TAYLOR'S UNIVERSITY
Wisdom · Integrity · Excellence

Passive Green Building Case Studies Poster & Booklet

Green Strategies for Building Design (ARC61804)

Group 14

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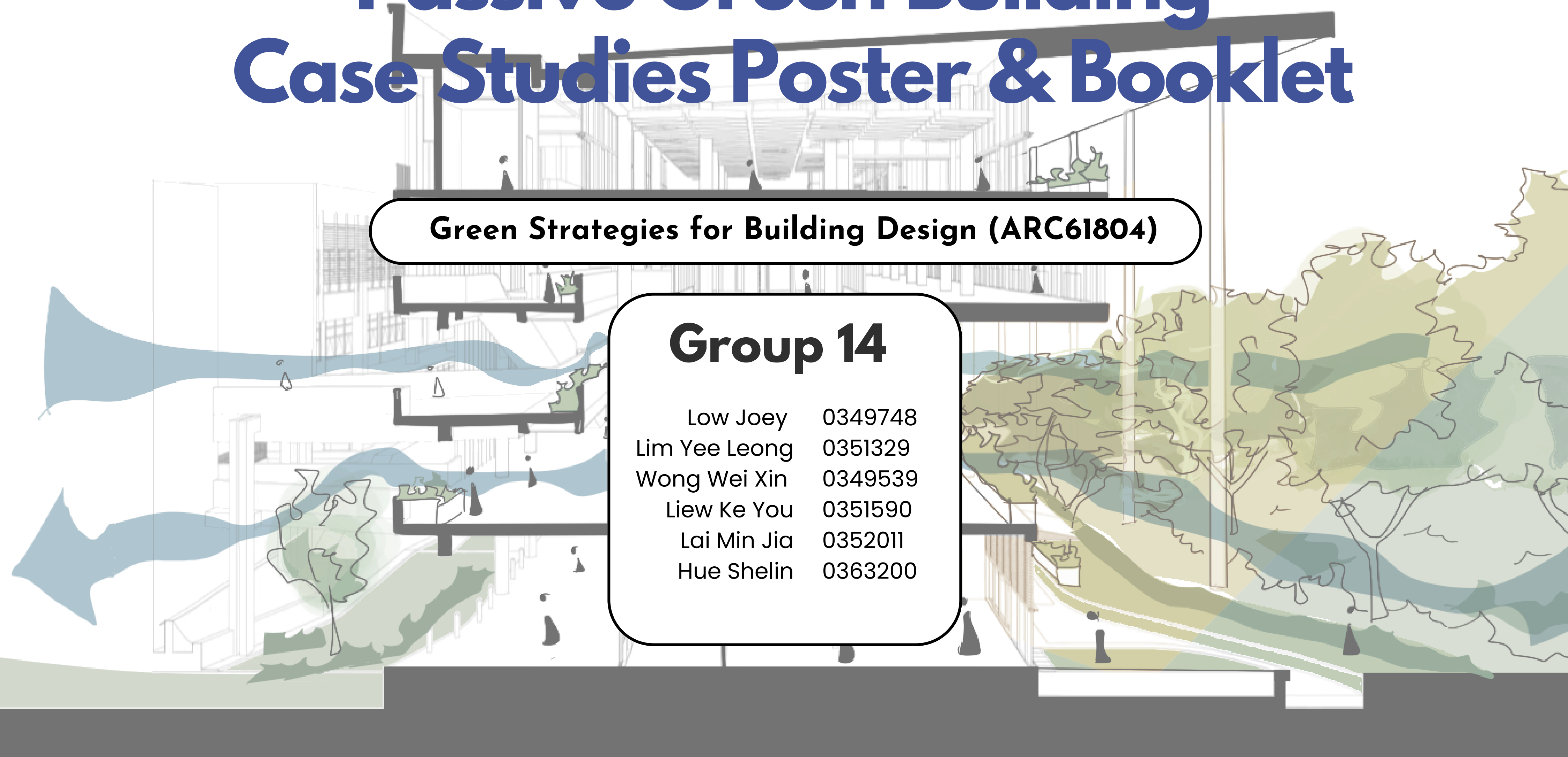

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1.1 NUS SCHOOL OF DESIGN & ENVIRONMENT

Queenstown, Singapore

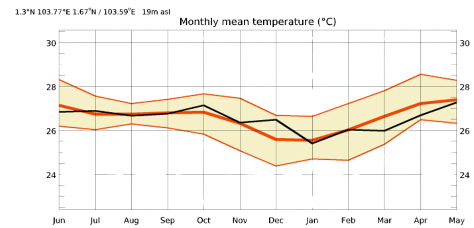
A Net-Zero Building

SDE4 is a academic building designed for interdisciplinary learning in architecture, design, and sustainability at NUS. It is **the first net-zero energy building in Singapore** on this scale.

1.2 Queenstown SITE CONDITION

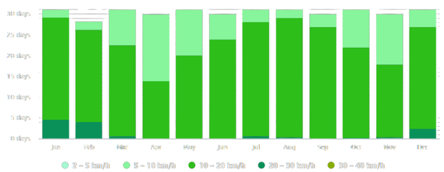
Dense Urban Context & Limited Space

Tropical Temperature



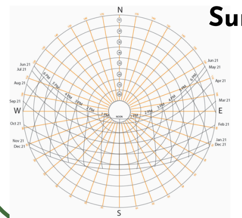
High temperatures (avg. 27–32°C), high humidity (>80%), and year-round heat

Low Wind Speed



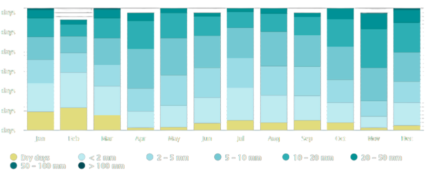
Wind speed is often low (~1–2 m/s), especially with dense surroundings

Intense Solar Radiation (Equatorial Sun Path)



Its equatorial location results in high solar angles and intense, year-round sunlight, strongly shaping the local climate and urban design

Dense Rainfall and Precipitation



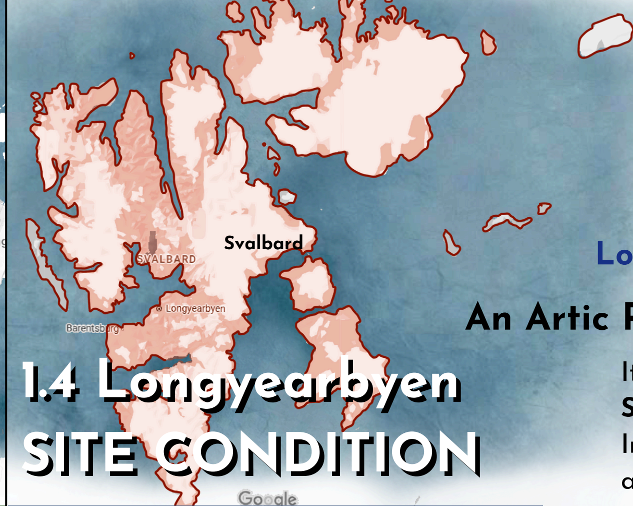
Heavy rainfall, especially during monsoon seasons (avg. >2,000 mm/year)

1.3 SVALBARD SCIENCE CENTRE

Longyearbyen, Svalbard, Norway

An Artic Research & Education Hub

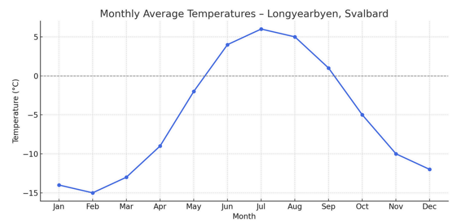
It houses the **University Centre in Svalbard** (UNIS), the Norwegian Polar Institute, and the Svalbard Museum, among other institutions.



1.4 Longyearbyen SITE CONDITION

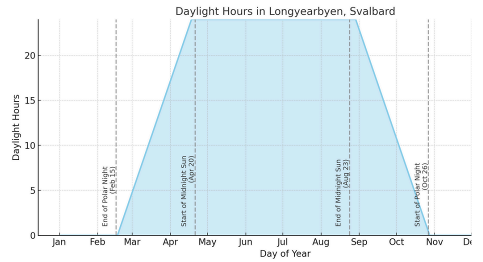
Northernmost Inhabited Settlements

Artic Temperature



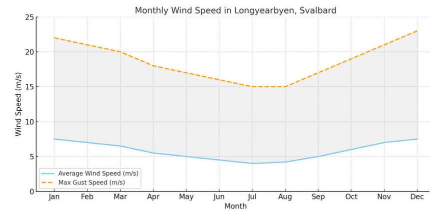
Winter temperatures range from -12°C to -20°C
Summer temperatures between 3°C and 8°C
The average yearly temperature is about -4°C.

Day and Night Hour



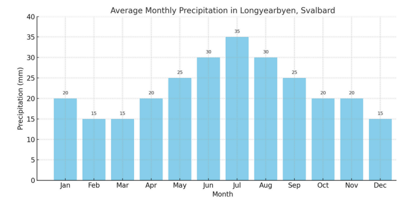
Polar night from late October to mid-February
Midnight sun from mid-April to late August
Daylight hours change rapidly in spring and autumn, with long twilight periods in between.

Wind Speed



During winter, with average speeds of 5-8 m/s and gusts that can exceed 20-25 m/s during storm.

Rainfall and Low Precipitation



Svalbard's polar desert climate brings 200-400 mm of yearly precipitation, mainly snow (Oct-May), light summer rain, low humidity, frequent fog, and occasional storms.

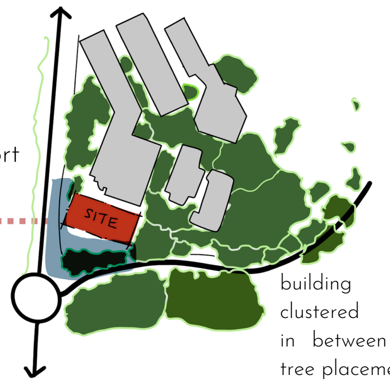
2.0 Site Planning

2.1 SITE SELECTION

The building was built on a challenging terrain around the existing building.

Landscape-led Design

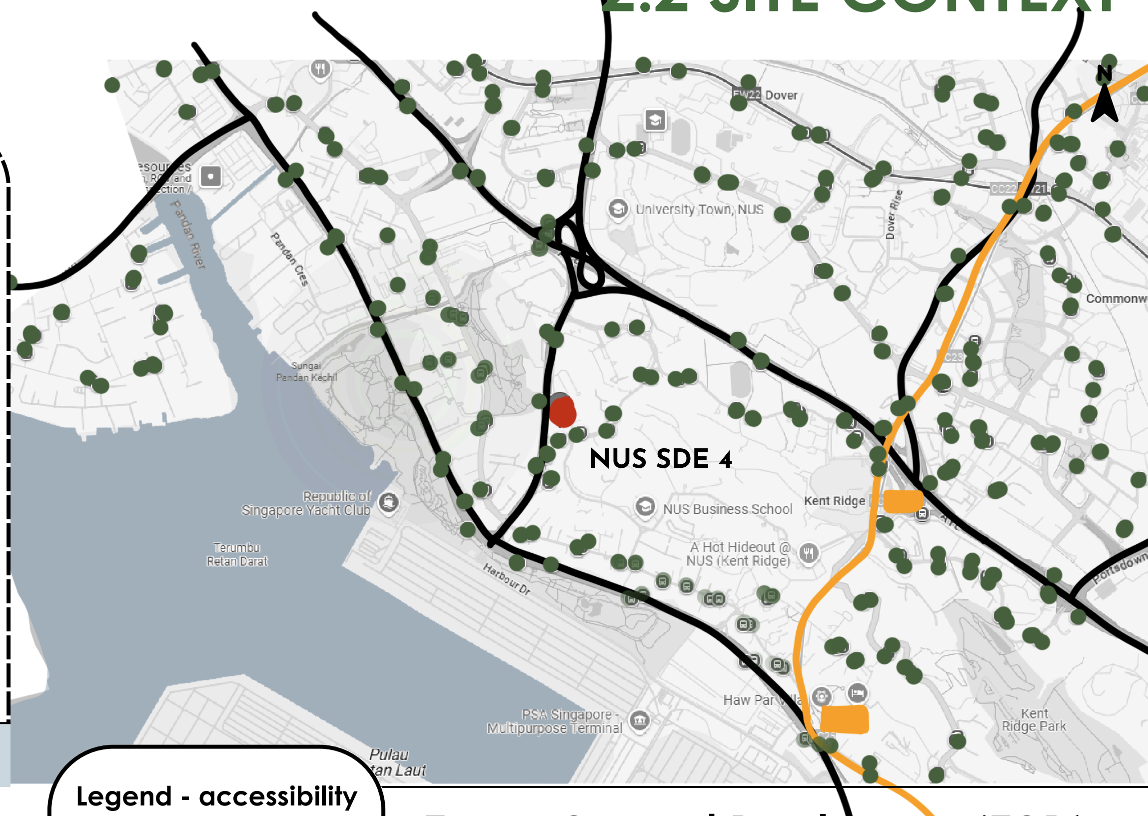
Trees and natural elements are treated as **design anchors**, shaping circulation, views, and massing



Trees as Buffers

Trees function as **thermal and acoustic buffers**

2.2 SITE CONTEXT



Legend - accessibility

- bus stop
- circle Line- MRT
- MRT station
- site
- primary vehicular

Elevated Building Massing -Pollution Mitigation

The structure is **lifted off the ground**, mitigating exposure to **traffic-related air** and **noise pollution**

noise and sound pollutions

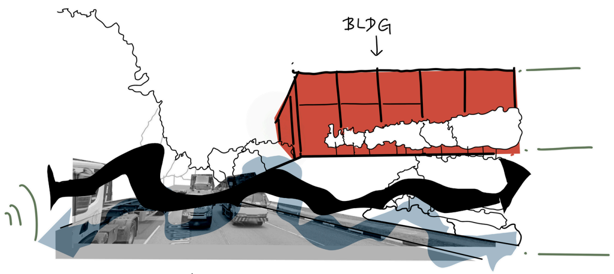
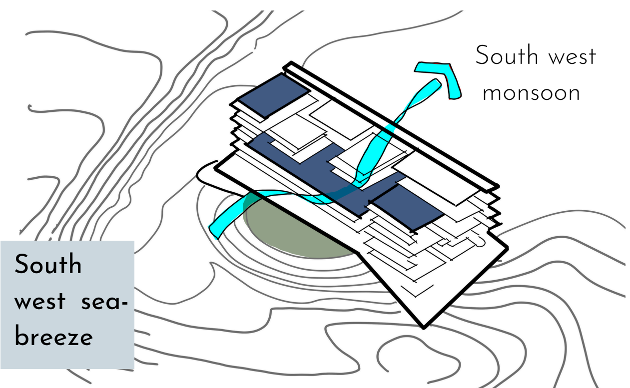


diagram - viewport A

Transit Oriented Development (TOD)

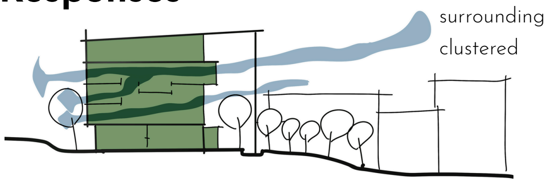
Singapore is well-known for its integrated urban places designed to bring people together with easy walking, and transit service which **reduces carbon footprint**.



