Welcomme to your STEAM dream!

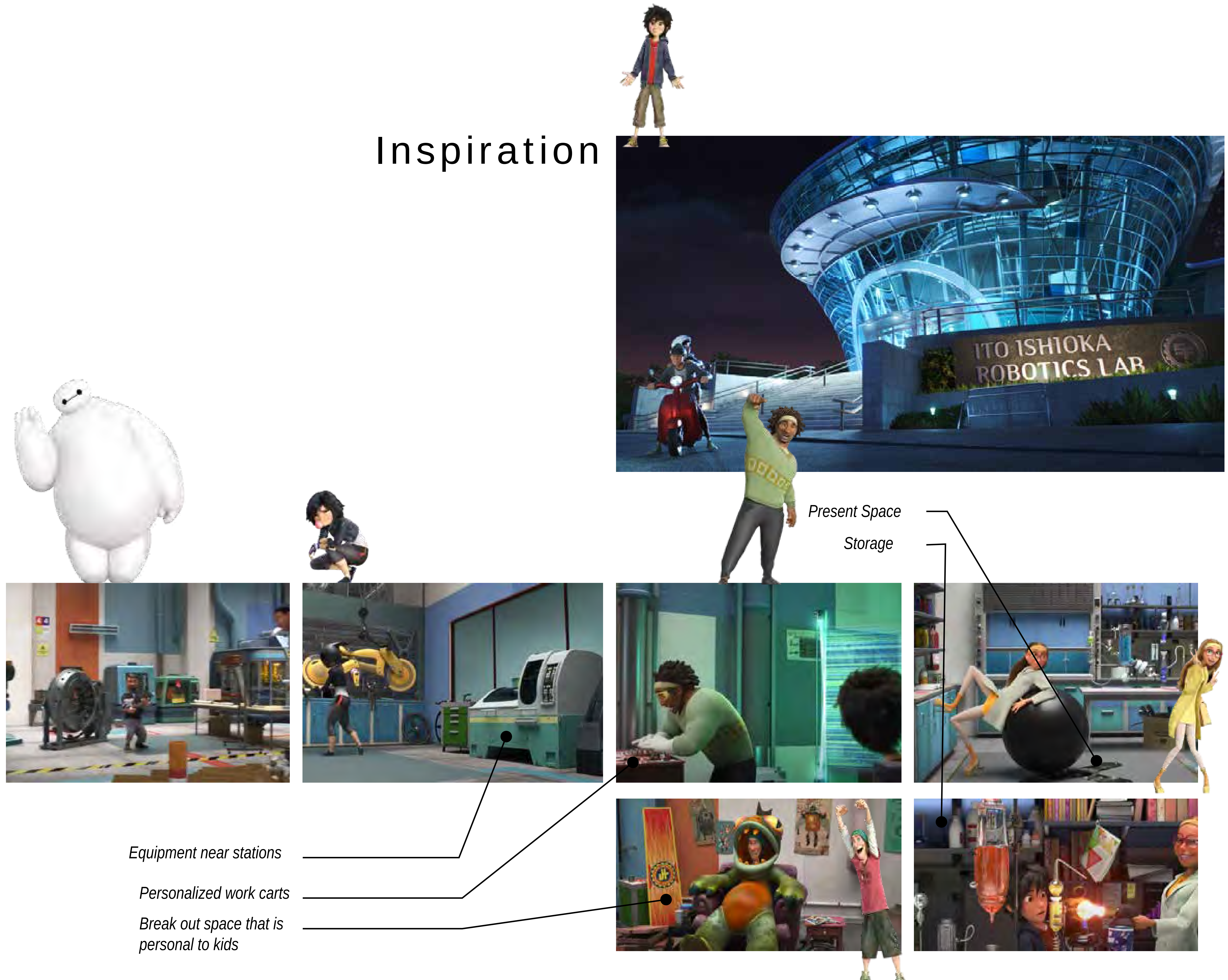
CONCEPT

Colors of individual characters inform the use of colored glass within light-wells.

