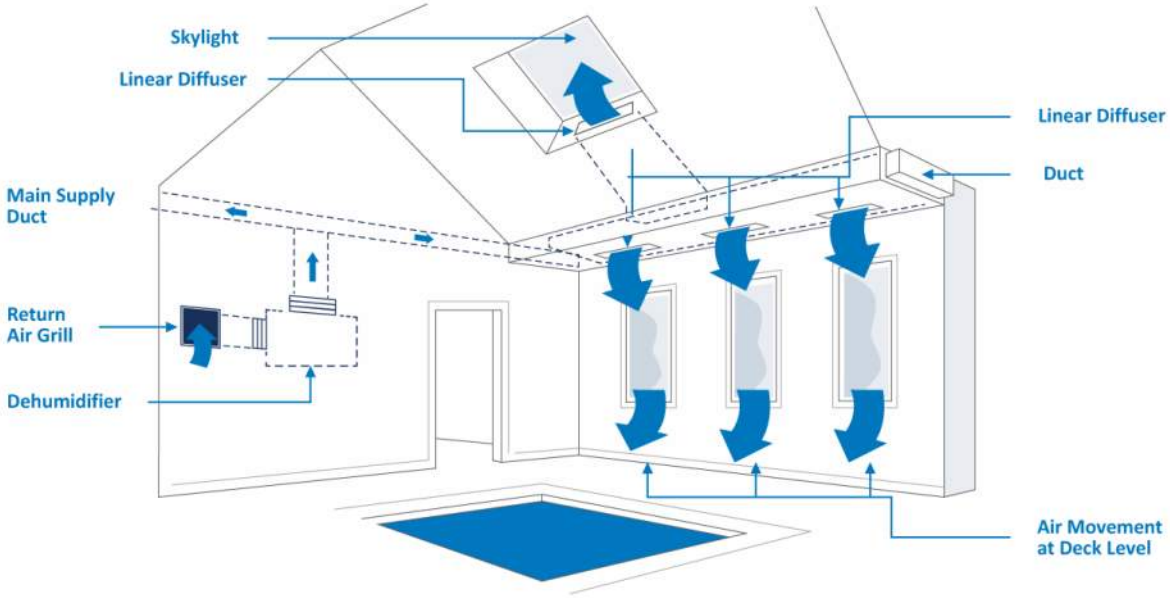
HVAC

- An indoor swimming pool's HVAC system must:
    - Distribute conditioned air in all the right places (e.g., at windows)
    - Condition the entire space,
    - Maintain the natatorium negatively pressurized (10 Pa – 15 Pa)
    - Circulate the entire room's air volume 4-6 times per hour,
    - Remove chloramine contamination.



The result?

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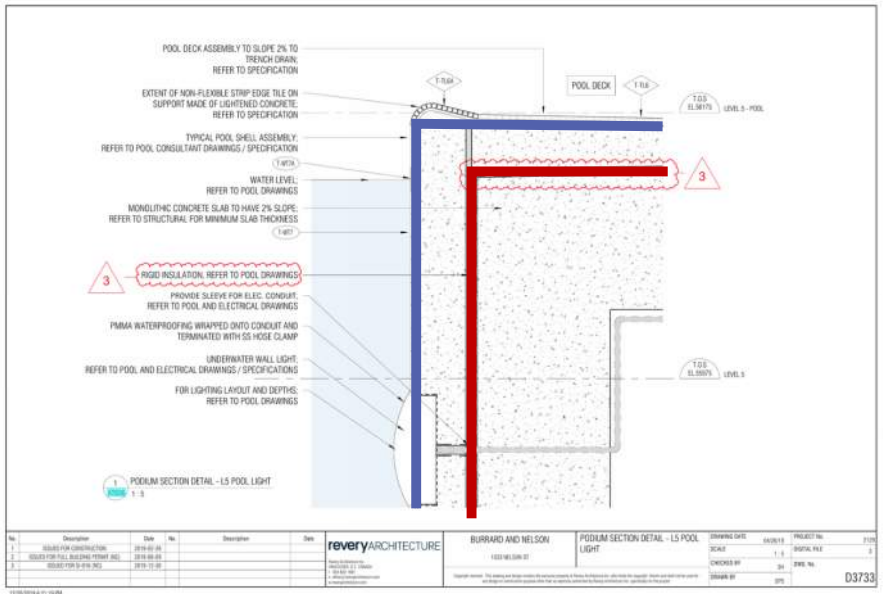
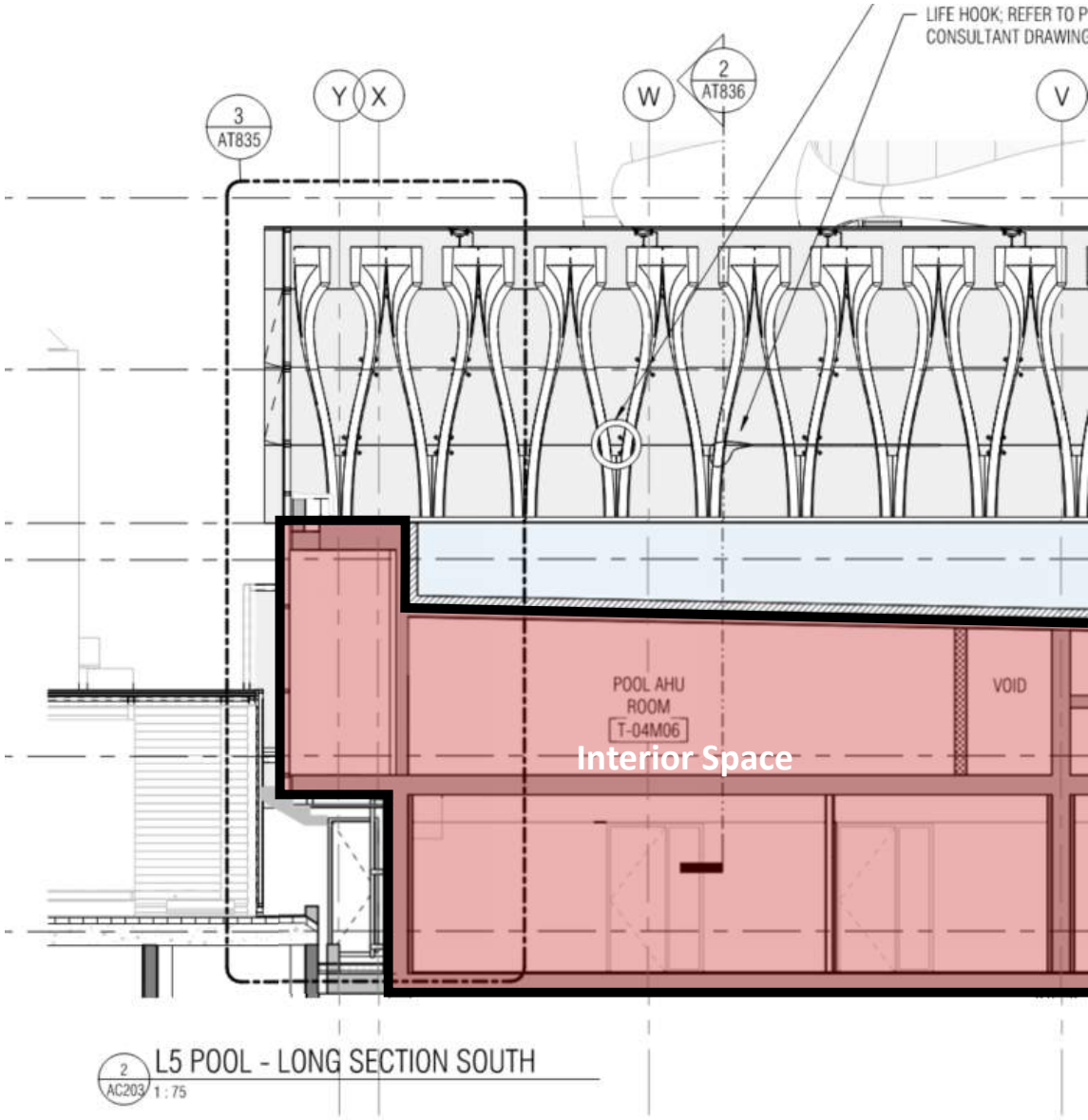
lortnoC retaW (Water Control)

- Water on the inside!
- Pool liner/membrane keeps water in the pool
- Gutters pick up and drain pool deck water independent of the roof
- **Roof** assembly below the pool
- Incorporate **leak detection** in roof drains





Material Selection

Vapour Barrier

- Fully adhered and primed
  - Recall ΔP > 1 kPa
- Correctly located

Vapour Permeable

- Avoid double vapour barriers when selecting finishes (e.g., paints)
- Allow for drying

Moisture Tolerant

- Use materials which can get wet (e.g., tile, concrete, etc.,)

Chemically Tolerant

- Additional chemicals in the pool atmosphere can attack otherwise “stainless” materials

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The Do's & Don'ts of pool design

Do

- Select exterior insulated rainscreen assemblies **(Insulate)**
- Minimize glazing area **(Small windows)**
- Deliver supply air around the full perimeter of the building enclosure **(Big Ducts)**
- Negatively pressurize the pool area relative to adjacent rooms/exterior
- Treat the pool as a roof when over living space with membrane, drainage, and leak detection

Don't

- Use moisture sensitive materials
- Build with 100% glass

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When stainless-steel isn’t stainless

New (8-month) hardware in pool environment poor condition

Original 30+ year old handrails, good condition

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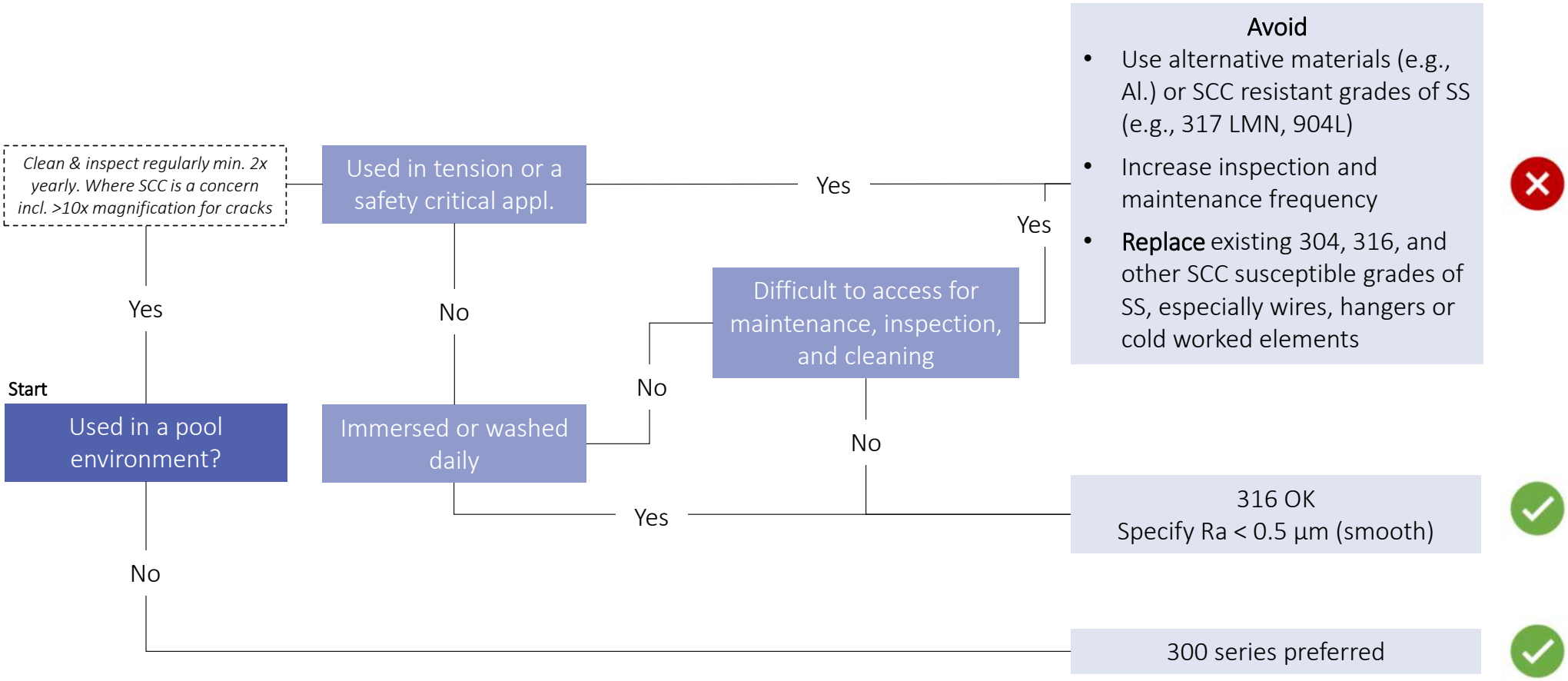
Stress Corrosion Cracking (Stainless-steel)