Prevailing Wind Responses

Southwest Monsoon (Jun-Sep):

The site is strategic exposed towards **Southwest breeze** accompanied by drier periods and short



Northeast Monsoon (Dec-Mar):

The building is lifted to maximize cross-ventilation **through leveling**

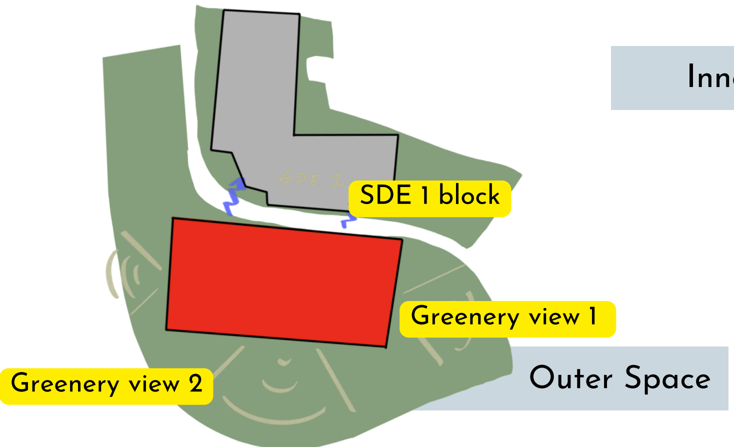
Carbon-Neutral Campus Strategy

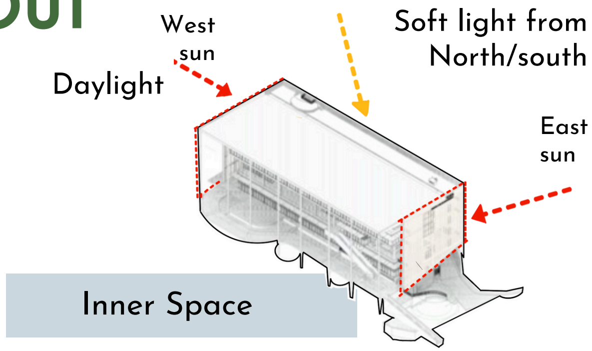
NUS extends sustainability beyond buildings by **electrifying shuttle buses with ComfortDelGro** and planting **100,000 trees** to cut carbon

2.3 BUILDING LAYOUT

"Floating Boxes"

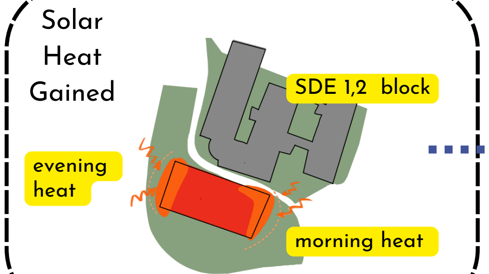
SDE 4 form is broken down using the concept of '**floating boxes**', where the **porous layout** allow for **cross-breezes.**



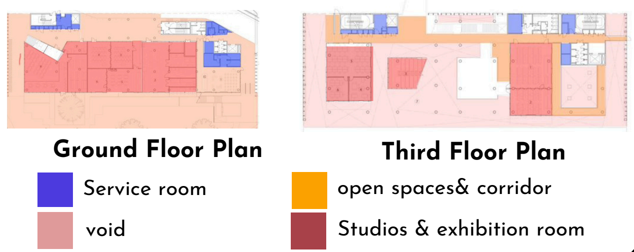


"Tilted Block"

The **View 2** receive soft, diffuse north **daylight**, while view 1 are **exposed to stronger** east and west daylight. To maintain comfortable daylight levels and prevent glare, **façade and shading devices** is used .

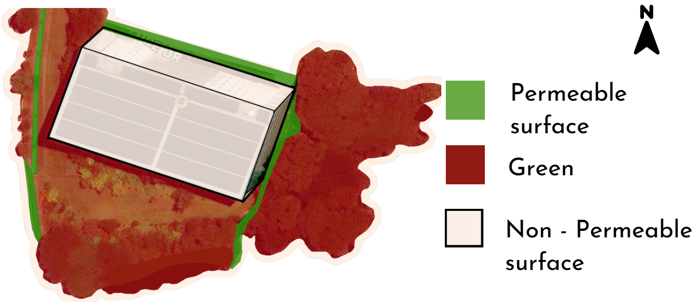


Spatial Analysis



2.4 IMPERVIOUS SURFACES

83% of the ground **are made up of permeable & green surface**, which significantly reduce water runoff and enhance groundwater recharge.



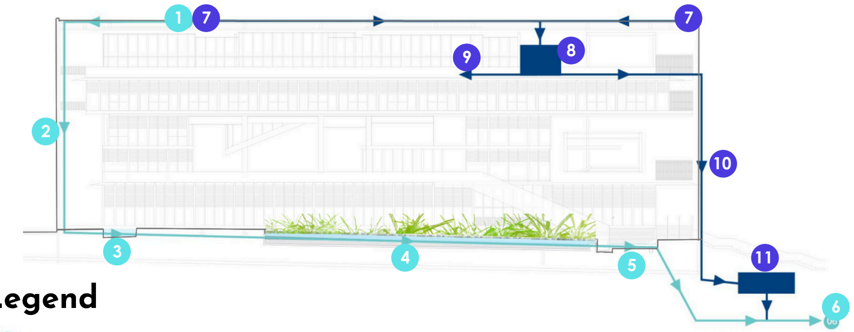
NUS Sde4 features soil beds and native planting **allowing rainwater to infiltrate naturally** into the ground rather than pooling on the surface.

Pervious Material

Gravels used in paths in landscaped areas **while soil beds filter** out sediments and soluble nutrients, exemplifies the use of pervious materials

2.5 GRADING CONSIDERATION & STORMWATER MANAGEMENT

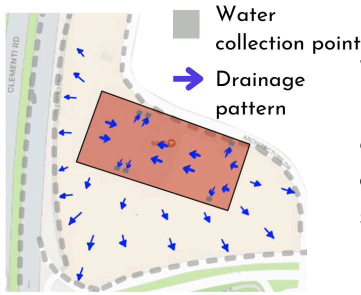
The **rainwater harvesting system** collects roof **runoff, with two-thirds used for flushing and irrigation**.



Legend

- 01 1/3 of Rainwater Runoff from Rooftop Catchment Area
- 02 Directed towards On-site Water Treatment
- 03 Pond 01
- 04 Bioretention Basin
- 05 Pond 02
- 06 Controlled Discharge to External Drain
- 07 2/3 of Rainwater Runoff from Rooftop Catchment Area
- 08 Rainwater Harvesting Tank
- 09 Harvested Water for Flushing and Irrigation
- 10 Overflow from Rainwater Harvesting Tank
- 11 Detention Tank

The remainder flows through a **bioretention basin** (simulated wetland) before entering sewers. This reduces erosion by slowing stormwater, filtering sediments, and **stabilizing soil with vegetation**



Rainwater Run-off

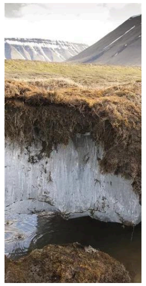
The large **over-sailing roof** directs rainwater to designated collection points, optimizing water flow while minimizing **erosion and runoff**. This stormwater strategy integrates absorption, **rainwater harvesting**, and wastewater recycling (detailed in Section 6.0).

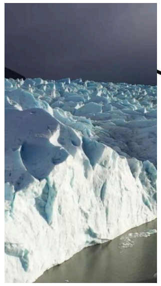
Svalbard Science Centre

2.1 SITE SELECTION

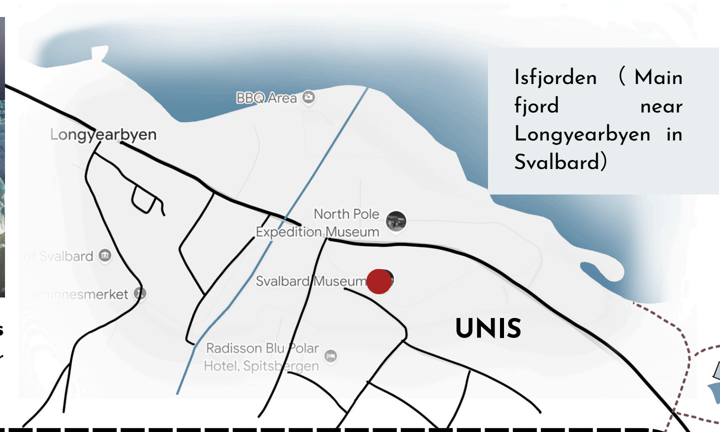
The building serves as the hub for Arctic research, selected for its strategic location for research and proximity to the University Centre in Svalbard (UNIS).

Climate-Conscious Research Ecosystem





Permafrost and Glaciers providing invaluable data for **environmental science**



Isfjorden (Main fjord near Longyearbyen in Svalbard)

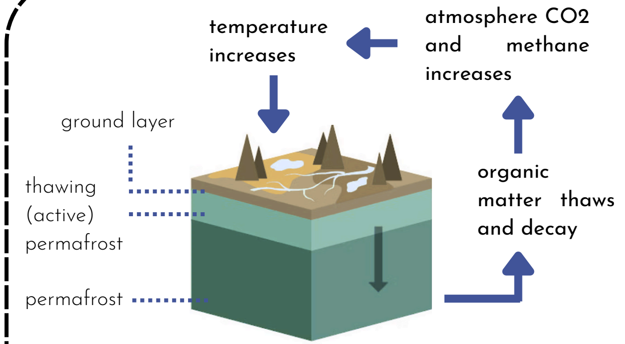
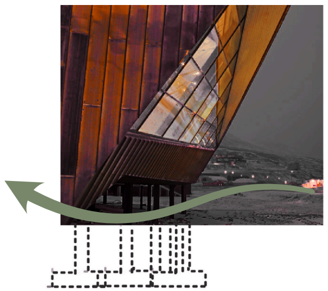


diagram- permafrost thaw cycle

Flat terrain with stable permafrost

Permafrost layer at site acts like a **lid**, **locking frozen carbon** deposits deep below ground



Elevated Pile Foundation

Minimal excavation

Reduced Environmental Impact

The foundation is a raised steel pile system designed to **limit thermal impact** on the permafrost, maintain ground stability, and ensure **long-term structural resilience**

2.2 SITE CONTEXT

Arctic Climate Extremes

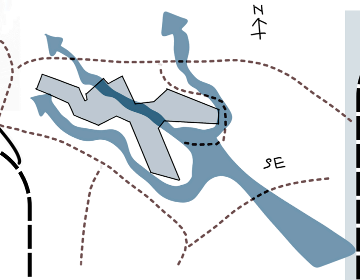
Midnight Sun
(April to August)

the sun stays above the horizon all day and night, creating **constant daylight**

Polar Night
(Oct-Feb)

the sun doesn't rise, and the **landscape stays in darkness** for months

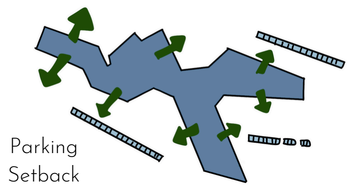
Dominant Wind Direction



Fjord and **valley** channeling the wind

Limited Infrastructure & Access

Roads are **not heavily developed or trafficked**, especially near the Svalbard Science Centre, which **encourages walking**



Snow Management

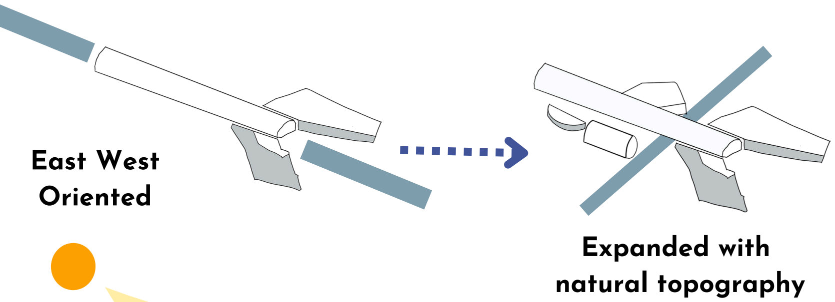
Parking set backed to prevent snow from sliding off roofs onto entrances or parked vehicles

Snowmobile Mobility

Primary mode of transport in Longyearbyen, especially in winter. The building has designated snowmobile access while **minimizing paved surfaces** to **reduce thermal impact** on **permafrost**.

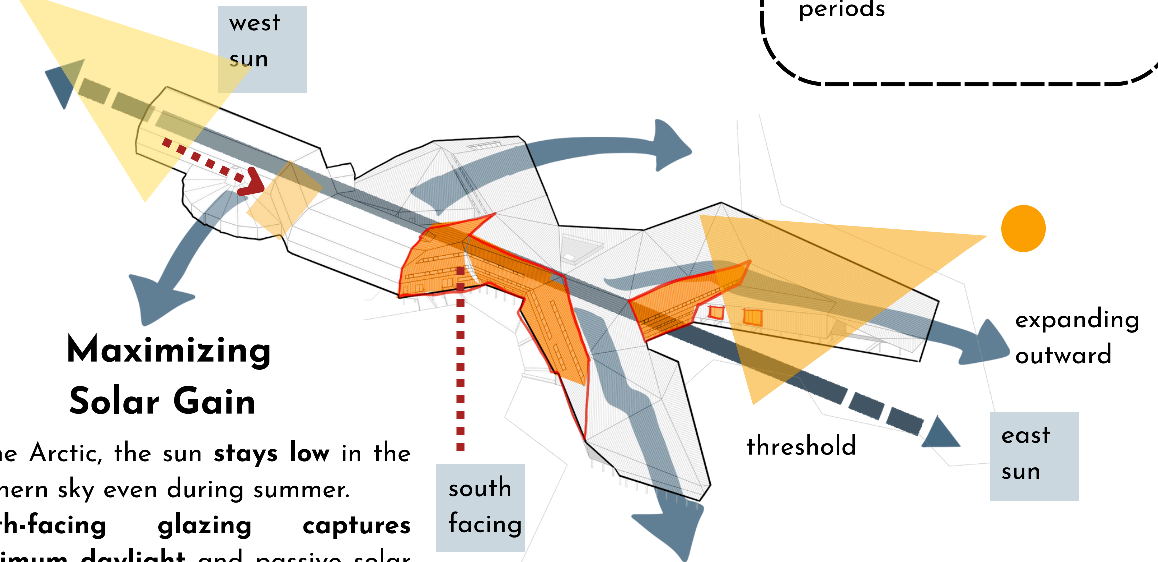
Svalbard Science Centre

2.3 BUILDING LAYOUT



The Linear Form

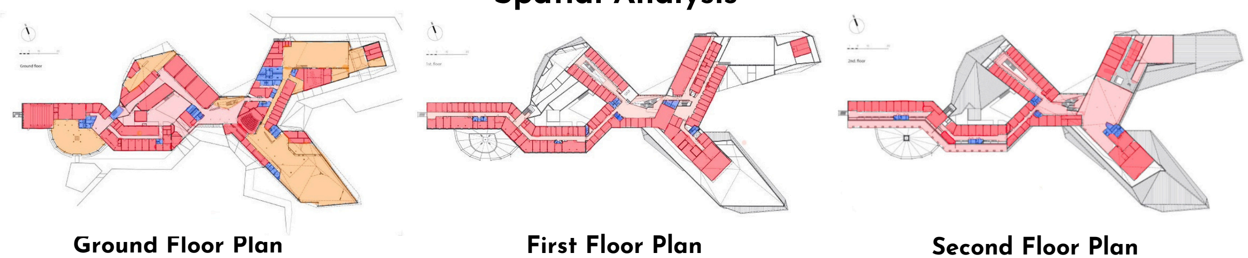
Follows the natural topography
Minimizes site disturbance on permafrost
Enhances solar exposure during low-angle sun periods



Maximizing Solar Gain

In the Arctic, the sun **stays low** in the southern sky even during summer. **South-facing glazing captures maximum daylight** and passive solar heat, essential during the long, cold months and polar twilight.

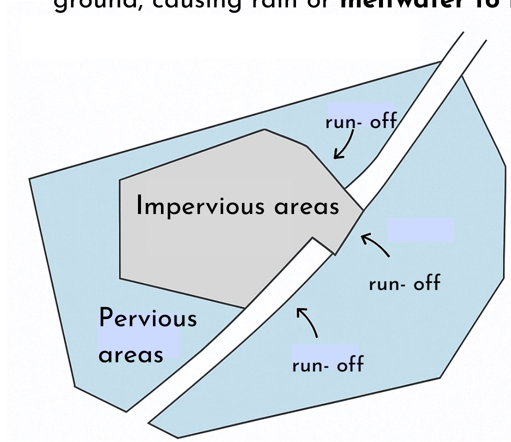
Spatial Analysis



Service room | void | open spaces& corridor | Studios & exhibition room

2.4 IMPERVOUS SURFACE

Impervious surfaces are **areas that prevent water from seeping** into the ground, causing rain or **meltwater to run off instead** of being absorbed.