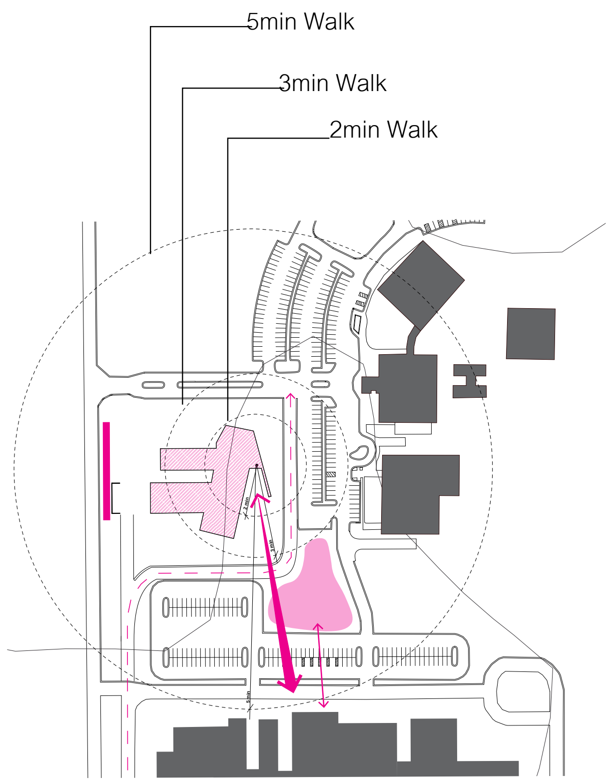
Each maker space is informed by the personalized presenting space each Big Hero 6 character has, teaching the students how to become independent and confident in their own work.

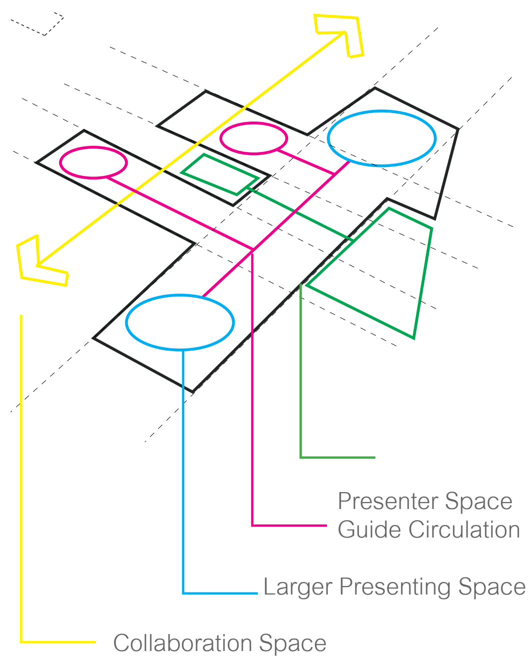
Each space begins to form around a specialized presenter space that is incorporated into the maker space.

Inspiration

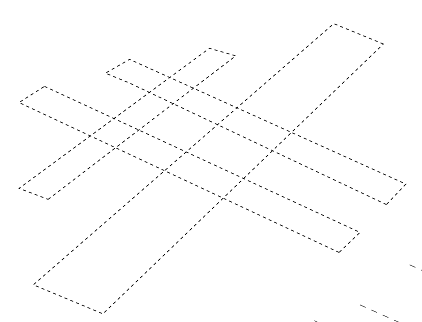


SITE ANALYSIS

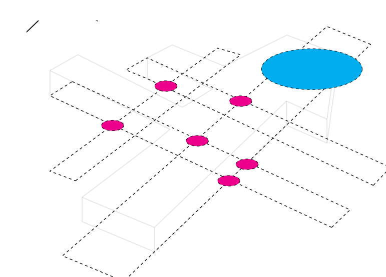




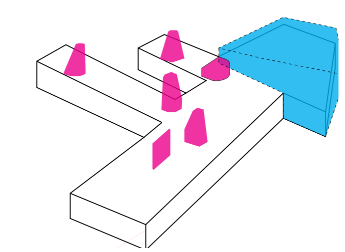
The school extends its curiosity to the adjacent schools by creating shared proposed play space and adventure path. Existing school pick up lines are utilized and continued onto the site. The existing church parking lot becomes a spill space that extends the robotics activities.



Intersection: Simple forms are overlapped to create space that engages the students minds creating a sense of adventure and curiosity.