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Ref: Nickle Institute, "Guidelines for Corrosion Prevention", 2014

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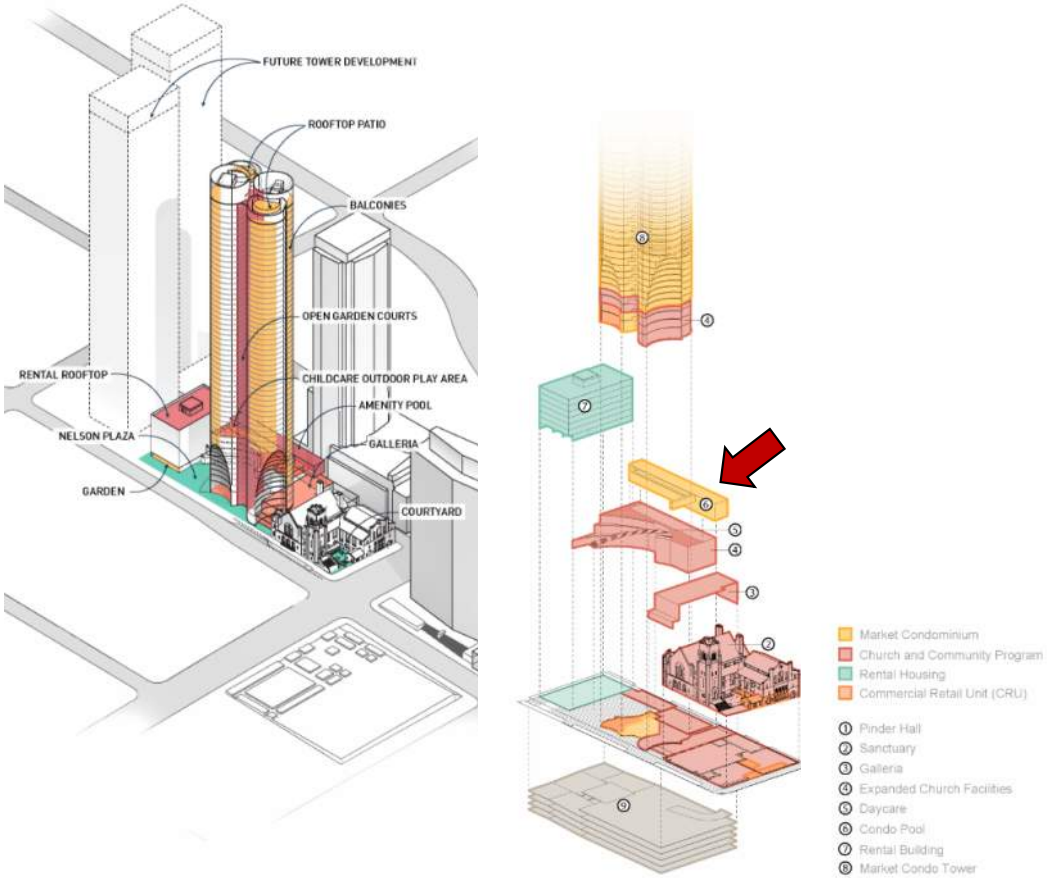
The Butterfly (FBC)



Exploded isometric project plan courtesy of Revery Architecture

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Rendering courtesy of Revery Architecture

The Butterfly (FBC)

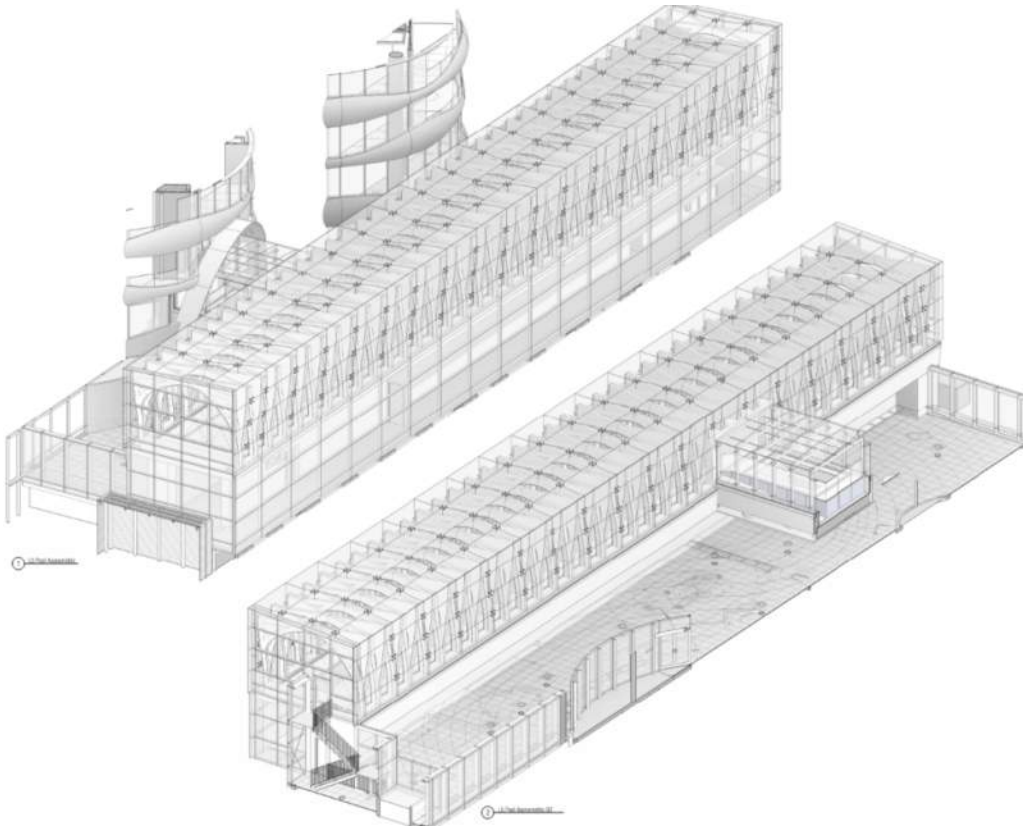
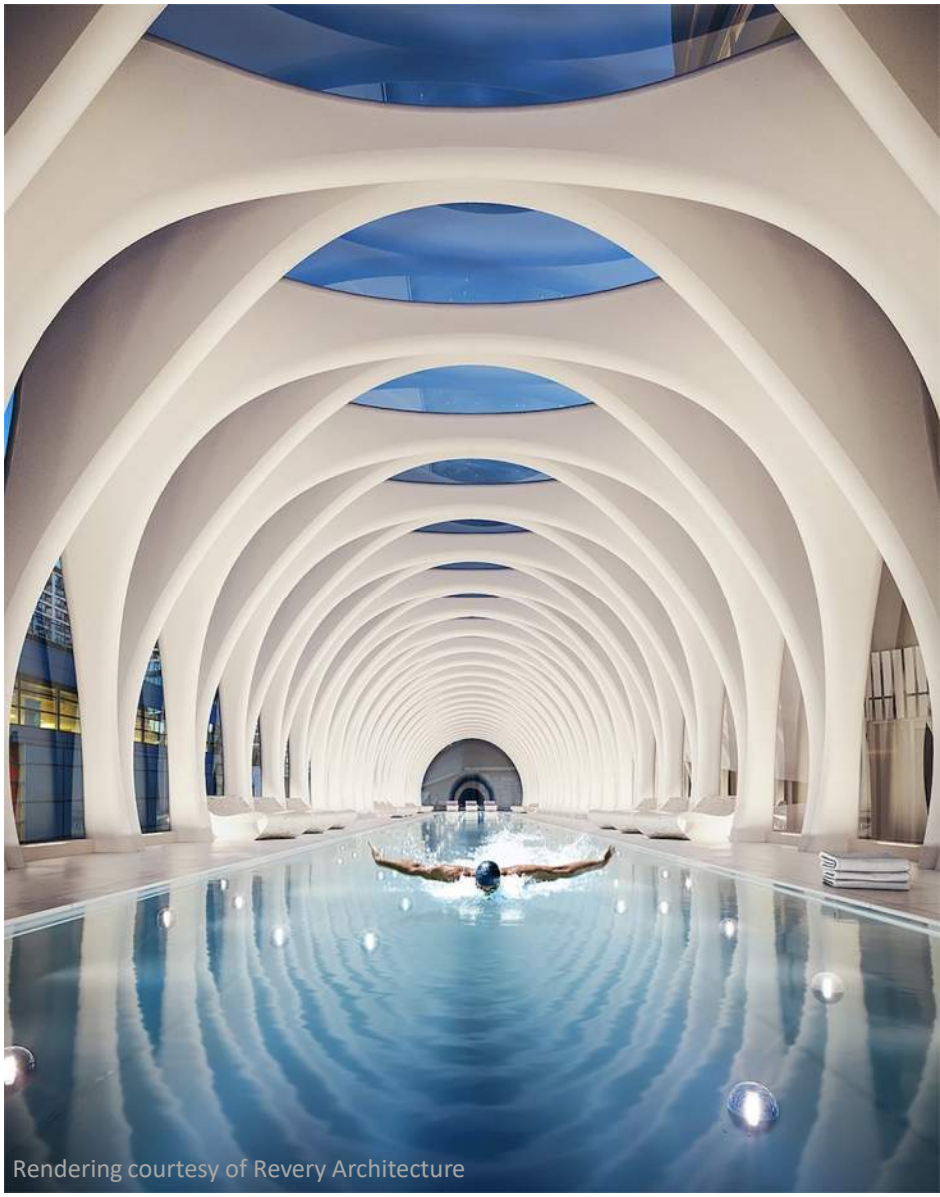


Figure: 3D Isometric view of the L5 Amenity Pool, AT830 (Revery Architecture)



Rendering courtesy of Revery Architecture

The Butterfly (FBC)