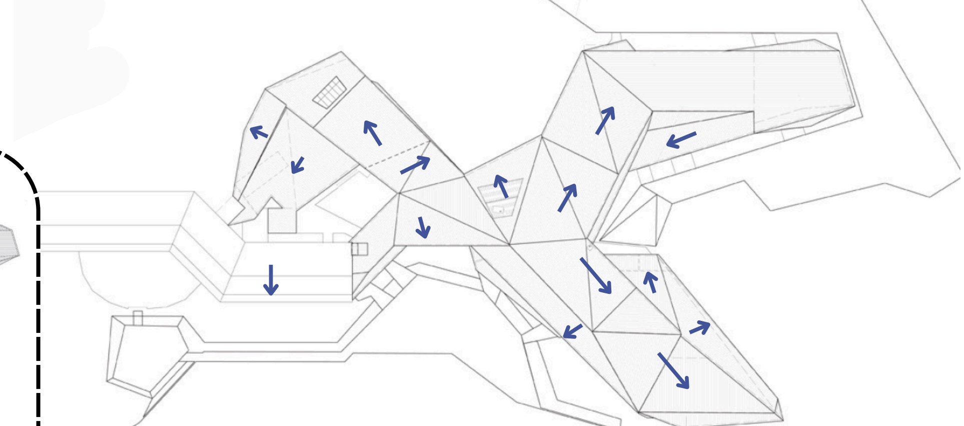
Kept to a Minimum

Only the **building footprint** and select walkways are impervious.
The majority of the site remains **natural tundra, gravel**, or **exposed rock**, which allows water to drain naturally.

This design respects the **fragile Arctic ecosystem** and avoids disrupting **natural permafrost patterns.**

2.5 GRADING CONSIDERATION & STORMWATER MANAGEMENT

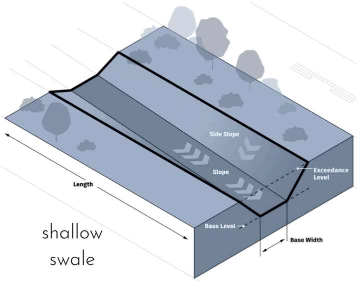
The site design prioritizes permafrost protection and safe handling of **snowmelt and rainfall** through thoughtful **grading and surface drainage**.



Drainage Pattern

Sloped roof channels snowmelt and rainwater away from the structure, allowing it to disperse safely across the surrounding gravel surface.

Shallow Swale + Gravel Path

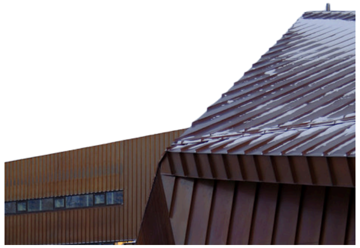


Shallow swales allow surface water to **drain without digging deep** into the frozen ground, minimizing thermal disruption

No underground pipes

avoid freeze damage

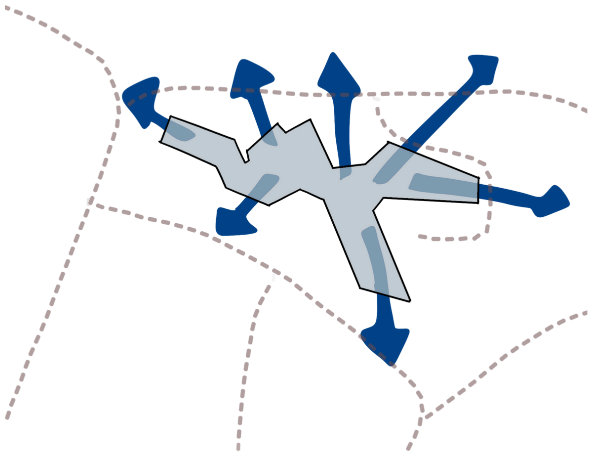
Snow Accumulation Management



Wind-driven snow control: **Grading and berms** are shaped to prevent snowdrifts near entrances or critical areas.

2.6 SPATIAL QUALITY

Spatial Integration

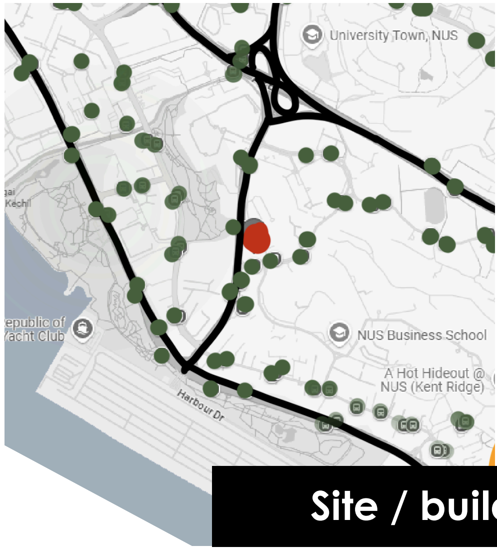


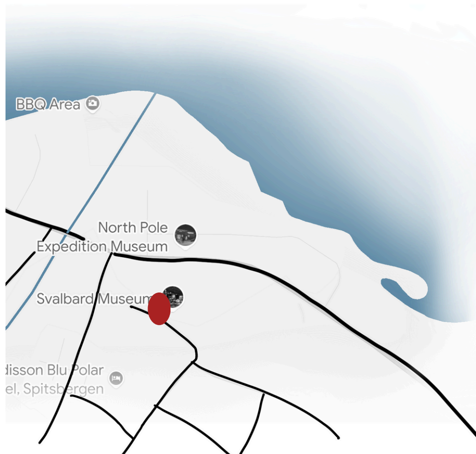
How the building responds to the vastness and openness of the **Arctic tundra.** The relationship between built form and natural topography.

"The SSC's **angular volumes** reflect the surrounding peaks, helping the building **feel anchored** and contextual.

2.7 COMPARISON

bus stop site primary vehicular





Site selection

The **Svalbard Science Center** is a purpose-built, proximity to the University Centre in Svalbard (UNIS) whereas **NUS SDE4 is a** larger push for sustainable campus development. built on a **challenging terrain** around the existing building.

Site context

The **buildings are oriented in a way favors prevailing wind & daylight** but with optimum control to reduce heat gain. While **Svalbard Science Center has limited Infrastructure** & access the NUS SDE4 has **more options access to public service & transportation (TOD).**

Site / building layout

Both buildings have **strategic form and layout configuration against context. Svalbard Science Center has a linear form** whereas **NUS SDE4 has a tilted floating block form.**

Impervious surface

The **Svalbard Science Center kept the building footprint** & select walkways **impervious** & remains natural tundra whilst NUS SDE4 uses **landscape & permeable ground cover materials (Gravels) to promote pervious surface** with minimal impervious surface.

Stormwater management

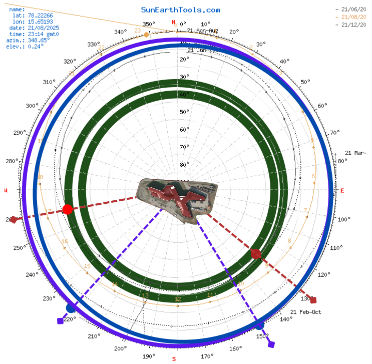
The Svalbard Science Center uses **grading and surface drainage to direct snowmelt & rainwater** to surrounding gravel surface. In contrast, **NUS SDE4 depends on existing topography** to conventional city drainage system & roof top gutter that leads to bio retention basin.

3.0 Daylighting

Svalbard Science Centre

3.3 FORM

3.1 SUNPATH ANALYSIS



Winter solstice

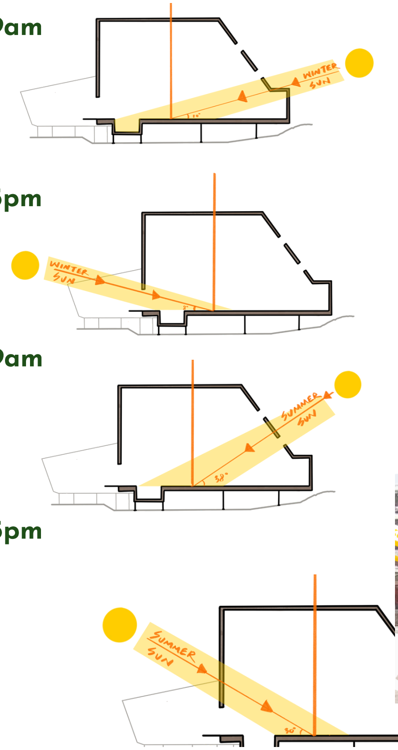
Summer solstice

Winter solstice
Dec - Feb

Twilight , no day length , polar nights
Low sun angles
(Altitude)
Azimuth = 149 °

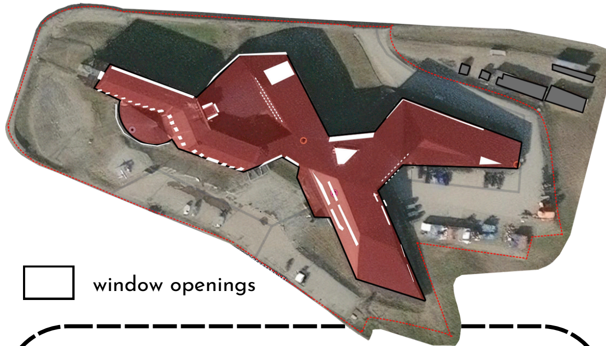
Summer solstice
April - Aug

Longer days
High sun angles
(Altitude)
Azimuth = 260°

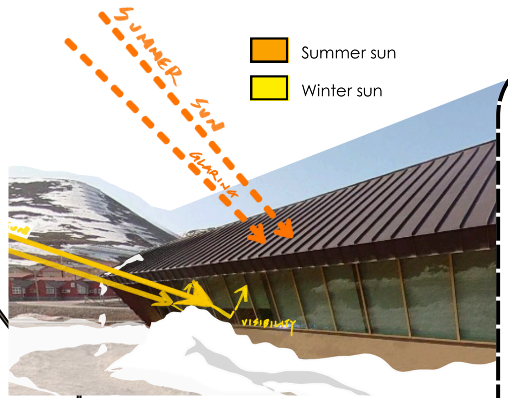


Lobster-Shaped Plan

The building features a lobster-shaped plan, . Low, angled windows are positioned along each facade, designed to **capture low-angled sunlight** more effectively, especially during the brief periods when the **sun rises above the horizon**.



window openings

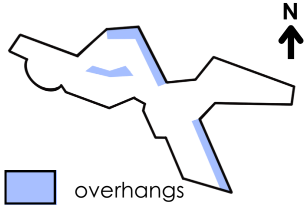


Summer sun

Winter sun

Low angled windows helps letting in light for **visibility when snow accumulation**

Shading Devices

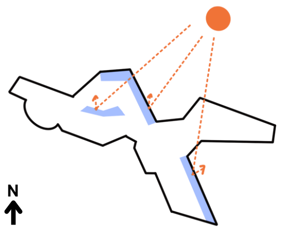


overhangs

towards **south & southeast,** the corners have **overhang and other shading devices**

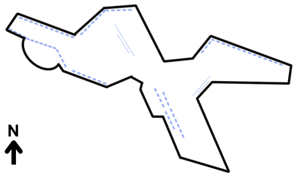
to **block the high summer sun** for glaring while allowing low-angle light during **winter months**

3.2 ORIENTATION



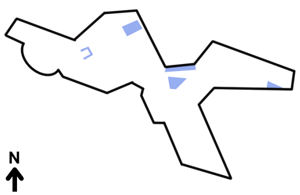
Summer

As the sun doesn't set at all The building receives **direct daylight** however the glare is reduces through overhangs & louvers.



Spring/Autumn

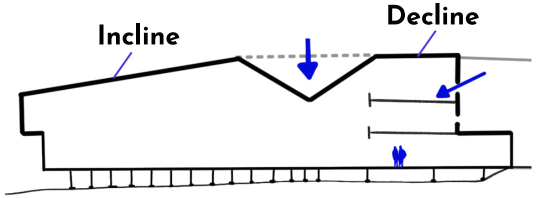
As the sun path starts getting very low , the Low position angled window maximize light entry



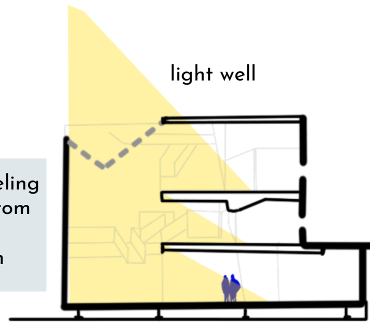
Winter

Sun stays below the horizon, twilight hours emerges, building's receives natural light for upper floor through clerestory & skylight.

Incline & Decline Roof Design



This building features **incline and decline as roof design** which forms a skylight & **clerestory elevation** layout that illuminates more internal spaces.



channeling light from top to bottom

3.4 INTERIOR LAYOUT

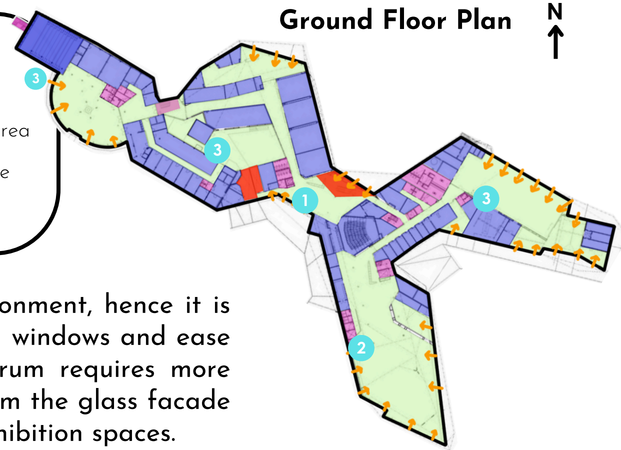
The forum has a lot of **double volume spaces,** even triple & quadruple volume. This is to increased height **allows sunlight to penetrate deeper** into the interior space, reducing the reliance on artificial lighting.

3.6 LIGHTING ANALYSIS

Ground Floor Plan

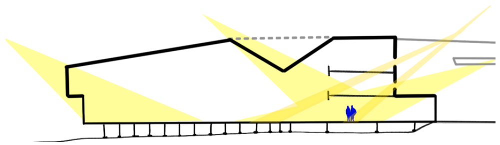
Legend

- corridor/ double volume spaces
- Single Volume spaces
- Service/ ancillary rooms
- 1 entrance
- 2 Exhibition area
- 1 Forum space



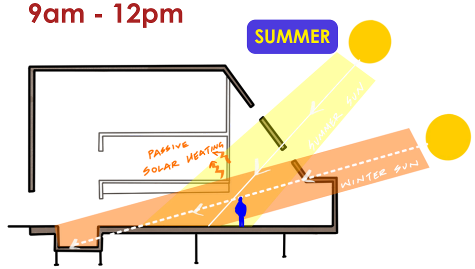
Most studios need control lighting environment, hence it is located at the **S/SE** sides with individual windows and ease access to The Forum . Entrances & forum requires more light in which utilizes natural lighting from the glass facade due to as a welcoming statement and exhibition spaces.

Due to the Low-Angle Glazed Facade maximizing the limited daylight entry, the daylight angle is at its **deepest between 9 to 12 PM.**



These diagrams illustrate the comparison between summer solstice & **winter solstice, the sunlight penetration is deeper** because of the sun's **more oblique** path.

9am - 12pm



Maximum daylight angle into building

- 8:00
- 12:00
- 17:00

3.5 FENESTRATIONS

At ~78°N, the building experiences **low sun angles** even in summer and months of polar night. Its orientation—with **key windows facing south or southeast**—maximizes available sunlight.

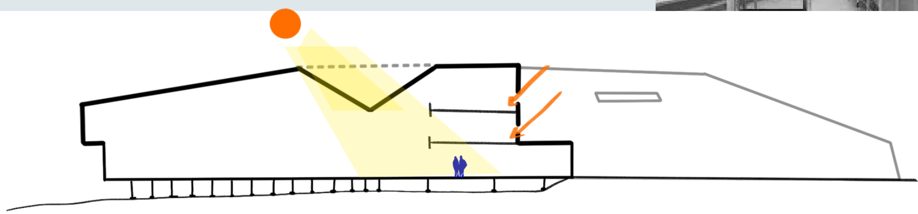
Angled Copper Clad Envelope with Low-Angle Glazed Facade

To maximise daylight for exhibitions and learning, the building's façade is designed to allow abundant natural light while **minimising heat loss, glare**, and **snow accumulation**. This is achieved through low-angled glazing that effectively captures daylight and copper cladding on the roof.