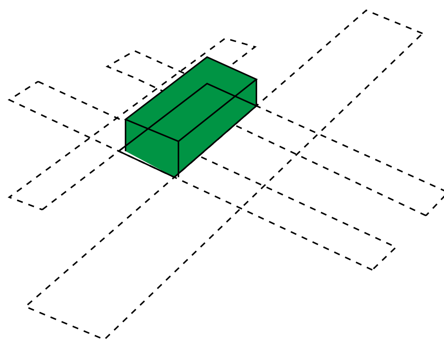
Light-well Presenter Space: Presenter spaces placed along axis for continuous curiosity.



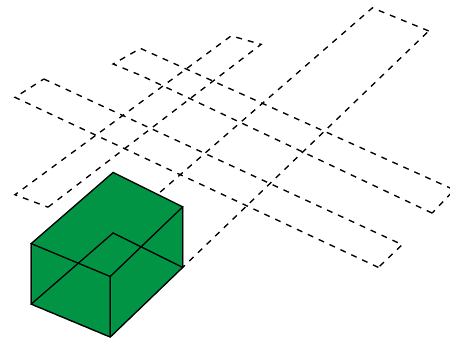
The Jewel: The big presenter space is the final point at which students get to embrace their inner Hiro and feel as if they are the inventors of their future.

CONCEPT

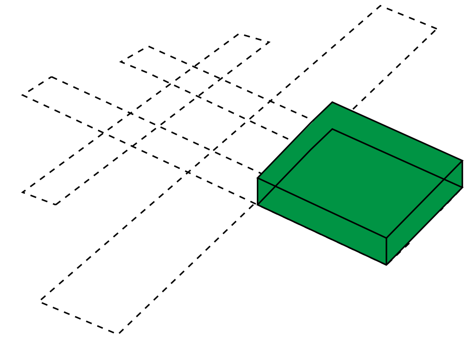
Collaboration



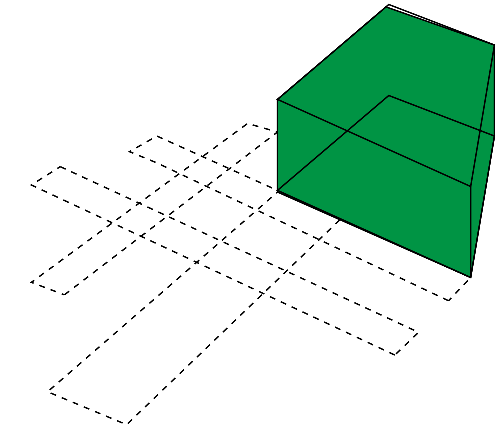
Outdoor Courtyard



Testing Space

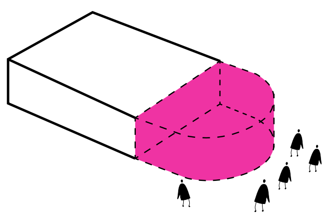


Outdoor Event Space



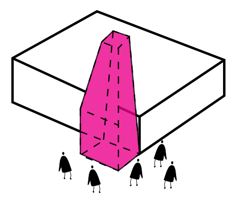
“Science Fair” Space

Presenter



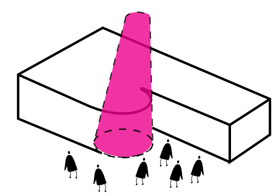
KITCHEN

A space where there are operable windows where students can “sell” their food they make to the public and the school



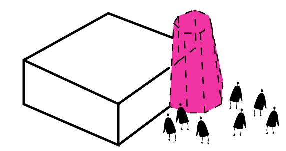
ROBOTS

A small stage where students can watch other students present their robots to the class



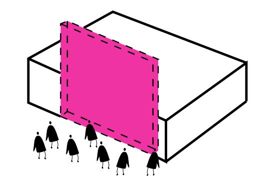
WOOD

A ramp and display stage where students can show how their creations operate



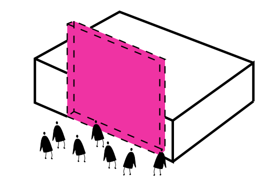
ART

A small gallery space where artwork, sculptures, posters can by displayed



CHEMISTRY

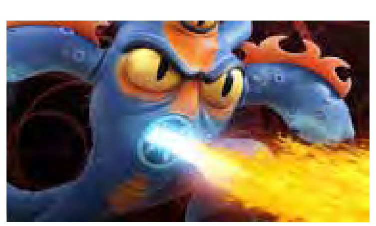
A small shelved wall were students can see the experiments that other students are doing