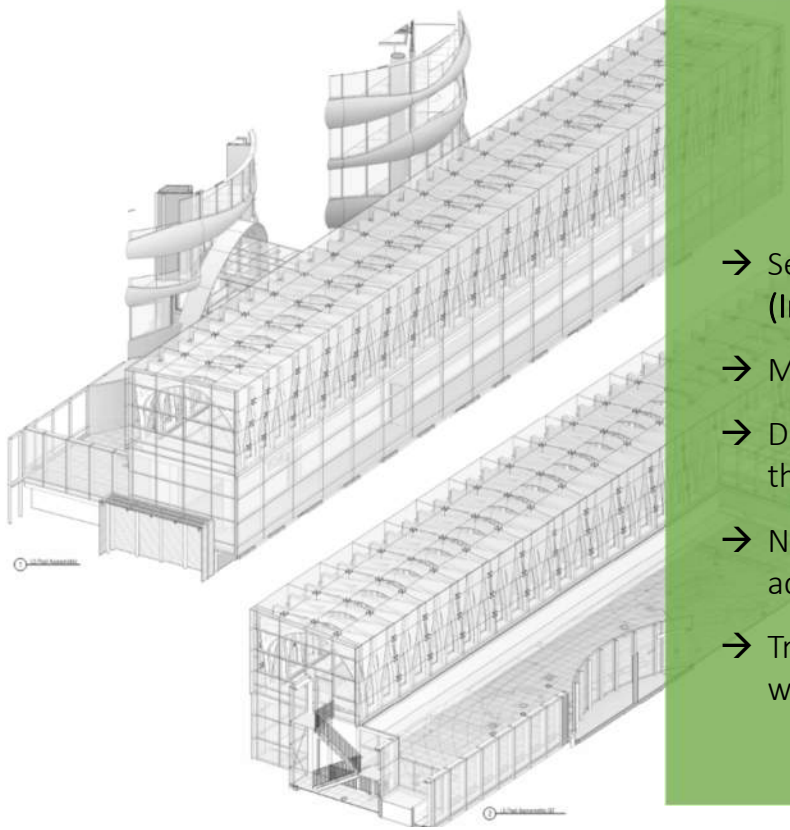
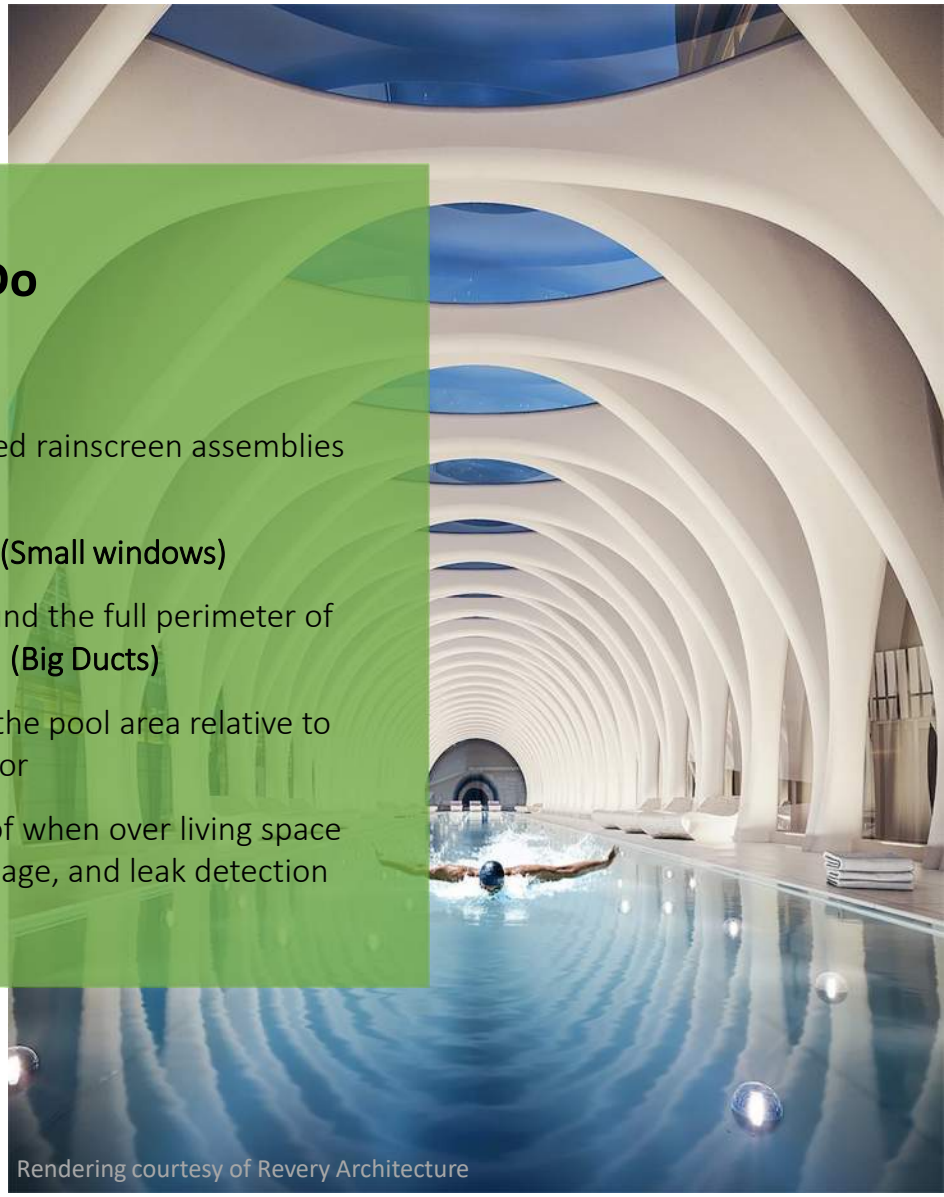


Figure: 3D Isometric view of the L5 Amenity Pool, AT830 (Revery Architecture)

Do

- → Select exterior insulated rainscreen assemblies **(Insulate)**
- → Minimize glazing area **(Small windows)**
- → Deliver supply air around the full perimeter of the building enclosure **(Big Ducts)**
- → Negatively pressurize the pool area relative to adjacent rooms/exterior
- → Treat the pool as a roof when over living space with membrane, drainage, and leak detection



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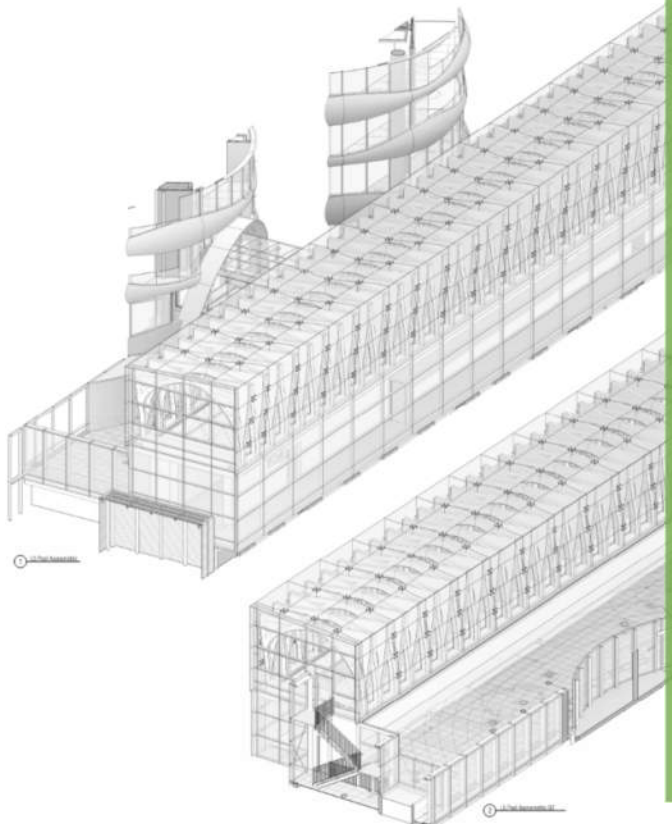
The Butterfly (FBC)



Do

No opaque assemblies

→ 100% Glass

- → Select exterior insulated rainscreen assemblies ~~(Insulate)~~
- → Minimize glazing area ~~(Small windows)~~
- → Deliver supply air around the full perimeter of the building enclosure ~~(Big Ducts)~~
- → Negatively pressurize the pool area relative to adjacent rooms/exterior

No visible ducts

- → Treat the pool as a roof when over living space with membrane, drainage, and leak detection

Rendering courtesy of Revery Architecture

Figure: 3D Isometric view of the L5 Amenity Pool, AT830 (Revery Architecture)

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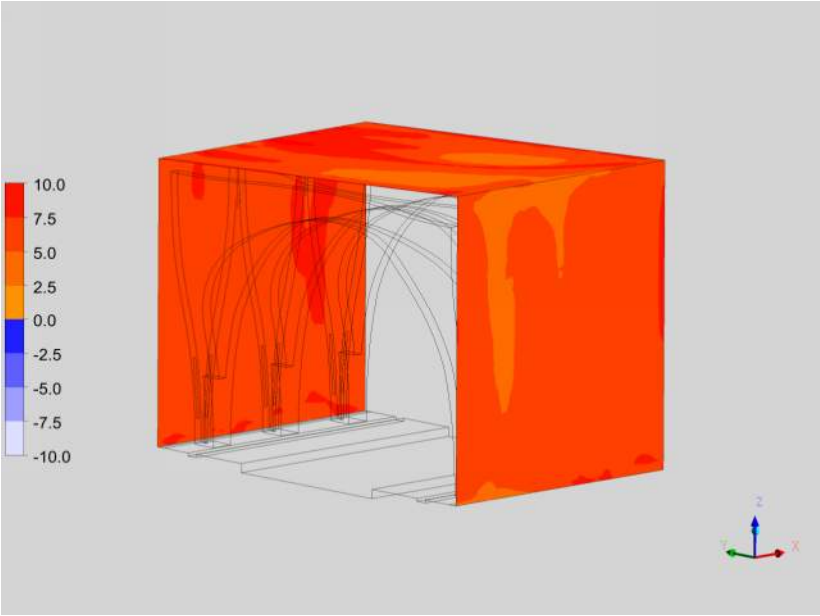
“Elevated” Condensation Risk

Natural Convection
(No Ducts)