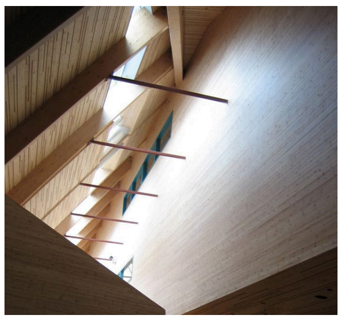
Skylights

Skylights are incorporated at the **rooftop ,** providing **extra daylight to the building's interior.** Light shelves and louvers are utilized to **regulate sunlight intensity**, reducing glare and heat gain.

The sun doesn't set at all from around mid-April to late August , lights could be maximized to capture through the skylight

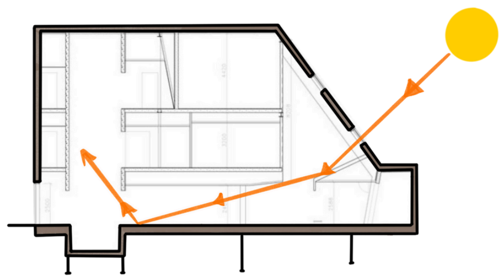


Clerestory



To emphasize the varied dynamics within the forum, the building incorporates a combination of **clerestory windows**, skylights, and **low-angled glazing**. These elements, along with the differing roof heights, create a **layered interplay of light** and space.

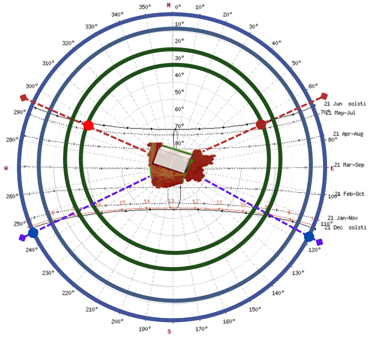
Light Redirected



Lights being **reflected and brought in** because of the clerestory construction of building combined with **The inclination of the walls & vivid space accentuates the lights reflected effect**

NUS SDE 4

3.1 SUNPATH ANALYSIS



Winter solstice

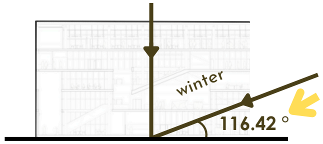
Summer solstice

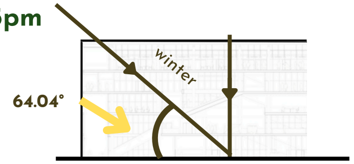
Winter Solstice
Dec - Feb

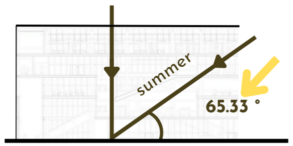
Short days
High sun angles
(Altitude)
Azimuth = 116.42°, 244.04°

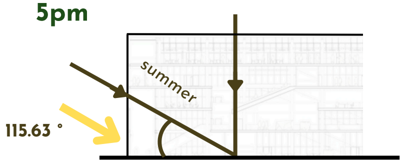
Summer Solstice
April - Aug

Longer days
High sun angles
(Altitude)
Azimuth = 65.33°, 295.63°

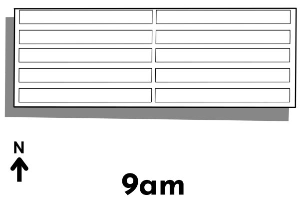






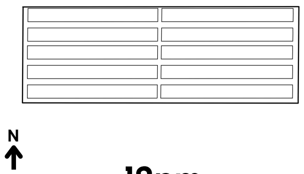


3.2 ORIENTATION



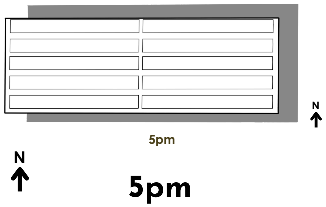
9am

At **eastern and northeastern facades** are **brightly lit** by direct morning sun, while **western sides remain shaded and cool**.



12pm

At noon, the overhead sun casts **minimal shadows**, creating uniform illumination. All facades and roof surfaces, especially in the southern and central courtyards, receive **strong direct sunlight.**

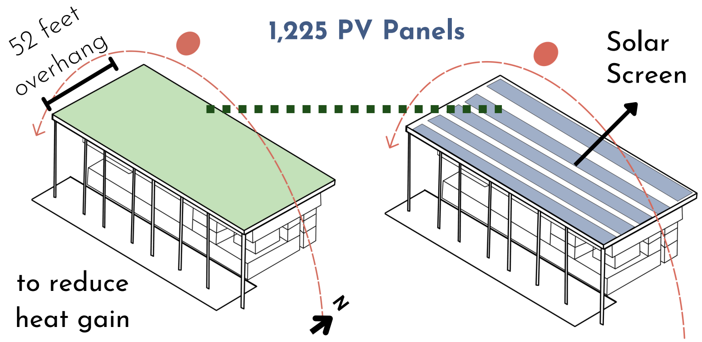


5pm

Direct sunlight **hits the northwest facade**, creating strong solar exposure and long shadows cast toward the **southeast**. **The eastern and southern sides are fully shaded**

3.3 FORM

Over-sailing Roof



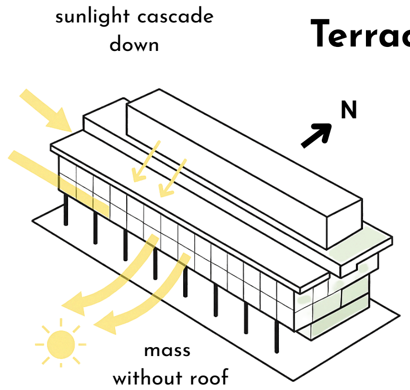
The roof's expansive surface area accommodates **1,225 PV Panels** generate

500 MWh
electricity annually

Typical Educational Building **without solar integration rely** entirely on grid electricity

1,000 MWh

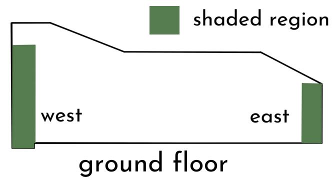
Terraced Massing for Light Access



The building is **shaped like stepped terraces**, especially on the **upper floors**.

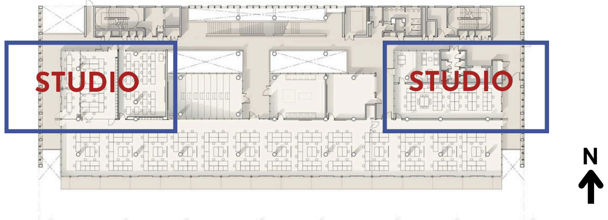
These **step-backs** prevent the upper parts of the building from casting shadows on lower levels, allowing sunlight to "**cascade down**" and reach deeper into the building's height, including **corridors and shaded lower zones**.

NUS SDE4 uses deep overhangs, vertical shading, and reflective surfaces to **reduce solar heat gain**, particularly on the **east and west façades** exposed to intense sun between **9-11 AM** and **3-5 PM**.



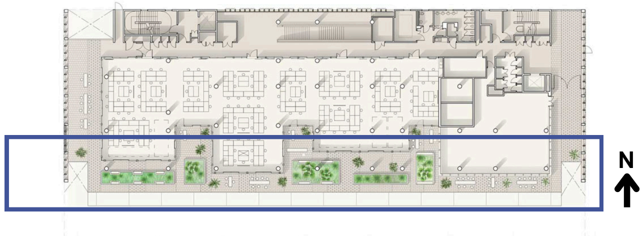
3.4 INTERIOR LAYOUT

Strategic Zoning Based on Light Needs



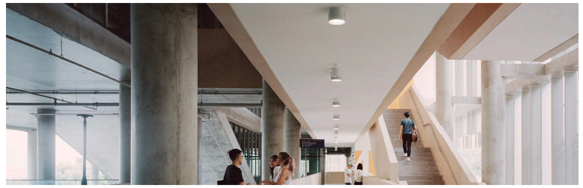
Spaces that benefit most from daylight, such as **studios and collaborative zones**, are **positioned along façades**, while utility spaces are placed **deeper inside to optimize light exposure** where it matters most.

Strategic Greenery



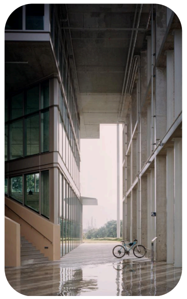
The plants act as a natural shading and cooling buffer to reduce glare and filtering sunlight.

Shallow Floor Plates for Daylight Access



The shallow floor plate of NUS SDE4, typically **15-18 meters wide**, is a deliberate daylighting strategy. By minimizing the distance between façades

> 75% regularly occupied spaces to achieve daylight autonomy



The building features numerous **double-volume spaces,** designed to enhance natural lighting. These **increased-height areas act as light wells, allowing sunlight to penetrate deeper into the interior and reducing reliance on artificial lighting.**

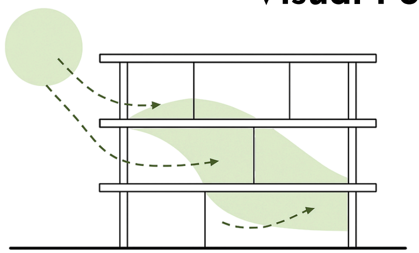
0 kWh	vs	5-10 W/m²
Natural Light		Artificial Lighting

Double-Volume Spaces as Daylight Funnels

Double-volume spaces serve as high-performance light wells, providing daylight levels of

2,000 lux	VS	300-500 lux
Natural Light		artificial lighting

Visual Porosity & Spatial Continuity



Open-plan layouts and **glass partitions** help extend daylight deeper, maintaining open visual connections.

The use of floating slabs and **exposed structure** creates spatial layering without obstructing light flow.

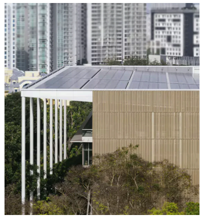
NUS SDE 4

3.5 FENESTRATION

The building's fenestration carefully **balances openness** and shading, **using a calibrated window-to-wall ratio**

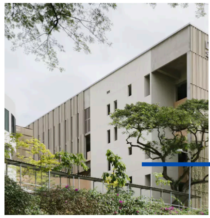
Balanced Window-to-Wall Ratio (WWR) Optimization


west


east

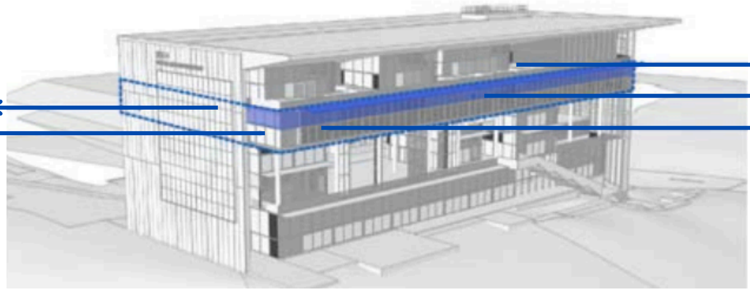
low WWR ratio → minimize heat gain


south



north

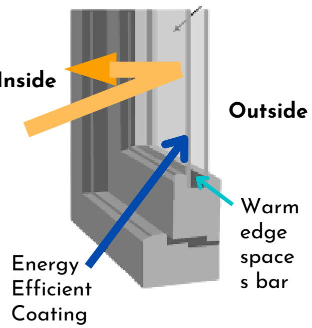
high WWR ratio → achieving daylight autonomy



view from south-west

reflectance and transmittance material to cool down the building

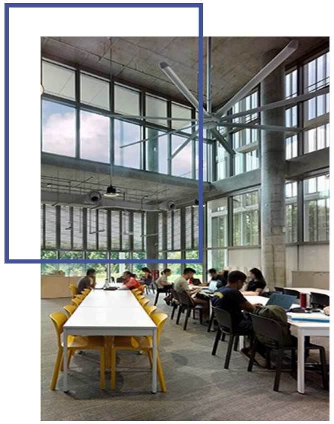
Double Glazed Unit



Double-glazed glass

Using high-performance double-glazed unit (**DGU**) along with large overhangs for facade, it helps to **reduce heat gain and cool loads through superior thermal insulation**

Single Glazing		Double Glazing
	U-Value	
5.0 - 6.0W/m²·K	**vs**	**1.1-2.0 W/m²·K**
Single Glazing	Solar Heat Gain Coefficient	Double Glazing
0.70 - 0.85	**vs**	**0.3 - 0.45**



Daylight Accessibility

Almost **100%** of occupants are within

7.5 metres

of the windows, ensuring that nearly all regularly occupied spaces receive adequate **natural daylight**

visual access towards the outdoors

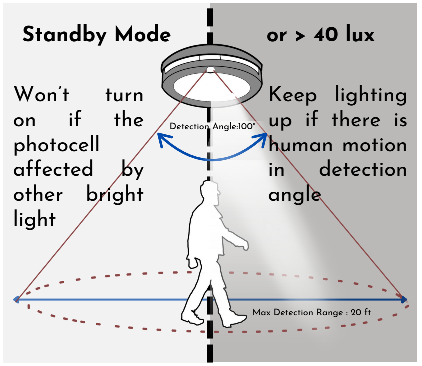
The WWR likely ranges between

30% -50%

3.6 LIGHTING ANALYSIS

Daylight-Responsive Lighting Systems

daytime night time

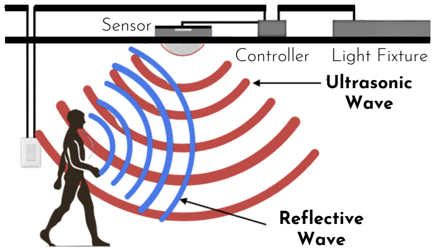


Adjusts lighting based on natural light availability

NUS SDE4 uses **ceiling-mounted daylight sensors (photocells)** to **measure ambient light** and **automatically switch off artificial lighting when natural light is sufficient.**

reduce **40% lighting energy use**

Occupancy Sensors & Motion Detection



Adjusts lighting based on presence of people

Motion-activated occupancy sensors in spaces like classrooms, pods, and corridors and areas with inconsistent daylight or during night-time use to **switch off lights when unoccupied**.

reduced **20% - 30% lighting energy use**

3.7 SPATIAL QUALITY

Bright

NUS SDE4's expansive glazing and **open layout flood interiors** with natural light, while smart shading prevents glare. **Light shelves and atriums** distribute daylight evenly, maintaining **visual connections** to **outdoor greenery.**

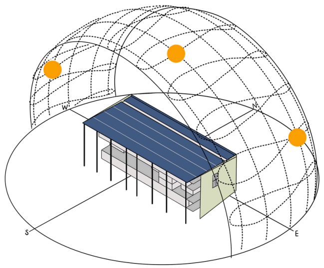
Adaptive

Smart sensors and **auto-louvers dynamically** adjust daylight levels for optimal comfort and energy efficiency.

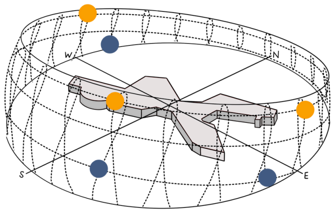
Organized

The building's **cluster design** places workspaces around central light wells, ensuring **deep daylight** penetration. Strategic zoning puts collaborative areas **near windows**, while reflective surfaces enhance brightness throughout.

3.8 COMPARISON



NUS SDE4's



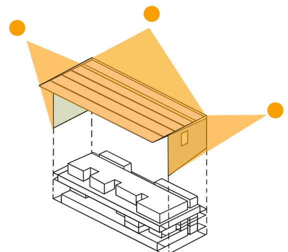
Svalbard Science Center

Summer Daylight

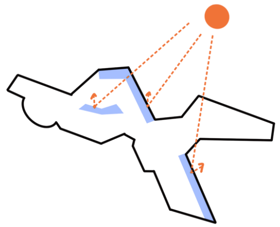
Winter Daylight

Sunpath analysis

Daylight hours in **Singapore** is **virtually the same all year round**, while in **Svalbard** , daylight hours are **continuous in the summer and twilight to no daylight in the winter**, and the sun elevation is much lower.