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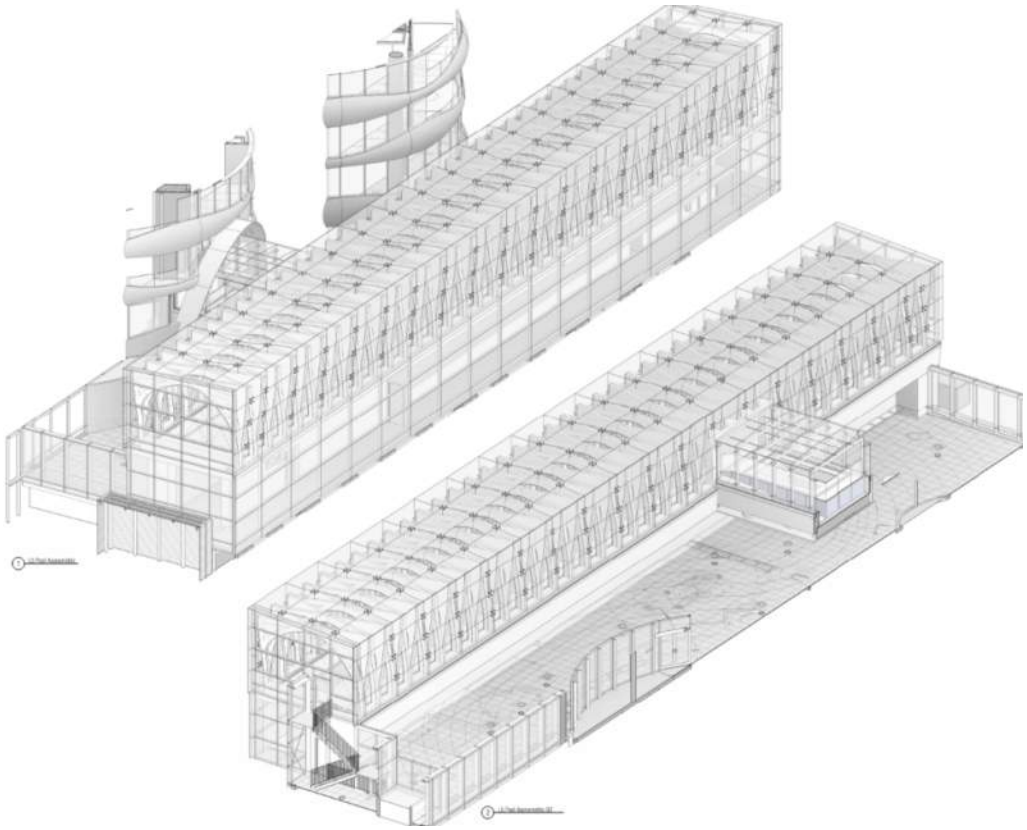
The Butterfly (FBC)



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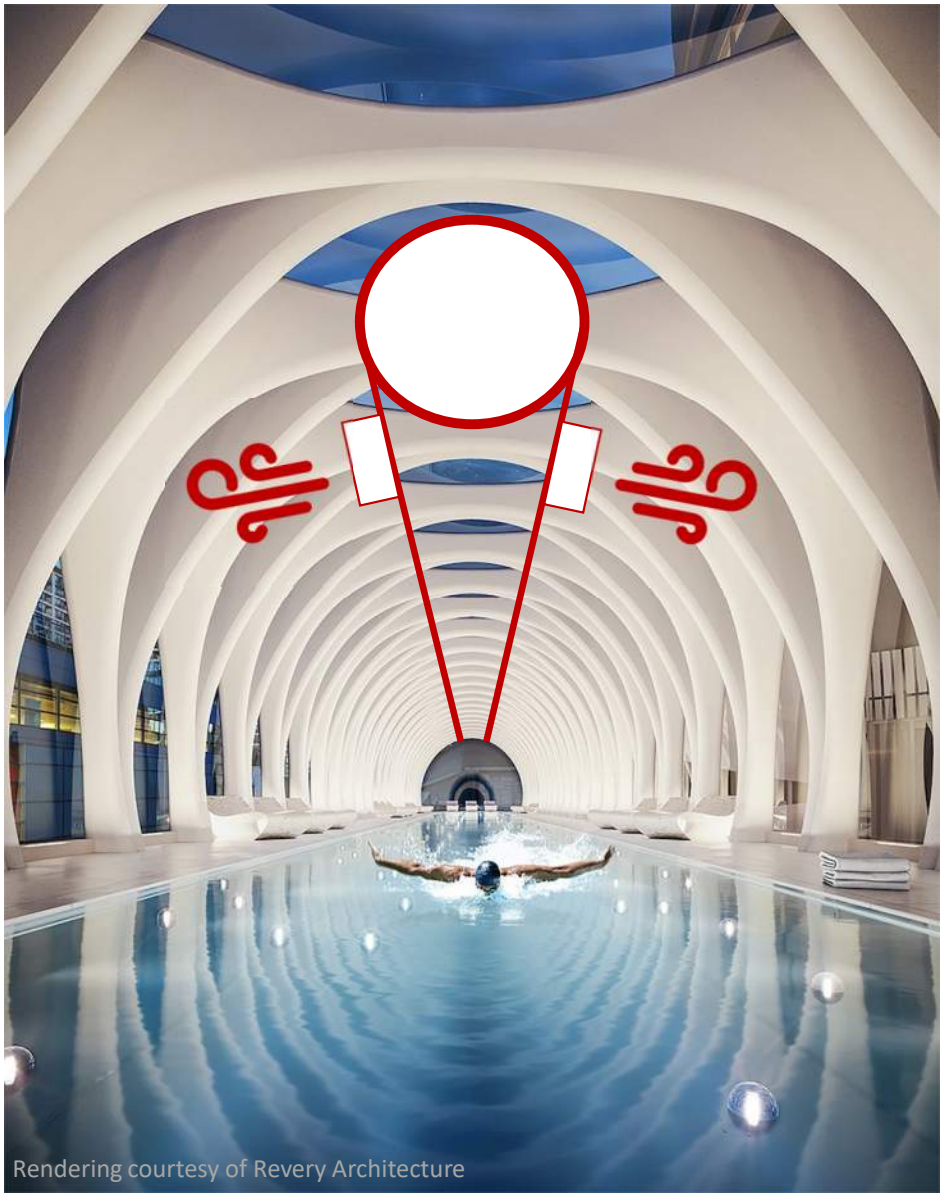

The Solution(s)

High-performance Triple-glazing

Concealed ductwork

Fans

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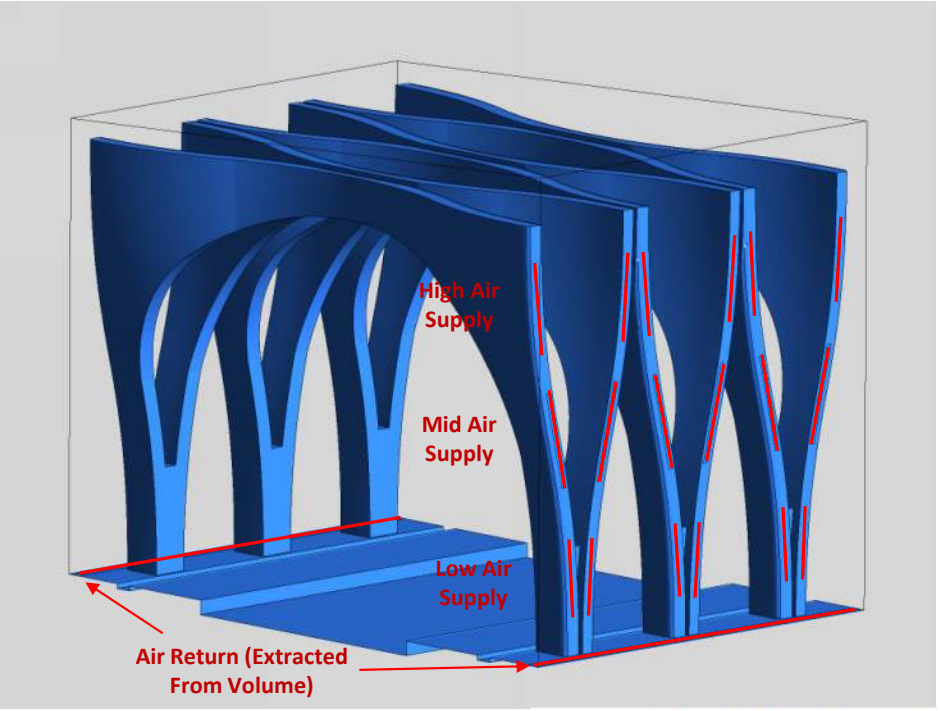
Overview

The Butterfly, L5 Amenity Pool

	Parameter	Values	Units
	Location	Vancouver, BC	
T_{ext}	Exterior temperature	-7	°C
	Water temperature, Pool	30	°C
	Water temperature, Hot Tub	37	°C
	Evaporation Rate, Pool	0.342	kg/(m^{2}hr)
	Evaporation Rate, Hot Tub	0.691	kg/(m^{2}hr)
	Supply location (above floor)	1.1, 2.5, 3.8	m
T_{sup}	Supply temperature	28, 38	°C
HR_{sup}	Supply humidity Ratio	2.9	g/kg$_{da}$
Q_{sup}	Supply flow (total)	3210 (6800)	L/s (cfm)
U_{Win}	U-value of glazing (Triple)	1.65 (0.29)	W/m^{2}K
U_{Sky}	U-value of skylight (Triple)	2.27 (0.40)	W/m^{2}K
	Fan Number	0, 8	
	Fan Blowing Direction	Up/Down	

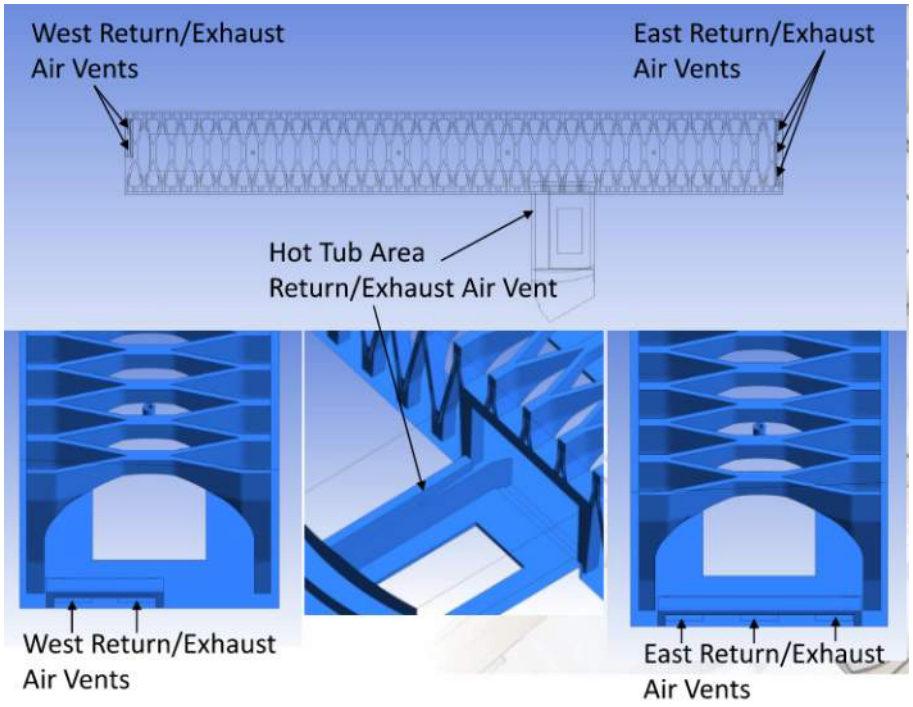


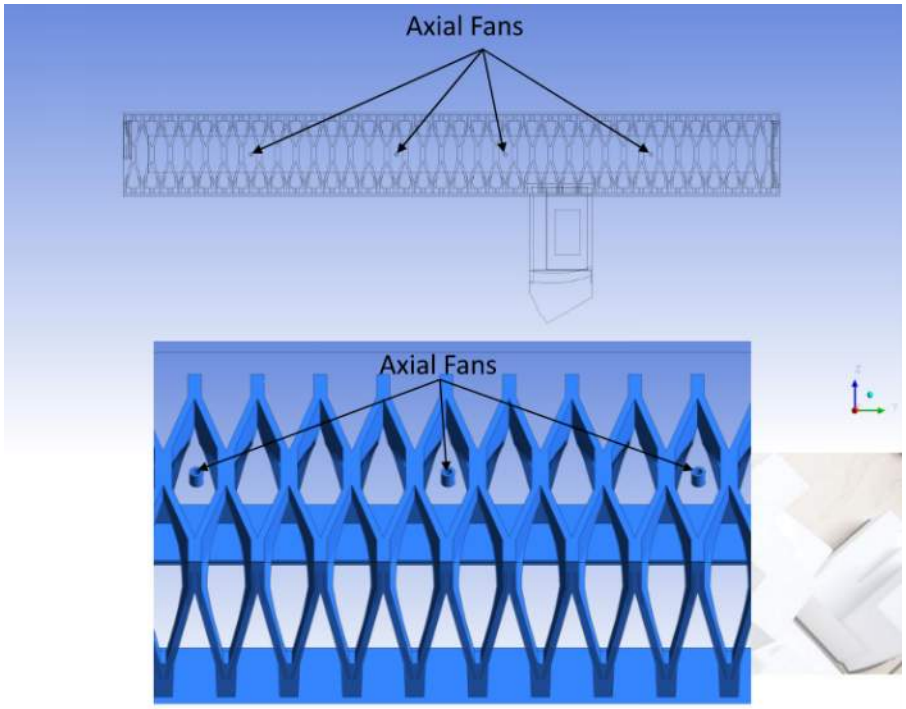
GRADIENTWIND
ENGINEERS & SCIENTISTS

1. Rzeźnik, I, *"Study on Water Evaporation Rate From Indoor Swimming Pools"*, ASEE17, 2017

Overview

The Butterfly, L5 Amenity Pool





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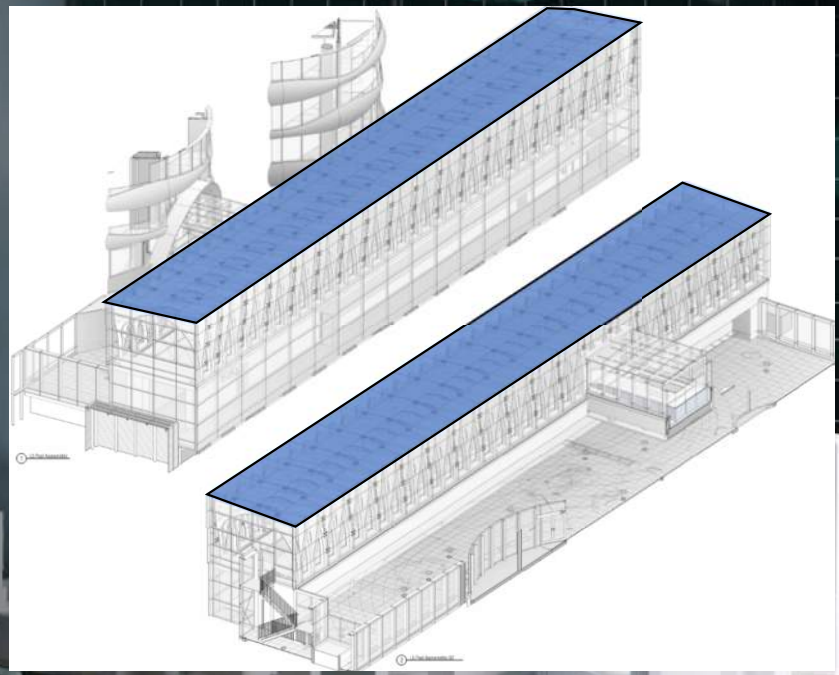
Condensation on Ceiling



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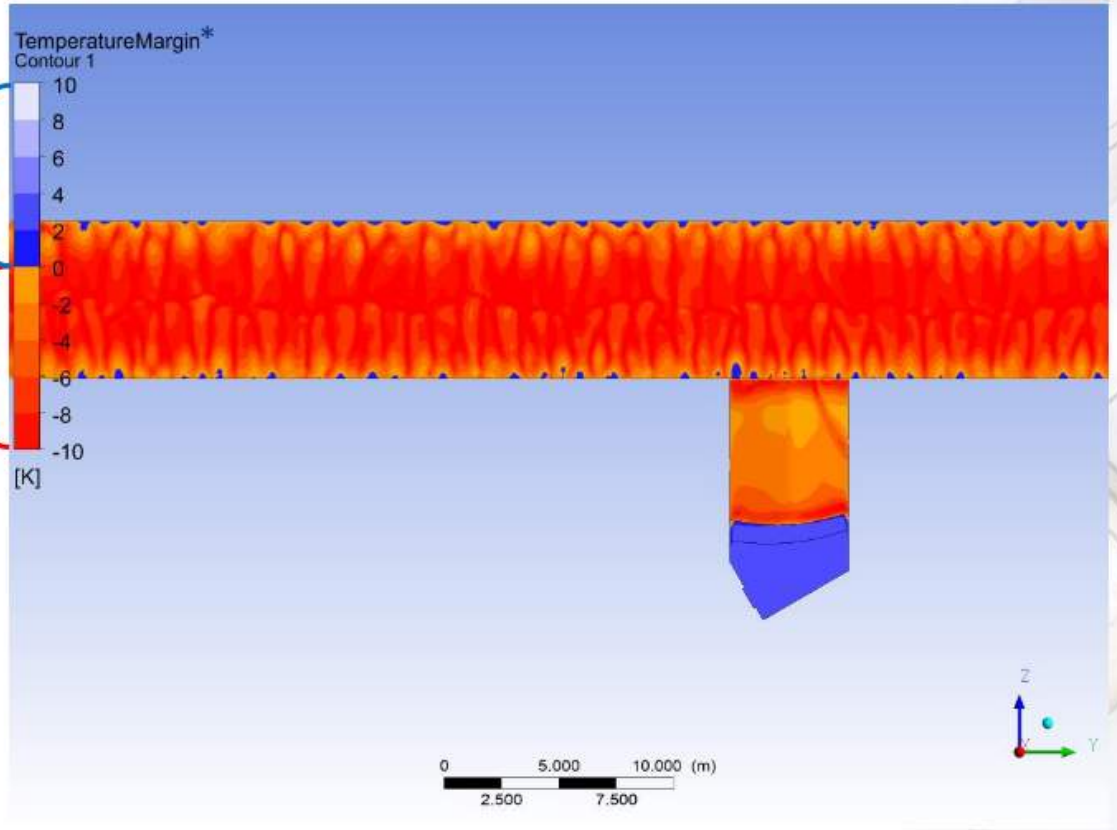
CONDENSATION STUDY: Set Point 1, Fans Off

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



*Temperature Margin measures the temperature change required to reach 90% RH in °C

TM = Temperature – $\text{Temperature}_{90\%RH}$

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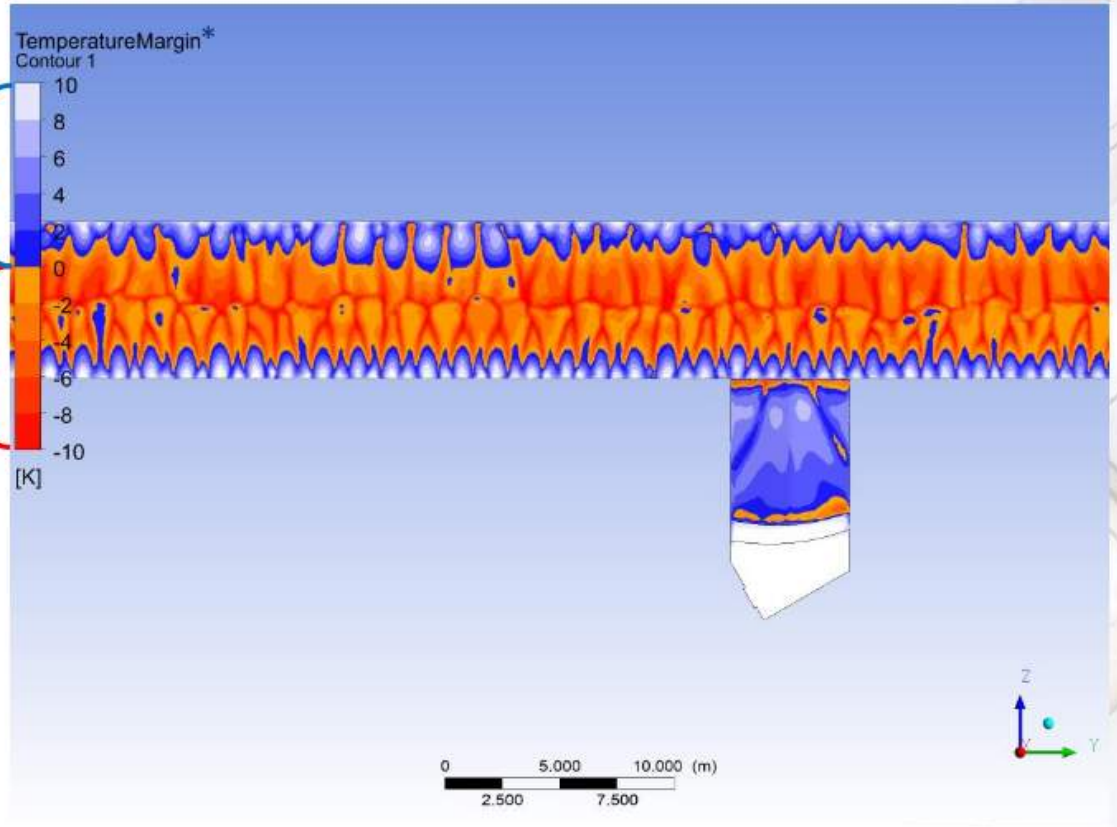
CONDENSATION STUDY: Set Point 2, Fans Off

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



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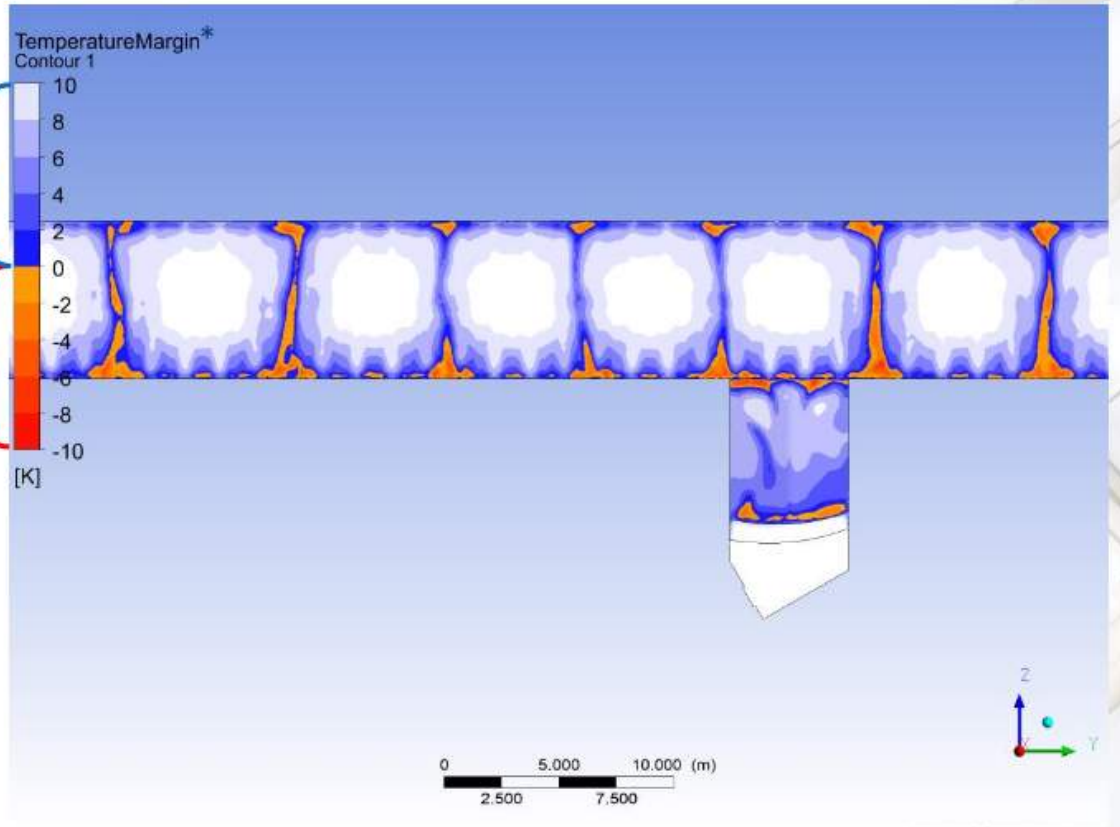
CONDENSATION STUDY: Set Point 2, Fans Upward, 8 Fans, Supply ¼ and 4/5