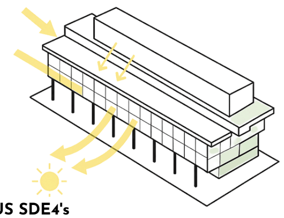
NUS SDE4's



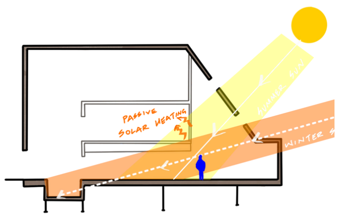
Svalbard Science Center

Daylighting Strategies

Both buildings maximizes natural daylighting by adding fenestrations to all faces, but **NUS SDE4 diffuses the harsh tropical sun.**



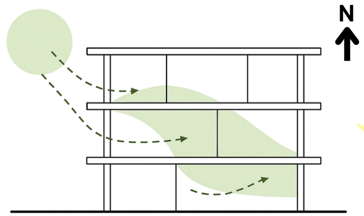
NUS SDE4's



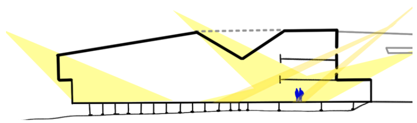
Svalbard Science Center

Fenestration

NUS SDE4's fenestrations mostly consists of **operable glass glazing windows** while The Svalbard Science Center utilizes **Low-Angle Glazed Facade. This is due to the temperate conditions at both regions.**



NUS SDE4's



Svalbard Science Center

Orientation

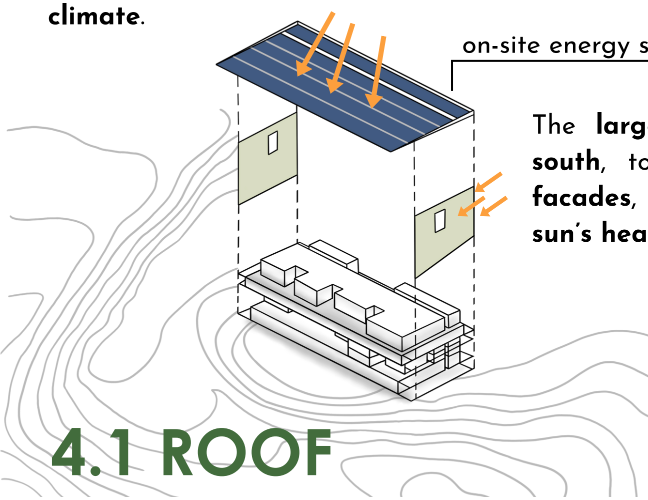
NUS SDE4 has a Floating Boxes porous layout that faces **North-South orientation** while the Svalbard Science Center is orientation is multi-directional for climate-responsive which allow daylight gain during low-angle winter sun

4.0 Facade Design

NUS SDE 4

4.0 INTRODUCTION

NUS SDE4 stands out for its deep, layered tropical facade system, which combines architectural shading, **operable windows**, and **natural ventilation tailored to Singapore's climate**.



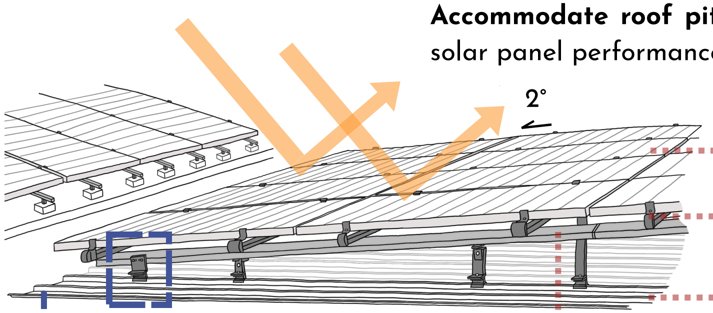
on-site energy sourcing with **rooftop photovoltaic panels**

The **large overhanging roof** on the **south**, together with **east** and **west facades**, **shade** the building from the **sun's heat** and provide a cooler interior

Grey gradient indicates the intensity of heat received within the building

4.1 ROOF

Accommodate roof pitches as low as 2° to optimize solar panel performance and energy harvest

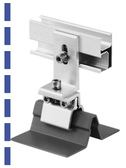


Photovoltaic (PV) Solar Panels

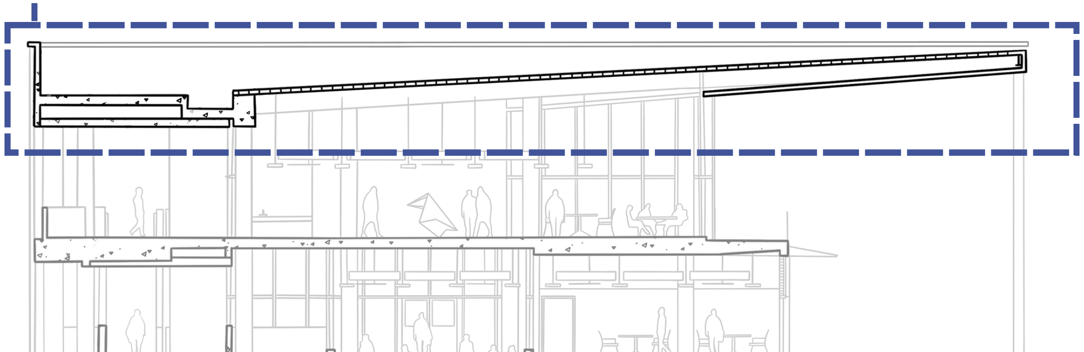
Standing seam roof mounting clamp

LYSAGHT® KLIP-LOK® 406 Metal Roof Sheets

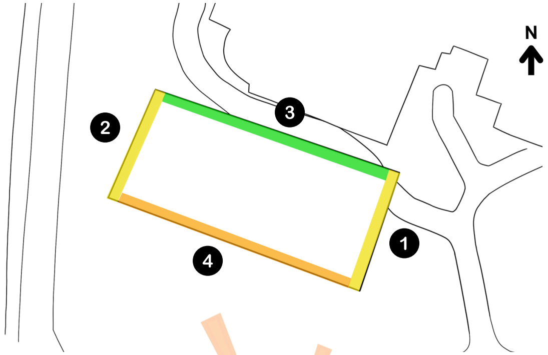
Structural Purlins



Mounting structure **clamps onto** the **raised ribs** of the KLIP-LOK® 406 roof system without having to make any **holes**

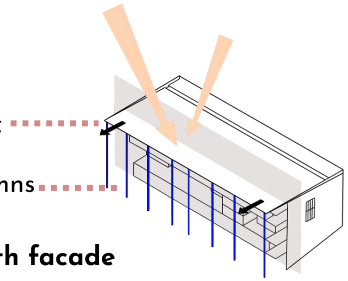


4.2 FENESTRATION & ORIENTATION



surface exposure to direct heat

- highest
- moderate
- lowest



large over-sailing roof

large columns

4 **south facade**

The south facade features **impressive columns** supporting a large over-sailing roof, forming a **sheltered portico**. Most openings face south to reduce direct solar gain

The rear of the building has **fewer openings** due to **limited direct sunlight** and the proximity of an adjacent building which also enhances privacy of the public realm

3 **North Facade**

operable glass window

perforated aluminum screen

East and **west** sides absorb the **most heat**

2 **West Facade**

1 **East Facade**

The **east** and **west facades** feature a responsive **double-skin system** designed to tackle harsh tropical sun, combining **operable glass windows** with a **perforated aluminum screen** to enhance natural ventilation, daylight control, and energy efficiency

4.3 MATERIALS

A double-skin facade is applied to both the **east** and **west sides**

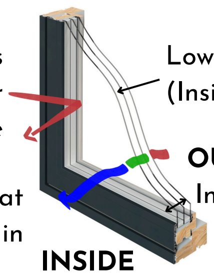
Inner layer is an **operable glass windows** that allow for natural ventilation and user control

The outer layer is a **perforated aluminum screen** that acts as a **sunshade** to **reduce direct solar heat gain** from the low angle morning east and afternoon west sun

Two passive approaches are effective in the tropics due to the suns path rising in the east, setting in the west, and reaching a high noon angle causing **intense solar radiation** on the **east** and **west facades**

Most Used Material: Glass

The glass window is set back from the exterior to **minimize direct sunlight exposure**



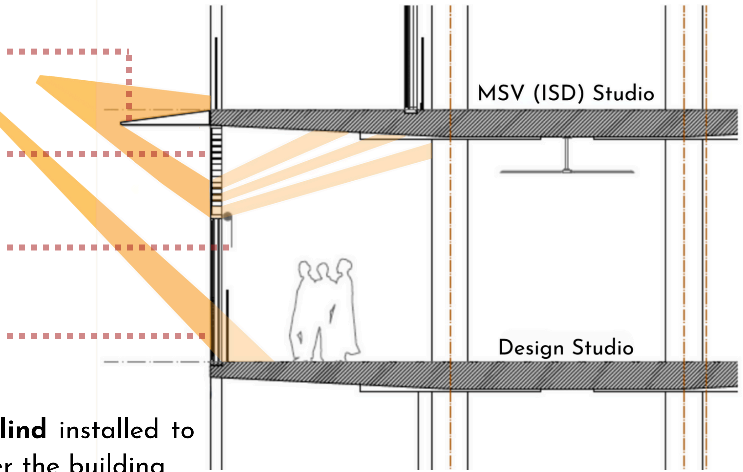
The building envelope uses high-performance glass to **regulate indoor temperature** and **reduce energy use**, enhancing overall efficiency

Perforated Aluminum Screen

The screen diffuses harsh sunlight into soft light and allows air to pass through for natural cooling

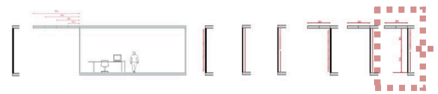
4.4 THERMAL INSULATION

Large windows facade to access to daylight. Occupants that are within **7.5 meters** to windows could access to the **daylight** and **view to the outdoor greenery**



Lamellas and **operable roller blind** installed to **control the amount of light** enter the building

East section view



	overhang	no	1m	2m	3m	4m	no	no	no	2m	2m	2m
	shading	no	no	no	no	no	ext. shading operable	int. screen operable	int. screen low operable	ext. shading operable	int. screen operable	int. scrren low operable
glazing	70/35	100%	88%	79%	74%	69%	59%	79%	88%	59%	72%	70%
glazing	50/25	87%	78%	70%	65%	62%	54%	73%	79%	54%	65%	64%
glazing	40/20	80%	72%	66%	62%	59%	51%	69%	74%	51%	62%	61%

reduction in ideal cooling demand to keep the room on T_op=26°C as indicator for solar gains

glazing	70/35	72%	55%	39%	25%	16%	1%	38%	54%	1%	23%	19%
glazing	50/25	51%	34%	18%	7%	3%	0%	24%	37%	0%	9%	6%
glazing	40/20	39%	21%	7%	2%	1%	0%	15%	26%	0%	3%	2%

% of operation hours operative temperature exceeding 29 °C (hybrid system)

glazing	50/25	51%	34%	18%	7%	3%	0%	24%	37%	0%	9%	6%

% of operation hours operative temperature exceeding 29 ° C (hybrid system)

glazing	50/25	100%	100%	100%	99%	92%	81%	3%	57%	78%	0%	76%

spatial Daylight Autonomy ($sDA_{300lx/50\%}$)

glazing	50/25	85%	84%	83%	83%	82%	67%	1%	0%	65%	0%	4%

glare potential (over 1000 lx; @3m); hours of exceeding in relation to operation hours

when combined the **overhang** and the **shading no more reduction occurs** for the external shading scenario after adding the overhang

operable external shading performs the best on the aspect of solar control

the efficiency of **reduction of cooling demand decreases** while the distance of the overhang increases

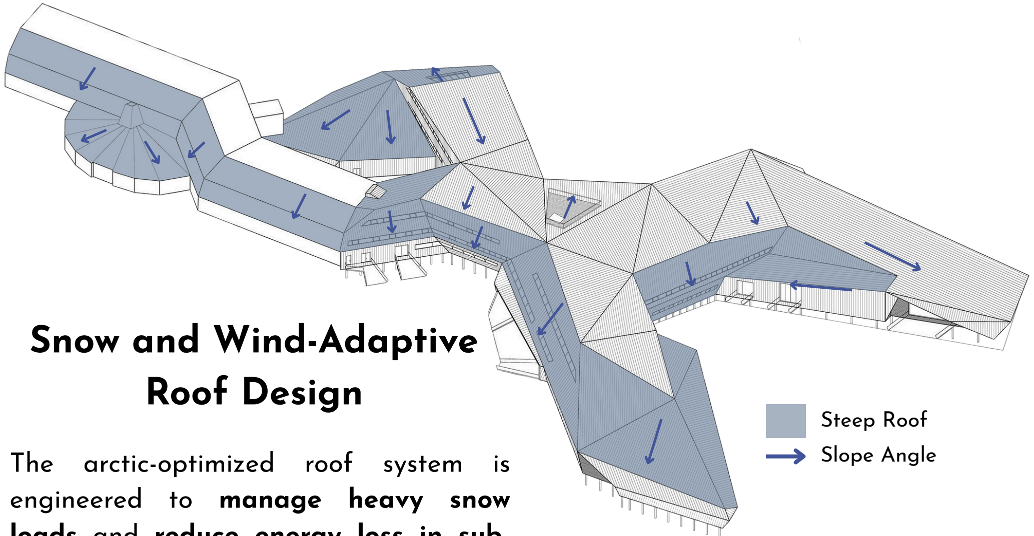
exterior view

interior view

Lamellas and **high-performance low-e glass** allow ample daylight, nature, and fresh air into the building. **External landscapes** are integrated along the perimeter, enhancing occupant productivity

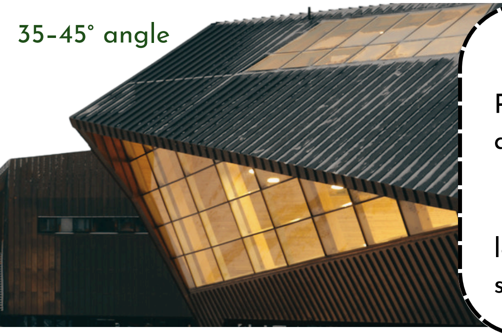
Svalbard Science Centre

4.1 ROOF



Snow and Wind-Adaptive Roof Design

The arctic-optimized roof system is engineered to **manage heavy snow loads** and **reduce energy loss in sub-zero temperatures**.



Steep Pitch

Prevents snow accumulation,

>1.5 tons/m² load

lowering structural stress.

Insulated Layers

High-density insulation retains heat and reduces reliance on artificial heating.

Summer

High-albedo Light-colored (albedo > 0.7) surfaces reflect **70%** sun radiation, preventing overheating.

Winter

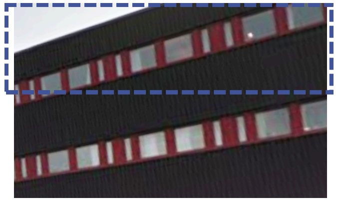
Snow acts as **natural insulation** when evenly distributed. (k ≈ 0.15 W/mK)

Thermal Performance

Svalbard Roof		Standard roof
0.08 W/m²·K	U-Value vs	0.25 W/m²·K
50% less	vs Heat Loss	Baseline

4.2 FENESTRATION AND ORIENTATION

North and Northwest Facades

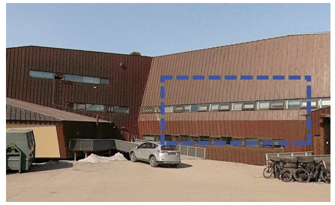


These sides are kept more enclosed to **block dominant cold winds** and reduce heat loss. Openings are limited and carefully positioned to minimize weather exposure.

South Facade

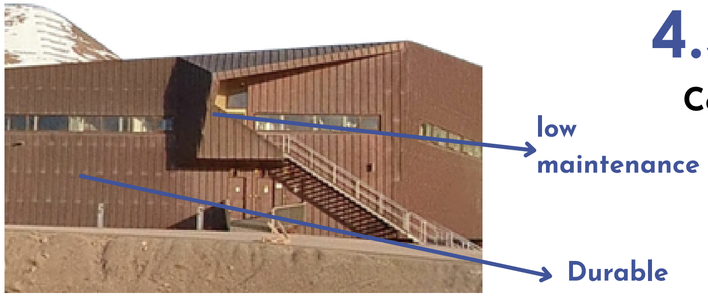
Though **solar gain** is **minimal** at this **latitude**, **south-facing areas help capture available daylight**. Larger windows in communal spaces improve natural lighting without major heat loss.