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



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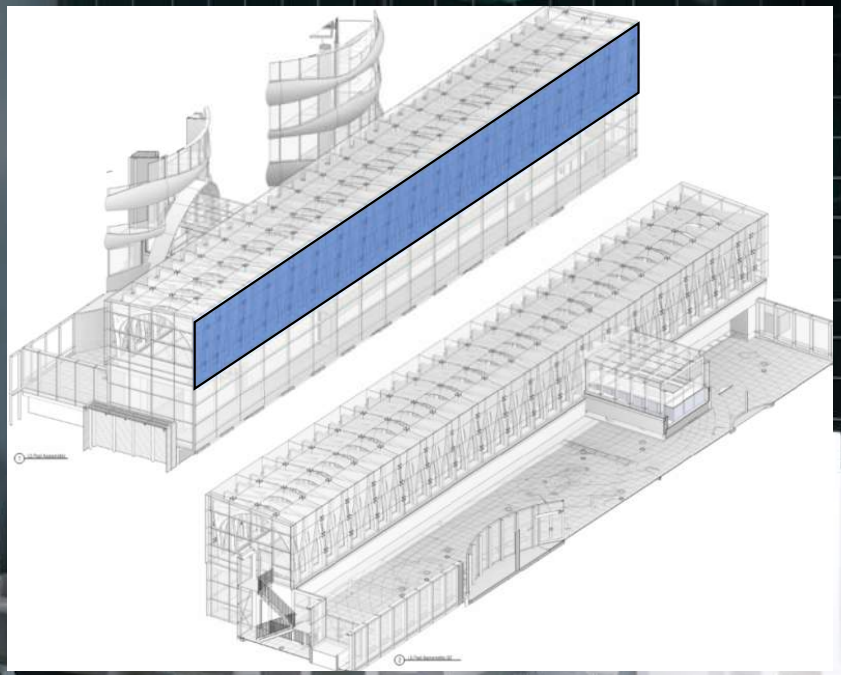
Condensation on North Wall



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CONDENSATION STUDY: Set Point 1, Fans Off

The Butterfly, Pool Building

No Condensation Expected

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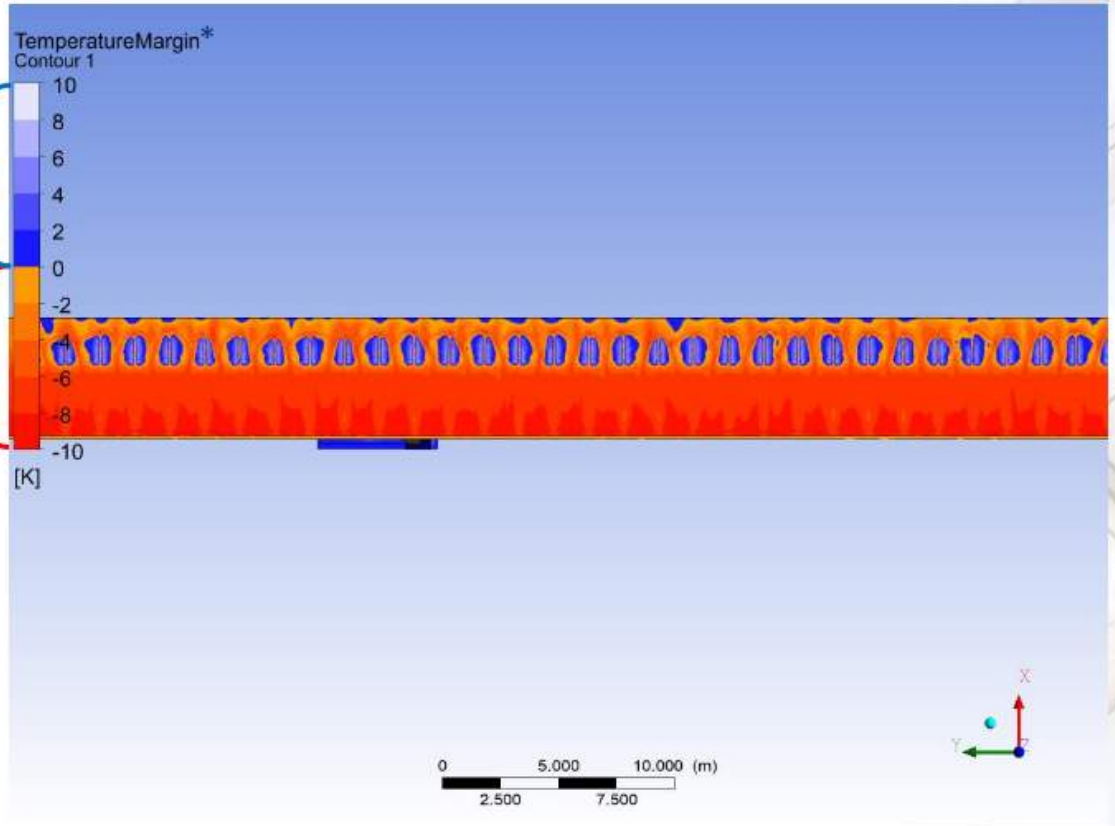

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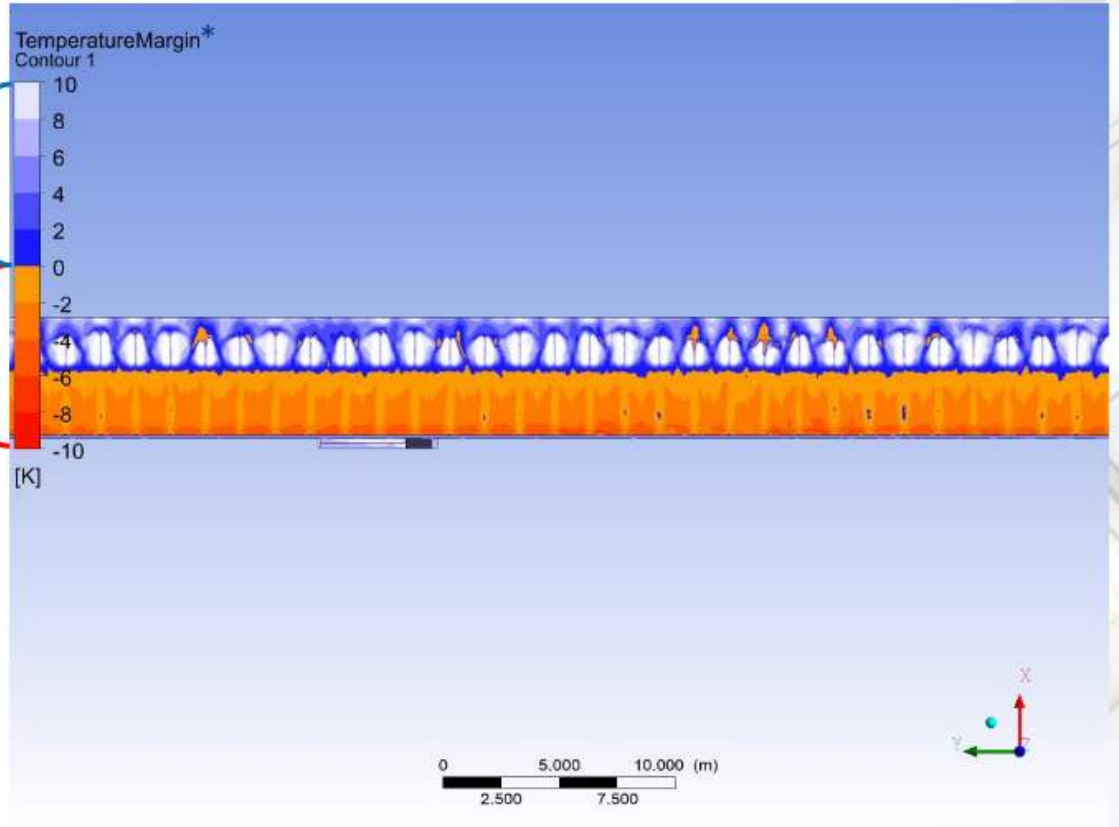
CONDENSATION STUDY: Set Point 2, Fans Off

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



*Temperature Margin measures the temperature change required to reach 90% RH in °C

TM = Temperature – $\text{Temperature}_{90\%RH}$

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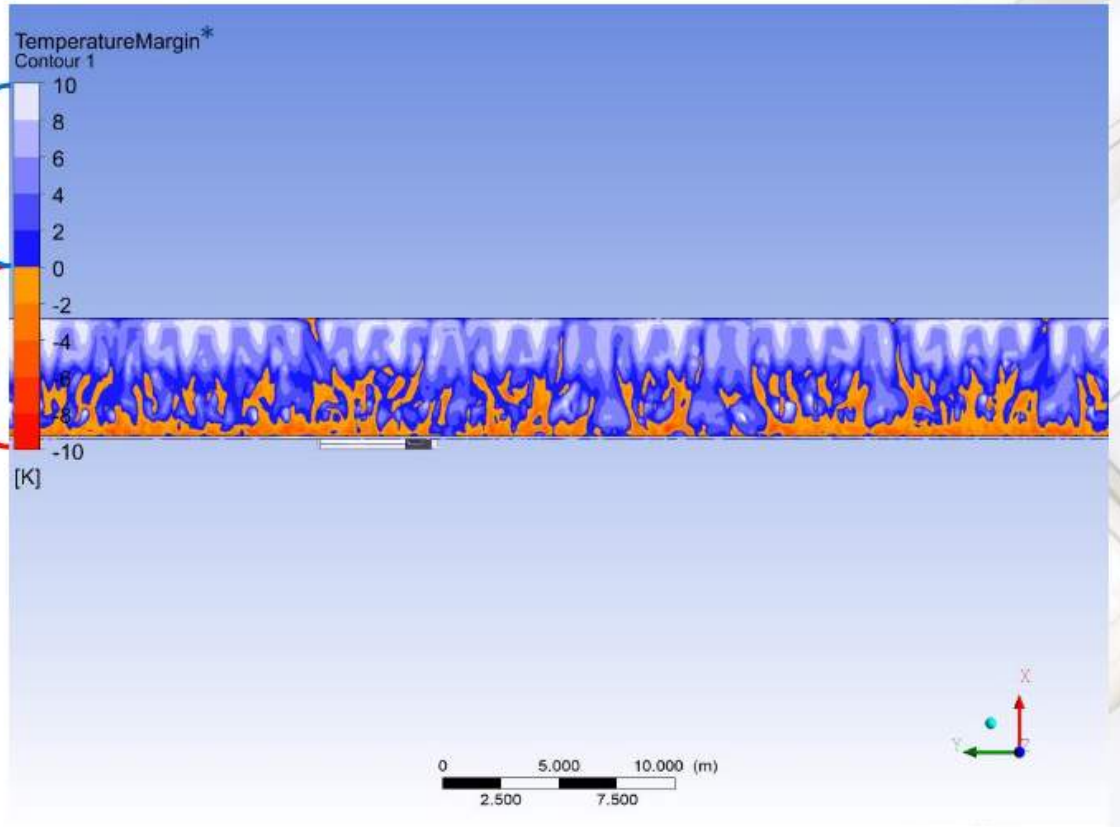
CONDENSATION STUDY: Set Point 2, Fans Upward, 8 Fans, Supply ¼ and 4/5