East and West Facades



Glazing is controlled to balance daylight and insulation. The design helps **reduce glare** from **low-angle sunlight during long summer days**.

4.3 MATERIAL

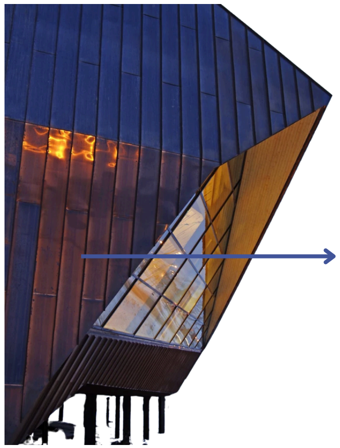


Copper as key material

Copper is 100% recyclable

recycling rate

65% Copper	vs	9% Plastic



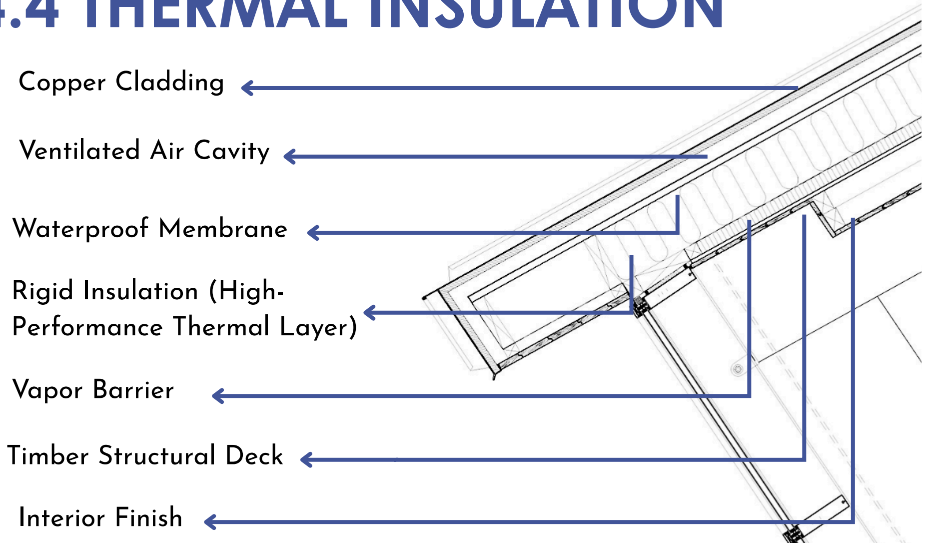
Self-developing patina eliminates chemical coatings while **blending** with Arctic landscapes.

Low embodied energy due to durability and recyclability reduces lifecycle impacts

The outermost layer consists of copper panels joined using a **double-fold technique**. To ensures durability against **harsh weather** and facilitates snow and ice shedding due to the roof's sloped design

Svalbard Science Centre

4.4 THERMAL INSULATION



Environmental Response

The facade functions as a **thermal barrier**, **shielding** the **interior** from **extreme cold** and **harsh Arctic winds**.

Insulated panels and **air gaps** within the facade system enhance thermal performance, reducing energy demands by **30%**

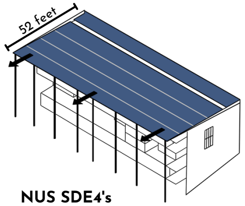
High-performance Thermal Envelope

Timber structural system minimizes thermal bridging and allows for on-site adaptability.

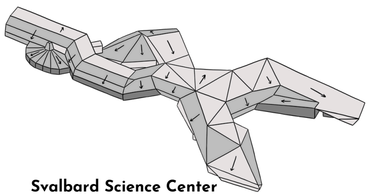
Triple-glazed window strategically recessed to improve insulation and minimize heat loss around

0.8 W/m²K U-value

4.5 COMPARISON



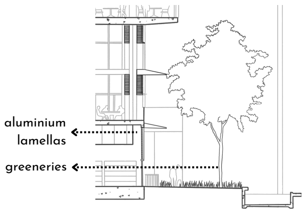
NUS SDE4's



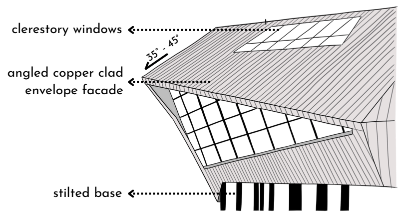
Svalbard Science Center

Roof

Both buildings roof have its own distinctive characteristic, Svalbard Science Center **roof plane** is **asymmetrical** and **steeply angled** while NUS SDE4 has **large sail roof** with **PV panel** installed.



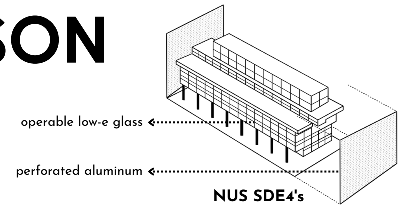
NUS SDE4's



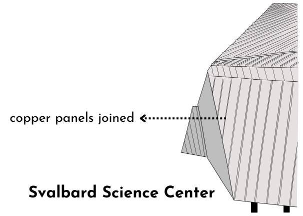
Svalbard Science Center

Fenestration & Orientation

Svalbard Science Center installed **Angled Copper Clad Envelope Façade** , **stilted base** & **clerestory windows** whereas NUS SDE4 use **aluminum Lamellas** & **greeneries** acting as their shading devices



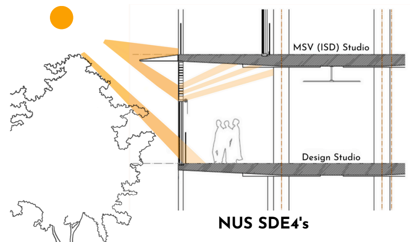
NUS SDE4's



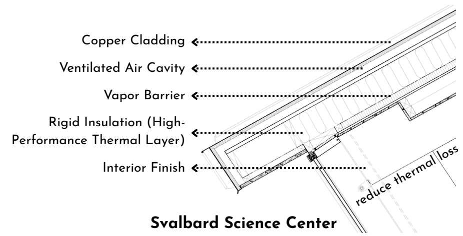
Svalbard Science Center

Materials

Svalbard Science Center utilised **copper panels joined** using a **double-fold technique** which is **low maintenance** & **durable** whilst NUS SDE4 used **perforated aluminum** & **low-e glass** the most for its facade



NUS SDE4's



Svalbard Science Center

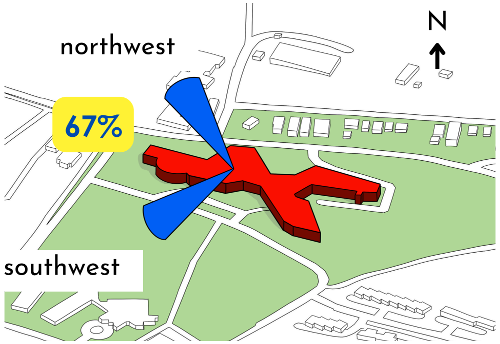
Thermal Insulation

Svalbard Science Center **copper cladding**, **insulated panels** & **air gaps façade** as thermal barrier with steep roof to reduce thermal loss . Whilst NUS SDE4 utilized **greeneries**, **perforated aluminum** & its porous layout to maximize natural ventilation

5.0 Natural Ventilation

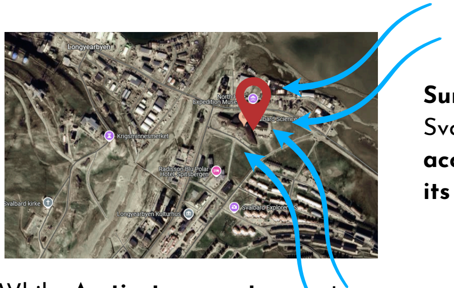
Svalbard Science Centre

5.1 WIND PATH ANALYSIS



Windrose analysis

Based on the wind rose analysis, **67% of prevailing winds** originate **from the northwest and southwest** sectors at **speeds of 5-40 km/h**, with peak gusts reaching **30-50 km/h from the northwest**, while **calm periods below 2 km/h account for 23%** of observations.

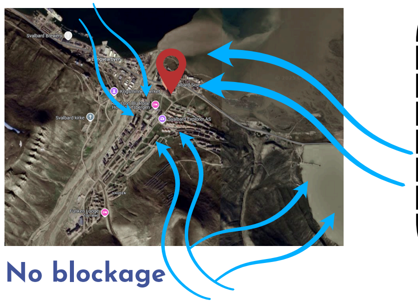


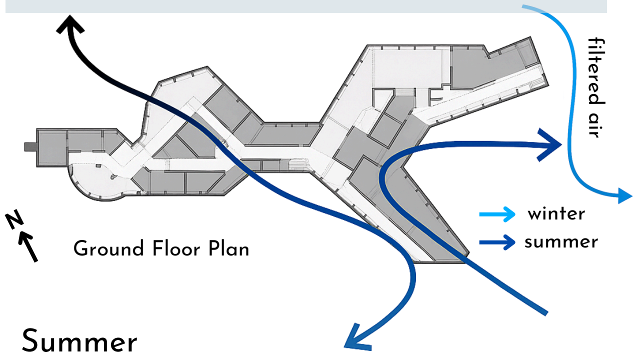
Air movement

Surrounded by mountainous terrain, the Svalbard Science Centre **utilizes valley-accelerated southeast winds** that **press against its oriented facades**.

While **Arctic temperature** extremes create dramatic **pressure differentials**, the **lower outdoor air pressure draws warm indoor air up through roof vents**

Higher-pressure cold air is **pulled in through ground-level openings**, forming a natural ventilation cycle that continuously refreshes interior air with **minimal energy** input in polar conditions.





Summer

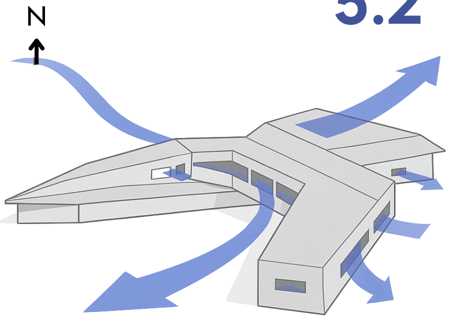
Utilizes operable windows and vents **during mild summer conditions**, harnessing southeast winds for natural cross-ventilation to cool interiors

Air Circulation

Winter

Sealed openings and heat-recovery mechanical systems replace natural ventilation, preserving warmth while maintaining air quality in extreme cold.

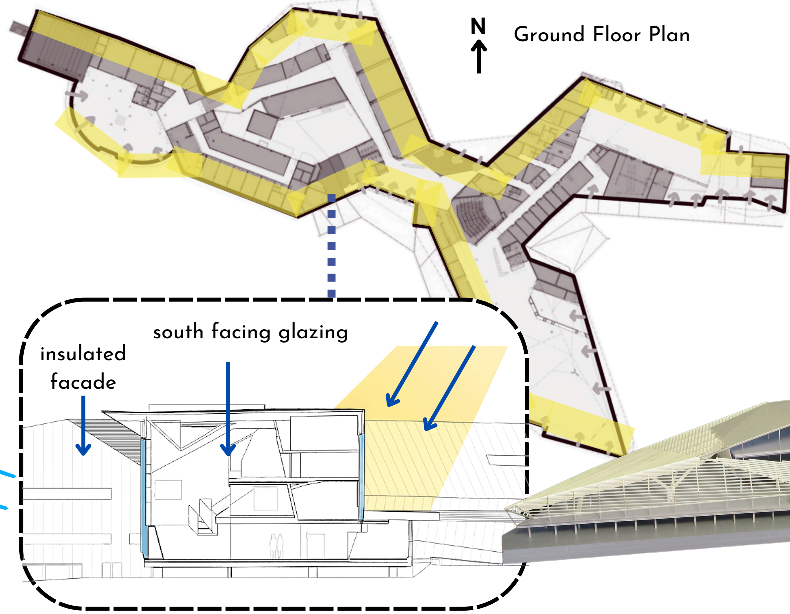
5.2 VENTILATION STRATEGIES



Wind-guided form enables seasonal cross ventilation

Harnessing Wind for Cross Ventilation

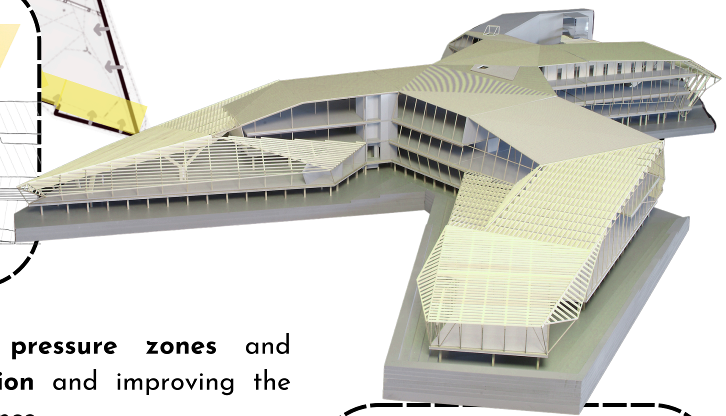
The building's **angled wings** and **open layout** allow **prevailing winds** to pass through internal zones, enabling **natural cross-ventilation during milder periods** and reducing reliance on mechanical systems.



North-south Oriented

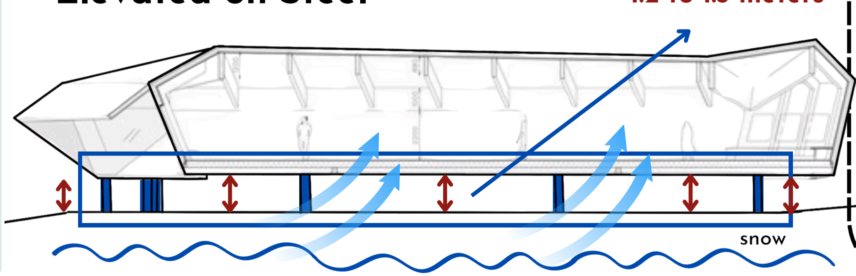
Elongated north-south orientation maximizes passive solar gain through south-facing glazing, while **solid insulated east-west façades shield the building from cold Arctic winds**

Aerodynamics



Aerodynamic form reduces wind pressure zones and **turbulence uncontrolled air infiltration** and improving the stability of passive ventilation performance.

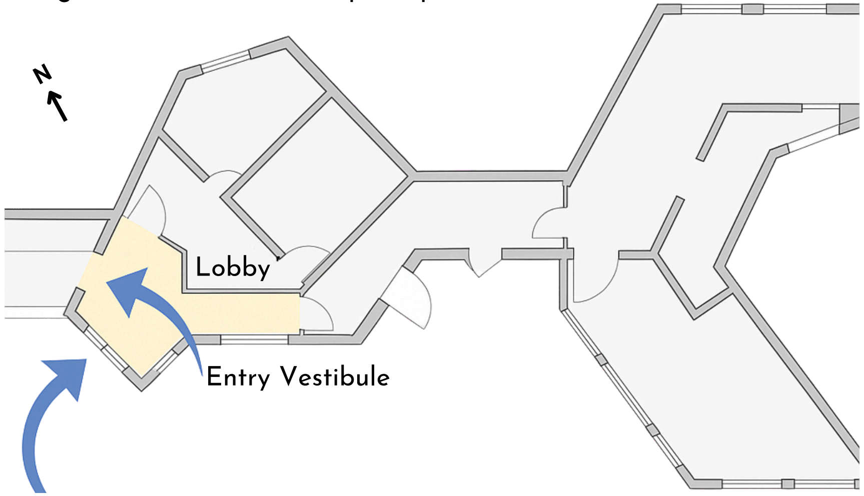
Elevated on Steel



The elevated structure **promotes cold air movement beneath the building**, reducing moisture accumulation from snow, improving pressure balance, and supporting stable passive airflow performance.

Thermal Buffer Zones

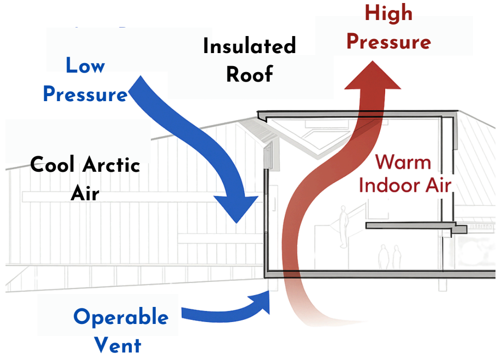
Entry vestibules and semi-conditioned transition zones act as thermal buffers, preventing cold air shocks in occupied spaces.



5.3 PRESSURE DISTRIBUTION

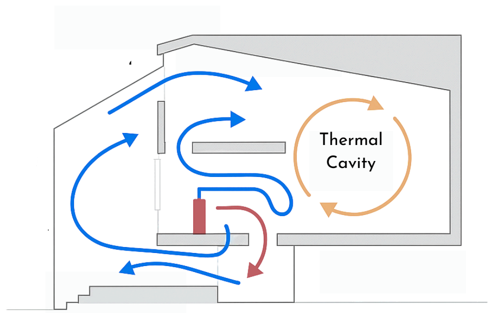
Buoyant Airflow & Natural Convection

Summer



During summer, natural convection occurs as **cool Arctic air** enters through operable windows, while warm **indoor air rises and escapes** via upper cavities.

Winter

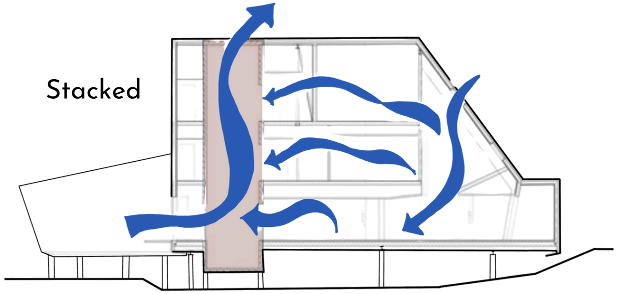


Forced convection through HVAC and radiant heating maintains indoor temperatures at **20-22°C.** Mild natural convection in insulated cavities supports heat retention, with passive leakage kept under **10% of total heat loss.**

5.4 SPATIAL QUALITY

The building focuses more towards interior experience, in- cooperating passive and active thermal control to fits in the artic context.

Stack-Effect Atria

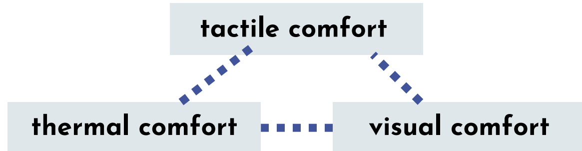


The **centrally placed atrium** leverages the **stack effect** to enhance passive ventilation, drawing in cool air **from lower openings** and improving indoor air quality **across all levels.**

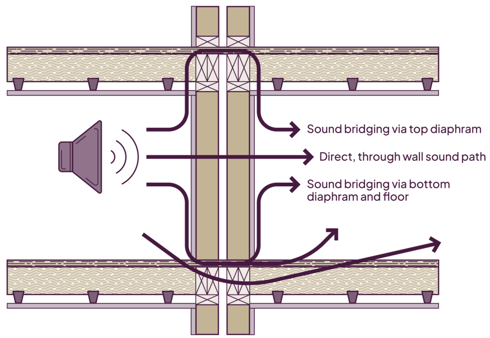
Material & Surface Comfort

Exposed timber and soft materials **create a warmer feel** in naturally ventilated spaces, while their **low emissions** improve indoor air quality.

timber provide coziness



Visual and Acoustic Comfort

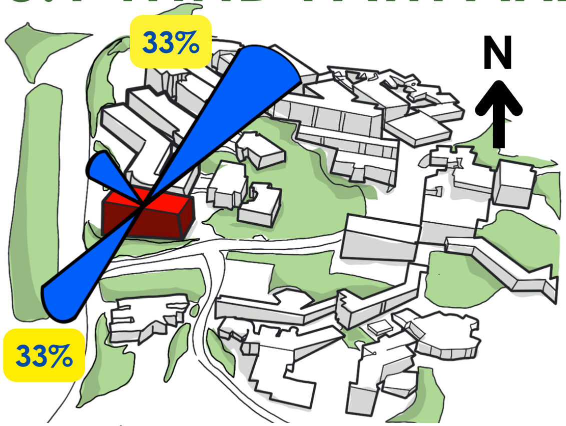


Spaces are **designed with sound-absorbing** finishes and **soft daylighting** to ensure that naturally ventilated zones remain calm and comfortable, **balancing sensory comfort** alongside airflow

sectional detail of how wood react to sound

NUS SDE 4

5.1 WIND PATH ANALYSIS



Windrose Diagram

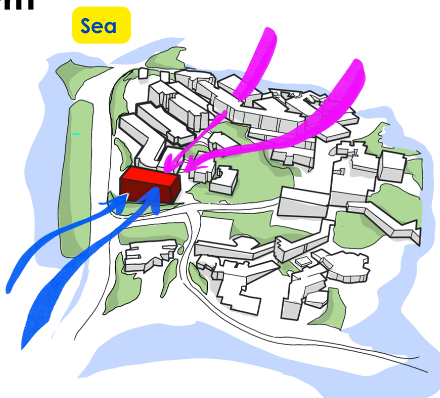
Windrose Analysis

Based on the **Windrose diagram** at a **mean** wind speed of **2.3m/s, almost 67% of prevalent wind comes from the North-East and South-West.** The remaining 23% serve as transitional periods between the monsoons.

Air movement

At NUS, **surrounding buildings** and water bodies, prevailing wind has a tendency to be **redirected.**

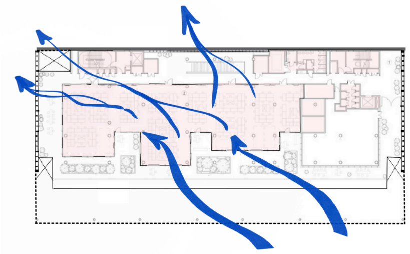
Northern winds are **partially blocked**, while the open treescape to the southeast and southwest allows airflow that helps lower ambient temperatures.



SDE4 also benefits from **sea breezes and evaporative cooling** from its wetland garden, where rising warm air pulls in cooler air **through pressure differences**

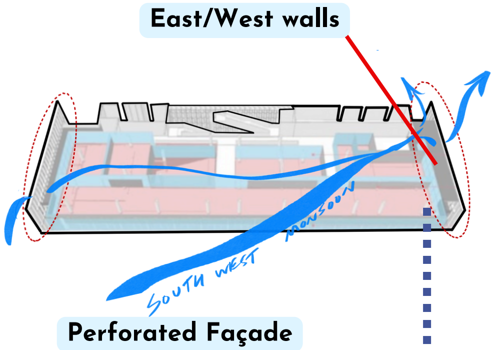
Legend - Prevailing Wind
- Prevailing wind
- Sea breeze
- SDE 4

Air Circulation



At SDE4, air enters through openable windows and doors, aided by multiple voids and open spaces that allow wind to **flow freely and support effective cross ventilation**

5.2 VENTILATION STRATEGIES

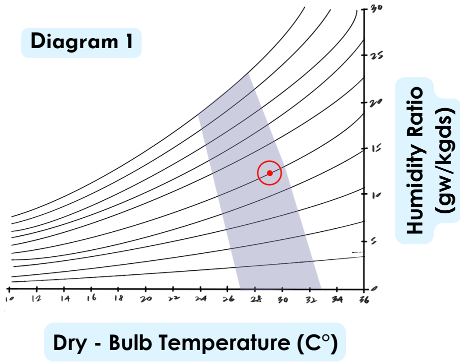


Building Orientation

SDE4 **North/South orientation** allows **predominant wind** direction to form **Cross ventilation** and **stack ventilation.** The **solid East/West walls to reduce heat** incoming to the building.

Perforated Facade

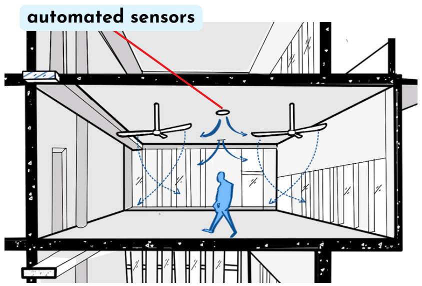
SDE4 features a **perforated facade** on the **east and west** that allows for **air movement and shading**. This design helps to **moderate indoor temperatures** by **preventing direct sunlight** penetration while facilitating air flow, which supports natural ventilation.



Operation and Occupancy Control

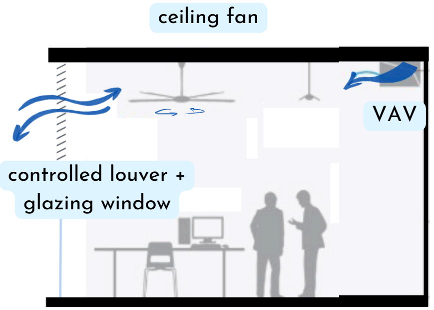
According to Diagram 1, achieving **thermal comfort at 29°C** requires an airspeed of 0.7 m/s, creating a perceived temperature of **26°C.**

Hybrid Tempered System



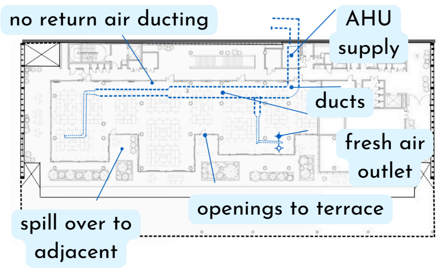
SDE4 uses a Hybrid Tempered System with **Adaptive Thermal Comfort Design** that works alongside natural ventilation.

SDE4 uses **VAV HVAC systems,** ceiling fans, and smart controls that cut AC when windows open. After 6pm, it switches to **natural ventilation** via openable windows for cross-flow.



Ceiling Fans and Airflow Management

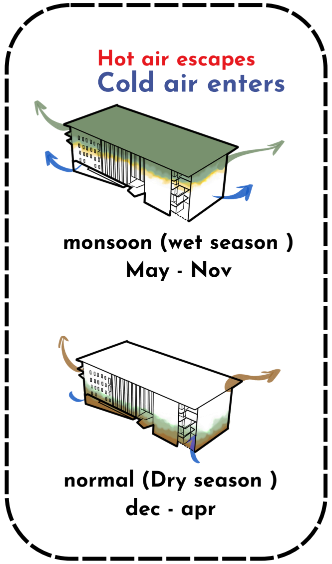
Ceiling fans distribute air effectively, supporting ventilation even with windows partially closed or HVAC at lower speeds. This ensures fresh air is tempered and delivered throughout the space.



Spillover Ventilation and Zoned Airflow

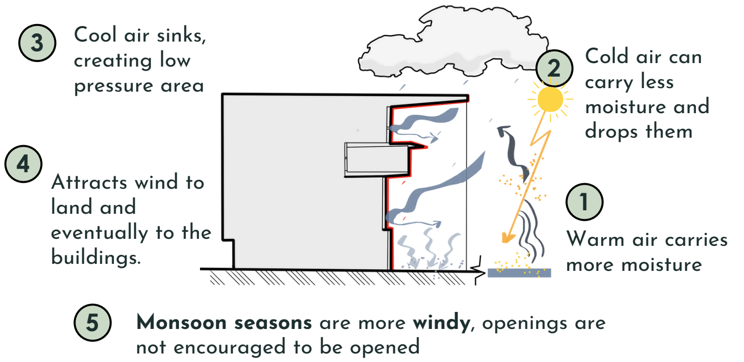
Spillover ventilation **allows air from naturally ventilated areas to flow into adjacent spaces.**

Together, the **supply air system, ceiling fans, spillover ventilation, and openable windows deliver Adaptive Thermal Comfort** in SDE4, promoting energy efficiency and occupant well-being.



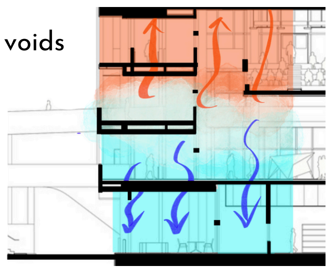
Wind Pressure

During **Monsoon seasons**, the direction of the winds change in the region. As the air gets **heated and rises,** Monsoon **winds blow from the ocean towards the land,** the air inside the building rises as it **warms up** and creates a pressure difference.

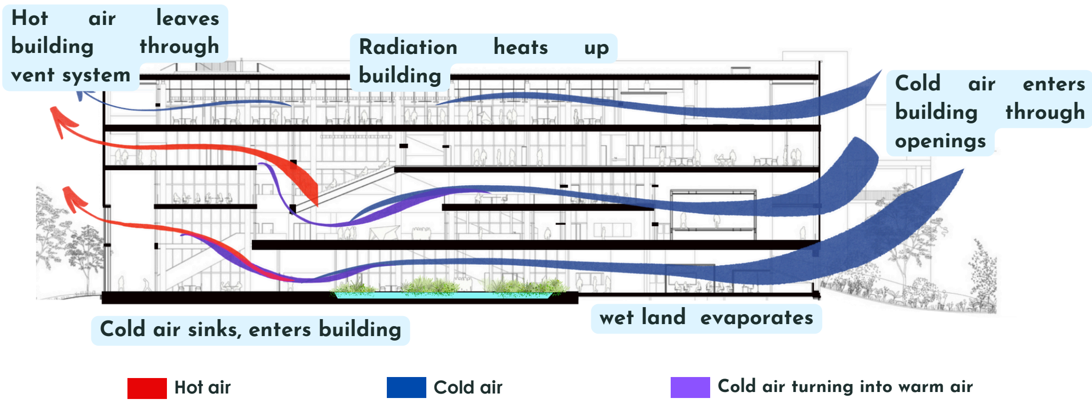


5.3 PRESSURE DISTRIBUTION

Natural Convection



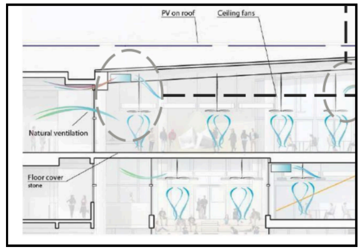
Double-volume spaces and **vertical voids form vertical air pathways,** allowing warm air to rise and exit through **high-level openings**. This **stack effect** draws in cooler air from **lower openings**. Openable windows and façades enhance this **stack-driven movement**, especially with indoor-outdoor temperature differences



5.4 SPATIAL QUALITY

Indoor air quality

Equipped with smart sensors that continuously monitor indoor air quality, including CO_2 **levels.** If concentrations approach **750 ppm**, the **system activates mechanical ventilation (VAV)** to introduce fresh air and reduce CO_2, maintaining air quality.



Permeable Interior

Louvres and openings ensure **natural airflow**, creating a comfortable work environment.

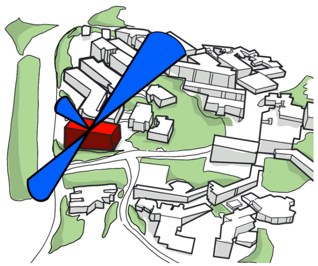
Green Blanket

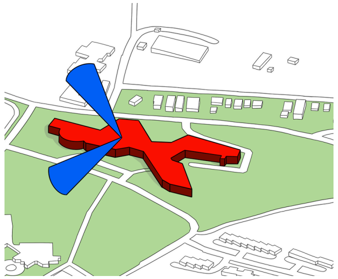
The surrounding **treescape & wetland garden** serves as a barrier against gust and other inconveniences such as glare and noise.
These **greeneries help to cool air** through evapotranspiration.

6.4 COMPARISON

Air movement

Both buildings are surrounded by buildings with NUS SDE4 **facing a massive treescapes and Svalbard Science Center** in a relatively less clustered area, causing wind direction to deviate.



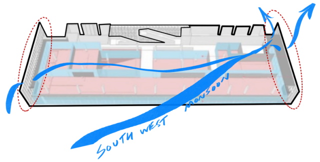


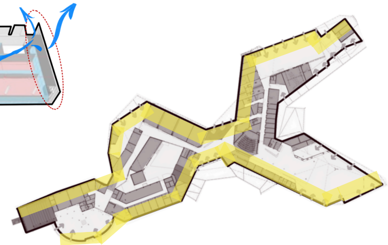
Wind analysis

Both buildings are affected by seasons, causing the Svalbard Science Center to rely on active ventilation while **NUS SDE4** utilizes natural ventilation & adaptive Thermal Comfort Design all year round.