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



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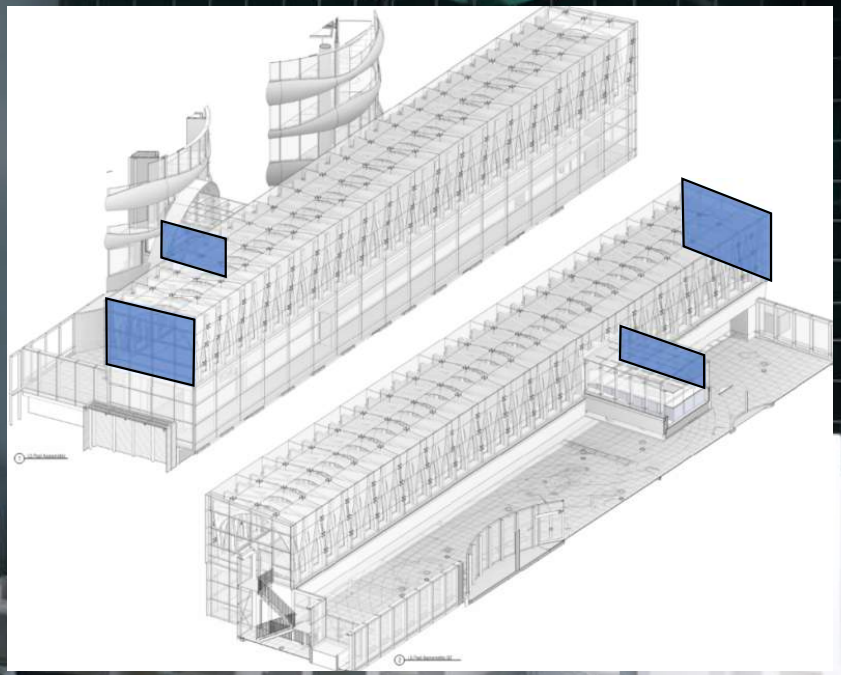
Condensation on East Wall



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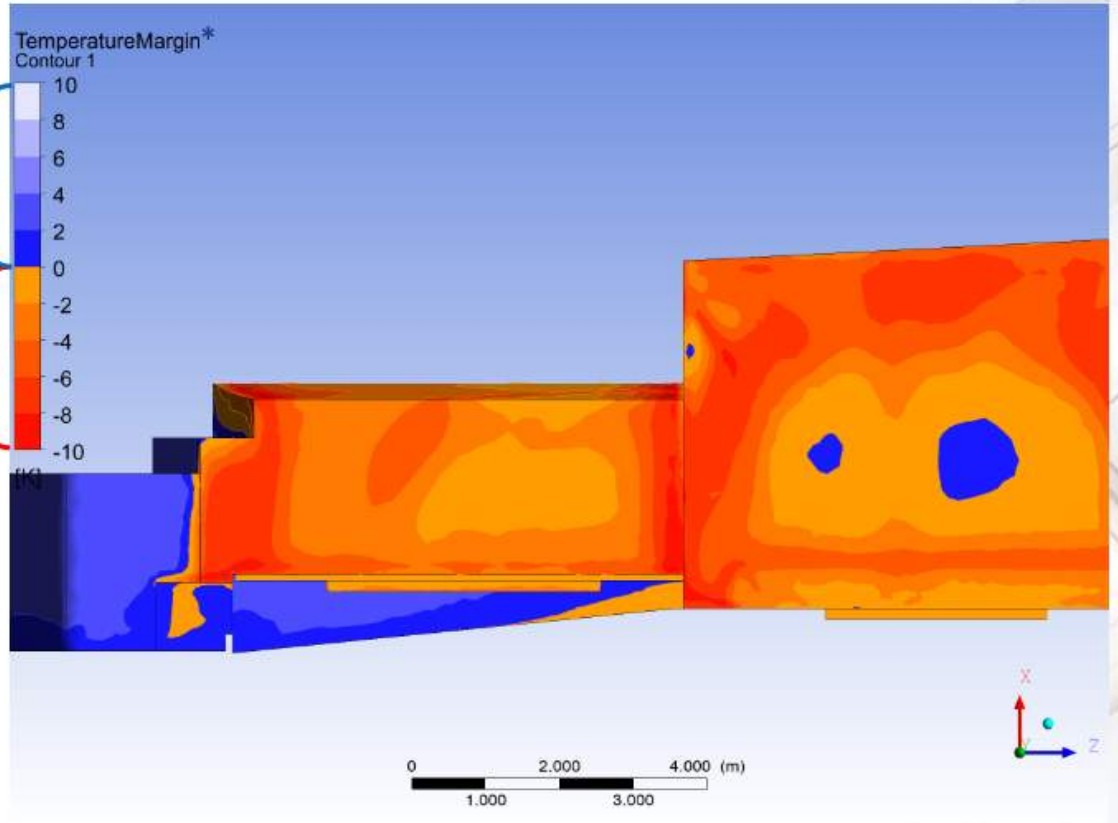
CONDENSATION STUDY: Set Point 1, Fans Off

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



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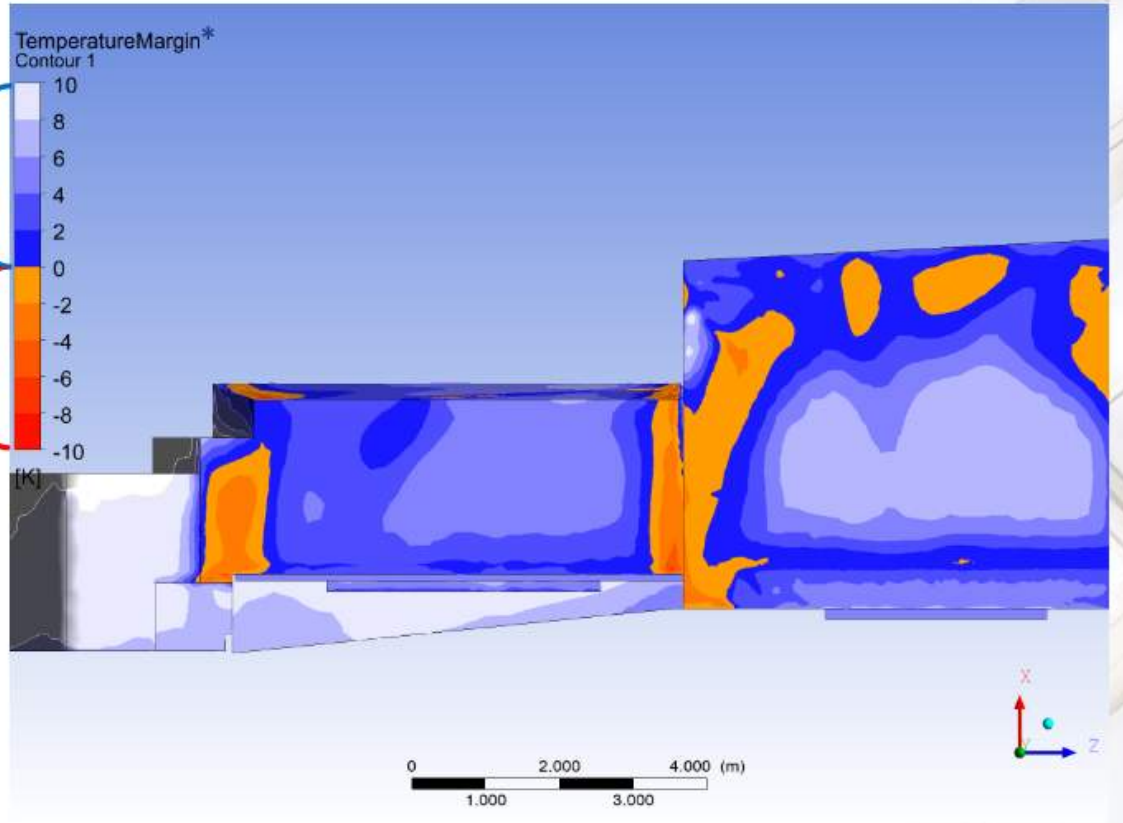
CONDENSATION STUDY: Set Point 2, Fans Off

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



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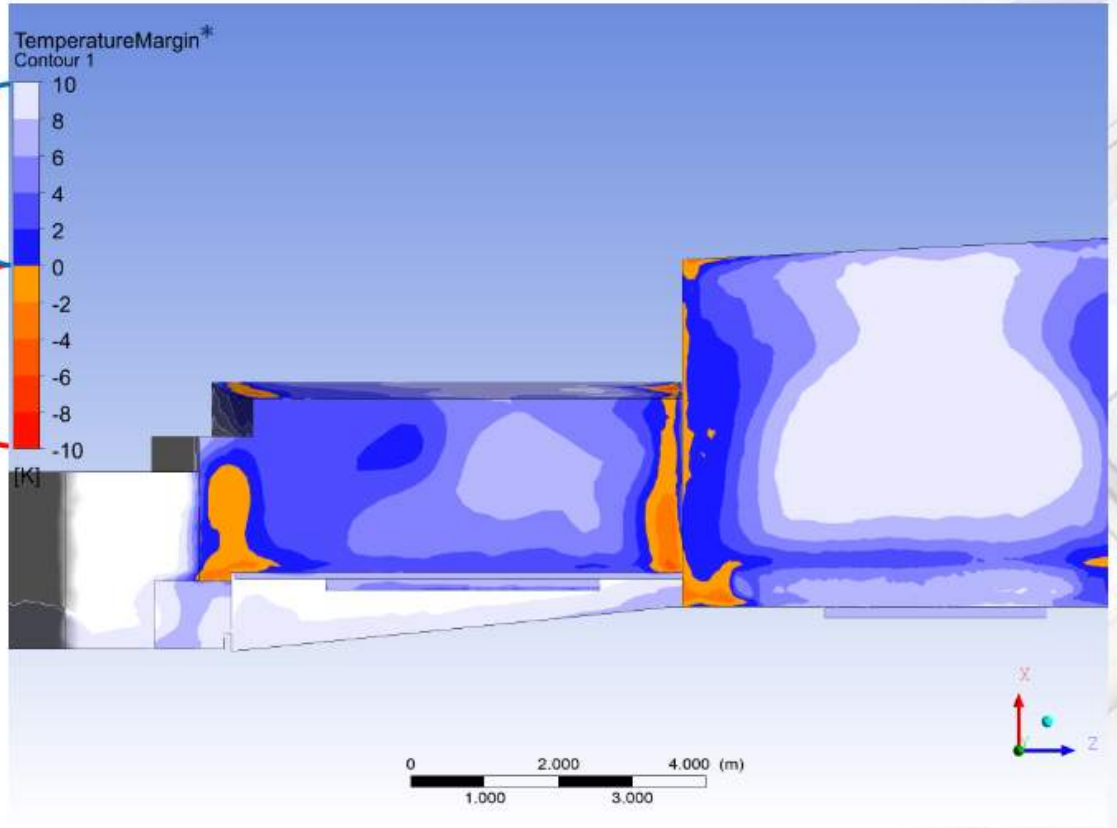
CONDENSATION STUDY: Set Point 2, Fans Upward, 8 Fans, Supply ¼ and 4/5