Orientation

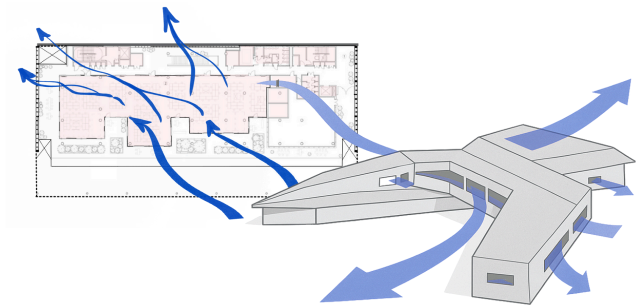
Both **buildings implement natural ventilation through strategic building orientation.** However, Svalbard Science Center relies more on mechanical ventilation. Where as NUS SDE4 takes advantage of natural ventilation.





Air circulation

The air circulation in NUS SDE4 may be more efficient as **compared to the Svalbard Science Center due to its smaller area**.



6.0 Strategic Landscaping

6.1 PLANTSCAPE

The south gardens function as a natural purification system, where runoff from the roof and hardscape is filtered through soil, removing sediments and soluble nutrients.

Native Plant Species

Approximately 50% of the plant species used are native to the region, enhancing biodiversity and providing educational opportunities related to local ecosystems.

Phytoremediation

Phytoremediation is subtly integrated through sustainable landscape features such as rain gardens and native vegetation, which **naturally filter pollutants**, support ecological resilience, and enhance the building's net-zero environmental performance.

polluted water

phytoremediation

clean water

Species Introduction and its Function towards Human

outdoor

Tradescantia Spathacea

-reducing stress-

Moses-in-the-Cradle, with its striking green and purple leaves, purifies air by removing toxins like **formaldehyde and xylene**, boosts indoor humidity, repels mosquitoes, and helps **reduce stress**

Alpinia Zerumbet

-improves air quality-

Known as Variegated Shell Ginger is a tropical plant with **striking variegated leaves** and **pink shell-like flowers**. It improves air quality, **attracts pollinators**, and thrives in bright.

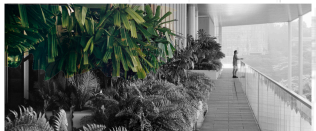
corridor

Nephrolepis Exaltata

-remove pollutants-

Known as Boston fern, is beneficial by removing harmful pollutants and can support respiratory health. However, it may cause allergic **reactions or skin irritation.**

Licuala Spinosa



-filter indoor air-

Improves indoor air quality by filtering toxins like **formaldehyde and benzene**, adds a calming natural touch.

Urban Oasis

Biodiverse, climate-sensitive design with shaded terraces and green edges that **contrast urban density** and enhance natural comfort.

Samanea Saman

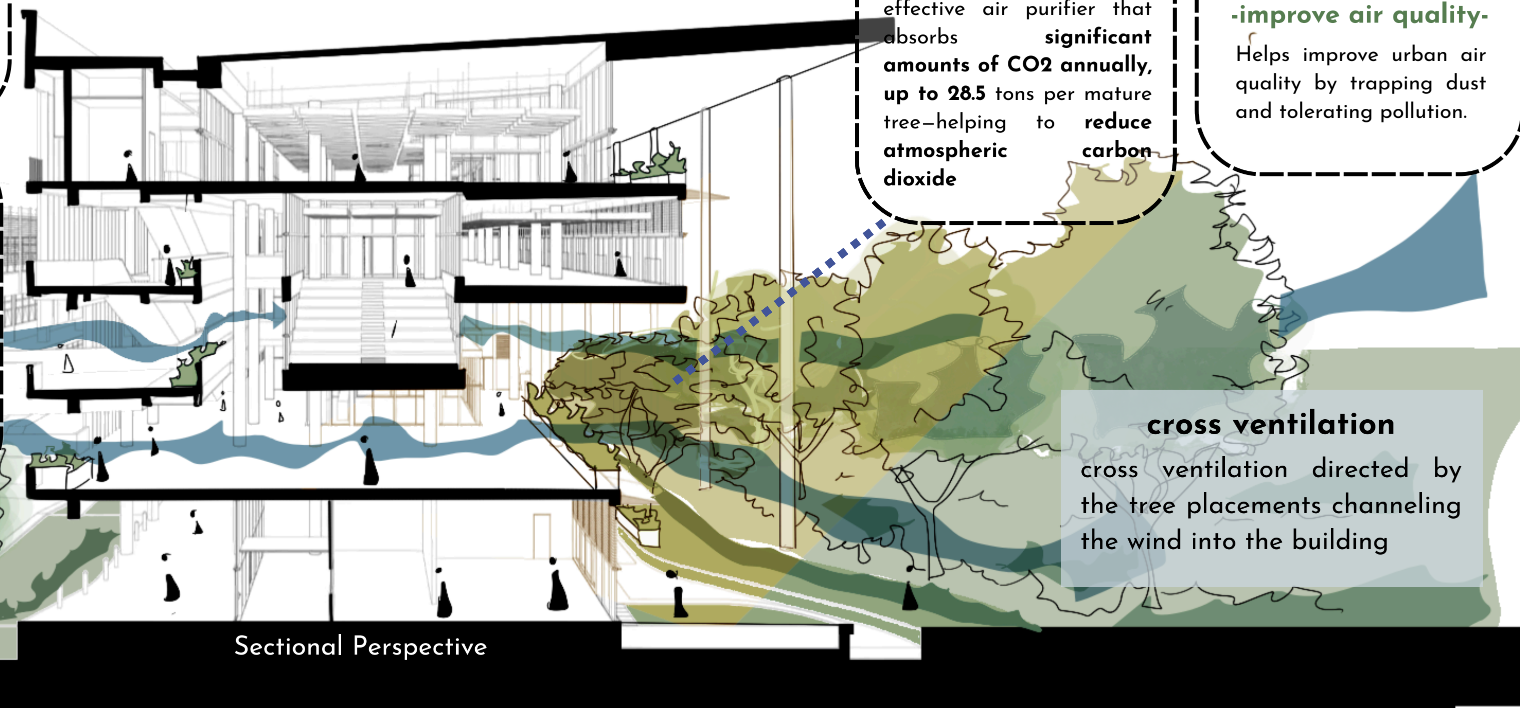
-reduce carbon dioxide-

Known as the **Rain Tree or Monkey Pod Tree**, is an effective air purifier that absorbs **significant amounts of CO_2 annually, up to 28.5** tons per mature tree—helping to **reduce atmospheric carbon dioxide**

Bougainvillea Glabra

-improve air quality-

Helps improve urban air quality by trapping dust and tolerating pollution.



cross ventilation

cross ventilation directed by the tree placements channeling the wind into the building

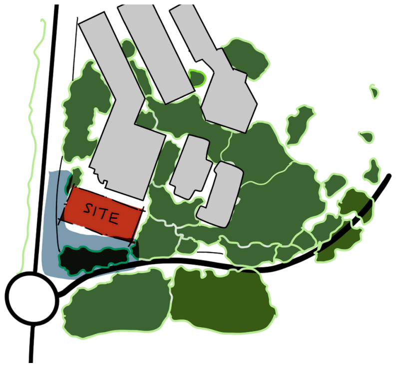
Sectional Perspective

NUS SDE 4

6.2 SITE RESPONSE

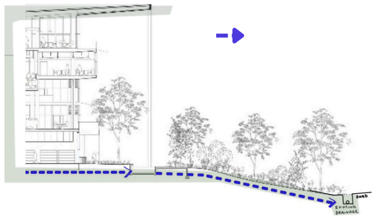
Plants act as a carbon sink, helping mitigate the **urban heat island effect.**

Integration With Nature and Topography



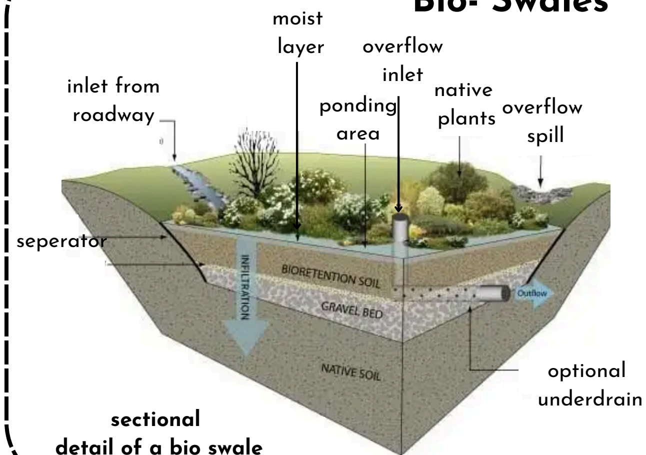
building tilted in the greenscapes

The building's layout **preserves existing mature trees and utilizes the site's natural slope**, embedding the structure seamlessly within its landscape.



The plants in the landscape are **native which are adapted** to rainfall patterns & soil conditions.

Bio- Swales



sectional detail of a bio swale

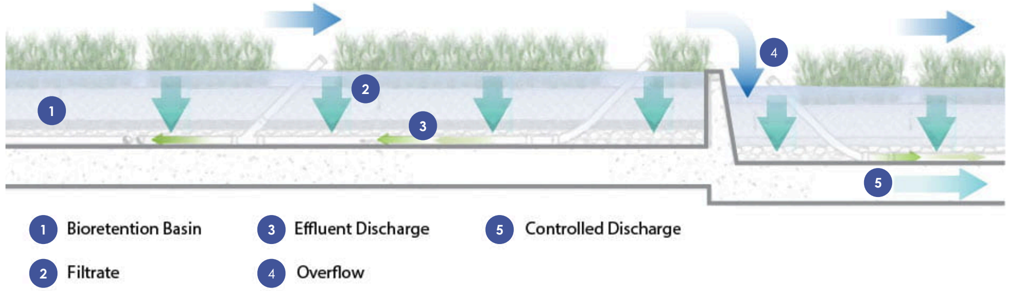
Enhances groundwater **recharge and prevents** rally discharge into sewers, reducing the risk of downstream flooding.

Bio Retention Controlled Wetland

Under BCA's Green Mark Criteria (2016), **buildings earn points for using non-potable scavenged water** to reduce reliance on potable supply. NUS SDE4 implements this by:

Harvesting rainwater from its **rooftop into a collection system**.

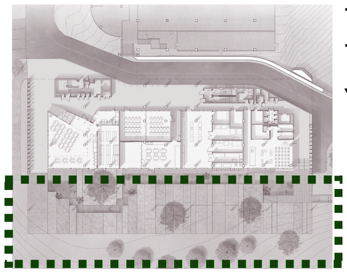
Using two-thirds of collected rainwater for **toilet flushing** and **irrigating rooftop** and **landscape gardens**, significantly cutting down potable water usage.



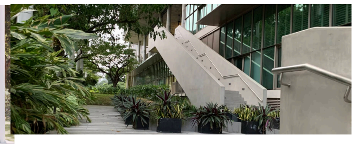
Channeling the **remaining water through a simulated wetland or bio-retention basin**, which naturally **filters pollutants through soil, gravel, and plant roots.**

6.3 SPATIAL QUALITY

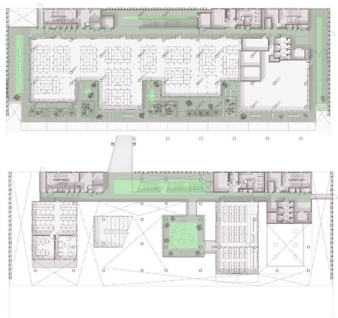
Outdoor Public Spaces



There is a plaza act as **communal gathering spaces.** These are open, flexible zones where students, staff, and visitors can pause, relax, or hold events.



Semi-outdoor Terraces



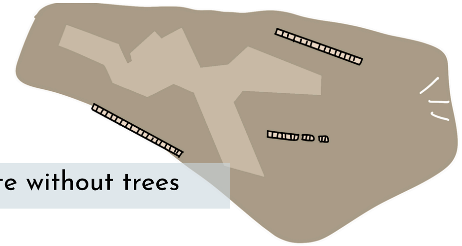
The terraces **offer areas for rest and group work** while serving as **thermal buffers** that enhance ventilation and provide shade.

Svalbard Science Centre

6.1 PLANTSCAPE

Clear and Concise Options

The site lies in the Arctic tundra biome, where **permafrost blocks root growth**, summers are short and cold, and the soil is nutrient-poor with poor **drainage—making tree growth impossible**.



Contextual Integration with the Tundra Terrain

Svalbard hosts around **180 vascular plant species** and over **300 mosses, lichens, and liverworts**. These form diverse vegetation types with varying resilience to disturbance.

Sanionia Uncinata

Also called Arctic moss, it forms thick carpets and is highly cold-tolerant.

Polytrichum Hyperboreum

Known as Arctic haircap moss, it thrives in Arctic zones and has a distinct gametophytic structure.

Sphagnum girgensohnii

A hardy peat moss with green to straw hues and a unique branching pattern.

Calliergon giganteum

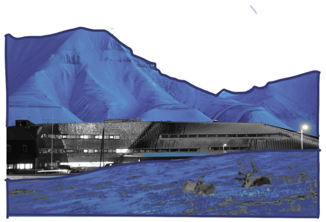
Also called giant spearmoss, this aquatic moss stores nutrients to survive cold tundra lake beds.

6.2 SITE RESPONSE

The ground cover at the Svalbard Science Centre is preserved in its natural Arctic state, **prioritizing protection over landscaping**.

Contextual Integration with the Tundra Terrain

Building was made **subtly embedded** within the landscape, framing the backdrop and simultaneously affect the form development and design process.



Natural Arctic Tundra and Rocky Terrain

Features native tundra with sparse mosses, lichens, hardy plants, and exposed rocks and gravel

No Traditional Lawn or Gardens

Lawns, flower beds, and cultivation are avoided due to the Arctic's harsh conditions and slow-growing vegetation

Svalbard Science Centre

6.3 SPATIAL QUALITY

Seasonal Sensory Experience

The design responds to **polar light cycles**, enhancing user awareness of seasonal changes.

Framed Natural Views

Large windows offer constant visual connection to the Arctic landscape such a, sky, mountains, and snow.

Colour and Material Selection

Use of **local materials and colors**helps the building visually blend with the rocky terrain, **creating harmony between built and natural elements**.

6.4 COMPARISON

Landscape as a Functional and Interactive Eco-System

NUS SDE4 **adopts an active, climate-responsive** landscaping approach, **using native vegetation, rain gardens, and tree placements** to support **phytoremediation, biodiversity, and natural ventilation**. Outdoor spaces like **plazas and terraces** promote human interaction, comfort, and learning in a tropical climate.

Landscape as a Preserved Arctic Canvas

Svalbard Science Centre, in contrast, follows **a minimalist, preservation-focused strategy.** It avoids traditional landscaping due to the fragile Arctic tundra, **instead embedding the building within the natural terrain and framing the landscape** through windows.

Its design fosters a **passive, contemplative connection to the environment,** emphasizing ecological respect over intervention.

7.0 CONCLUSION

Through this comparison of NUS SDE4 in tropical Singapore and the Svalbard Science Centre in the Arctic, we see how architecture can be deeply responsive to its climate and environment. While both buildings aim for sustainability, they take very different paths based on their local conditions. NUS SDE4 embraces openness, daylight, and natural ventilation to reduce energy in a hot, humid climate. Its terraced massing, porous form, and green strategies—like rain gardens and hybrid cooling systems—create comfort while staying connected to nature.

Meanwhile, Svalbard Science Centre works with extreme cold, snow, and low sunlight. Its copper-clad envelope, steep roofs, and low-angle glazing are designed to manage snow loads and capture limited daylight without losing heat. The building's orientation and form reflect a respect for the Arctic landscape, blending into its context with minimal environmental disruption.

What ties both buildings together is the idea that architecture isn't one-size-fits-all. Instead, it should adapt—visually, technically, and emotionally—to where it stands. These two case studies remind us that good design listens closely to place. In the end, green architecture isn't just about saving energy—it's about creating spaces that work in harmony with the world around them.

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