The Butterfly, Pool Building

No Condensation Expected

Condensation Expected



*Temperature Margin measures the temperature change required to reach 90% RH in °C

TM = Temperature – $\text{Temperature}_{90\%RH}$

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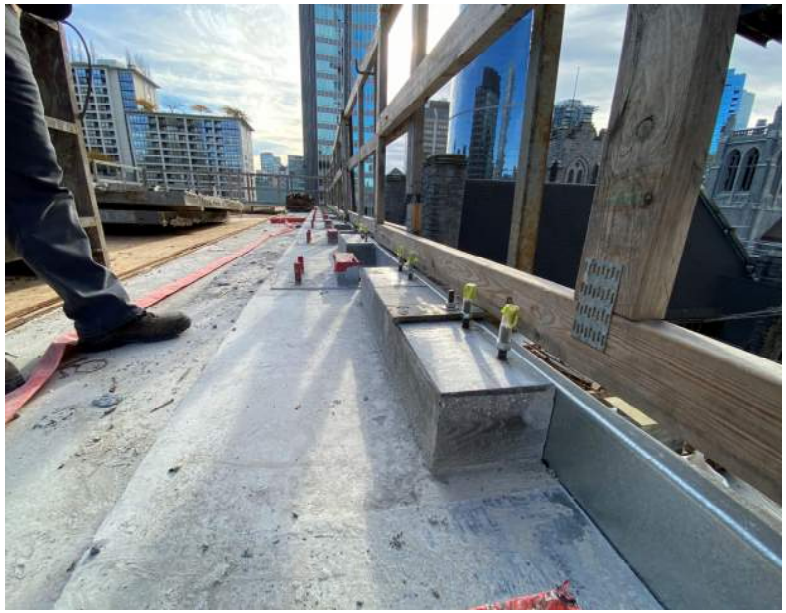
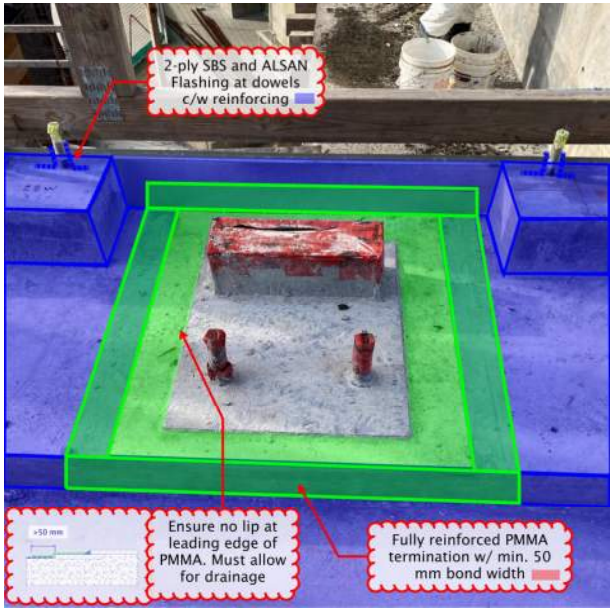
Structural/Mechanical Penetrations



HDG Embeds w/ stepped plate

Bolts fully welded and duct extension raises connection above the plane of drainage



Fully reinforced liquid membrane completes the termination

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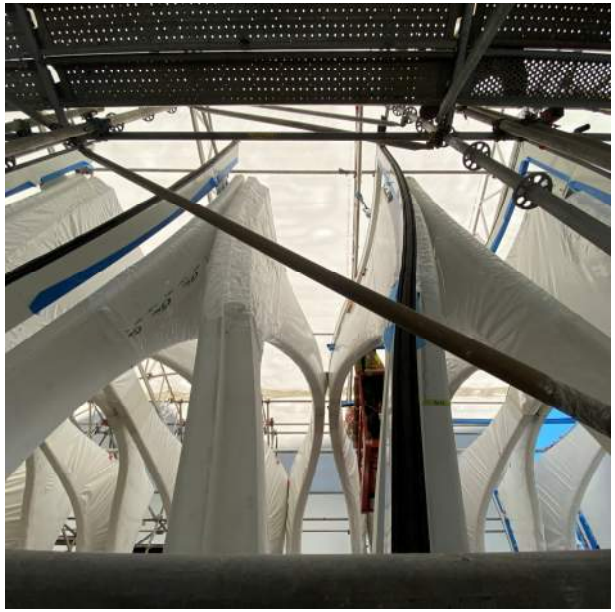
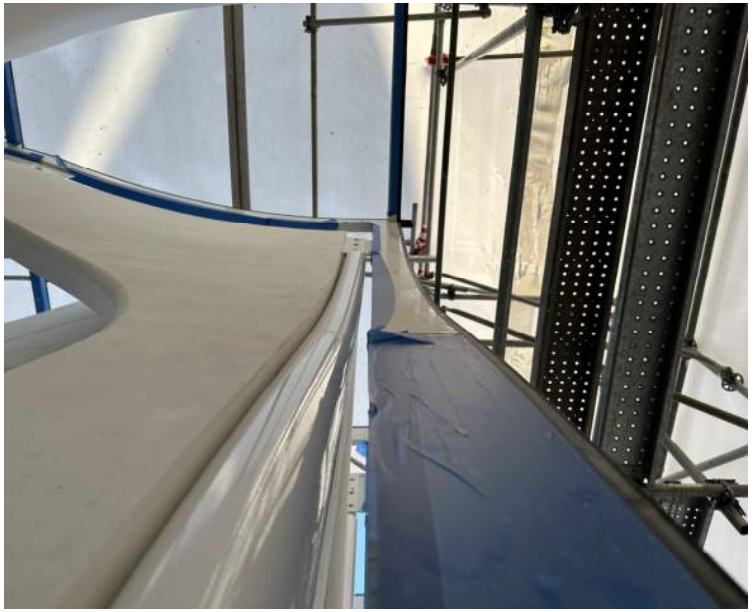
Mechanical Penetrations (cont.)

HDG duct adapter set in sealant





Curved HDG steel ducts run along a curved recess in the precast

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Mechanical Penetrations (cont.)

Diffusers located based on CFD

Steel duct set in sealant and sealed to HDG duct extension

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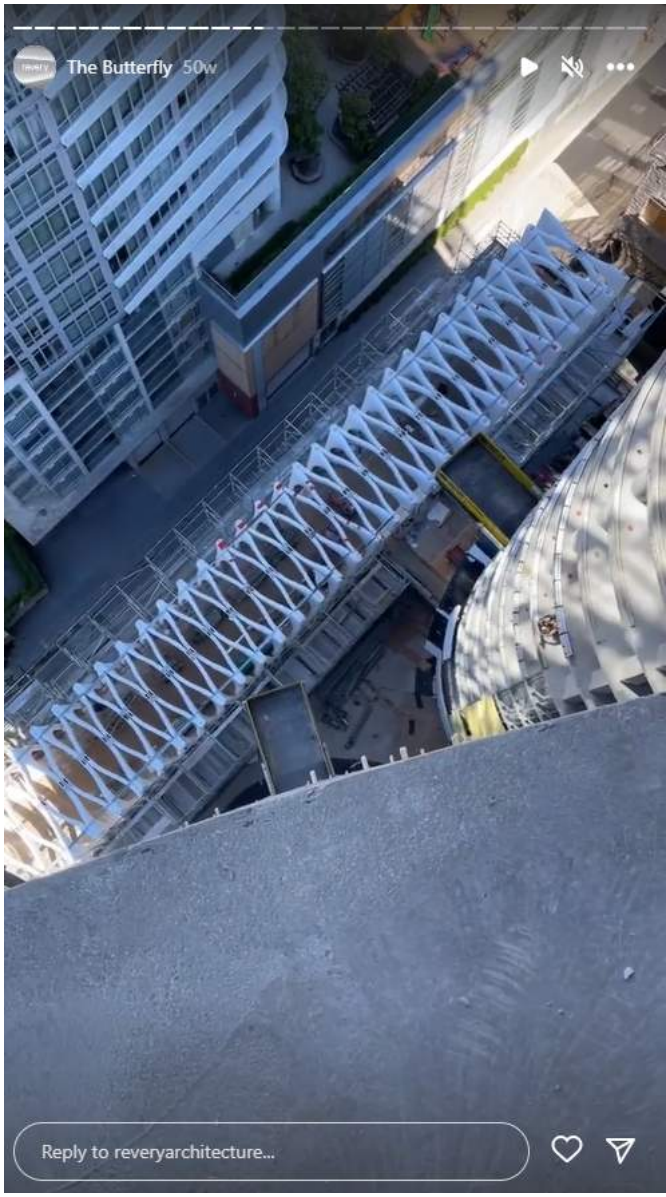
The Solution

- High-performance triple-glazing U < 0.20 Btu/ft^2·°F·hr to prevent bulk condensation
- 8 fans spaced evenly along the ceiling and directed upward to avoid stratification
- Concealed vents at each pool rib with diffusers along the length
- Supply temperature 38 °C



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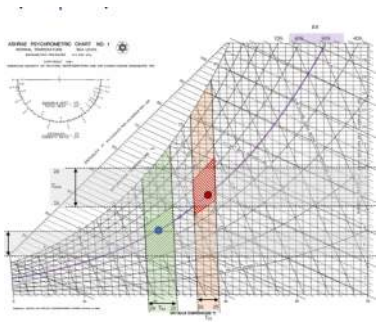
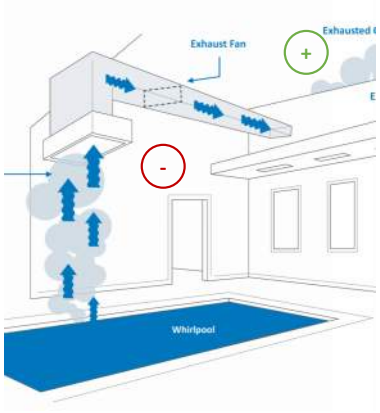
Concluding thoughts

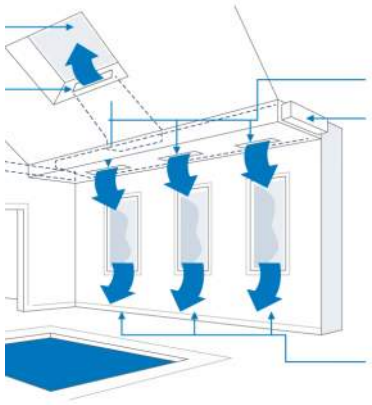


Pool atmospheres contain LOTS! Of moisture

Avoid cool surfaces (ext. insulate, reduce glazing)



Negatively pressurize pool area



Deliver warm/dry air to all windows

Beware of stainless-steel

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A POOL WITH A VIEW

Discussion + Questions

dhaaland@rdh.com

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