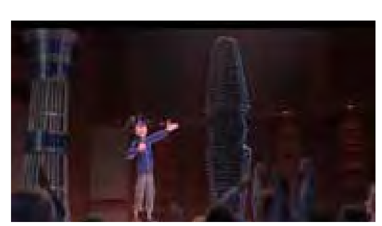


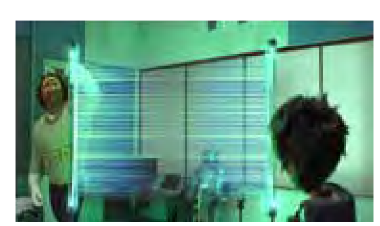
COMPUTERS

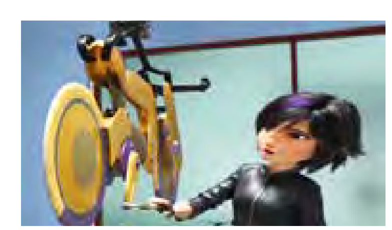
A digital wall that is translucent where codes and other programing methods are displayed

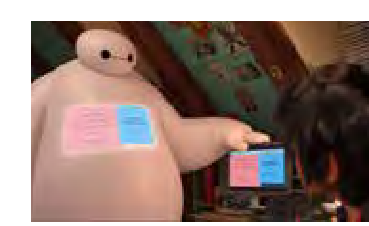
Activity









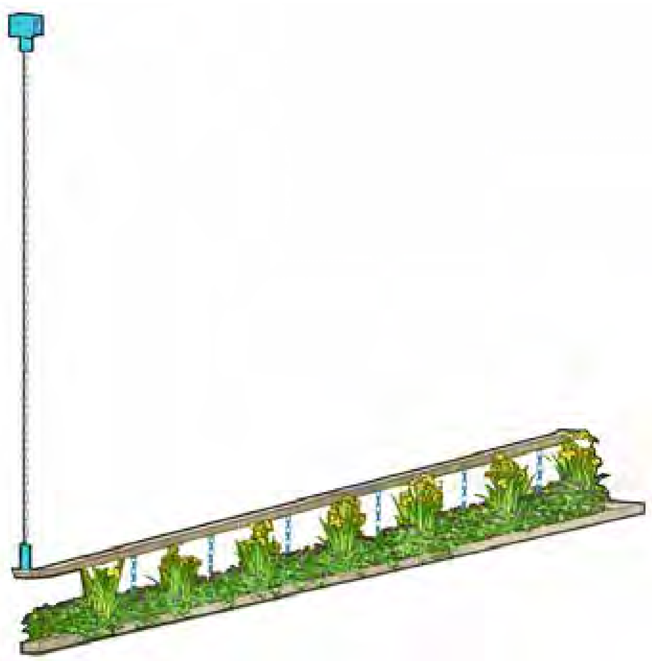


View of Presenting Space

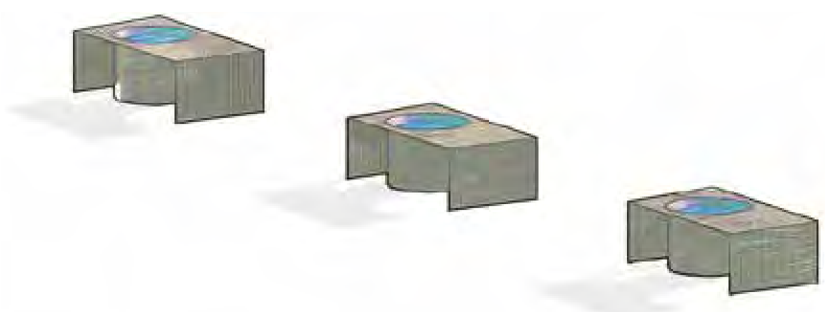
Science Fair Space

SITE PLAN

Drainage

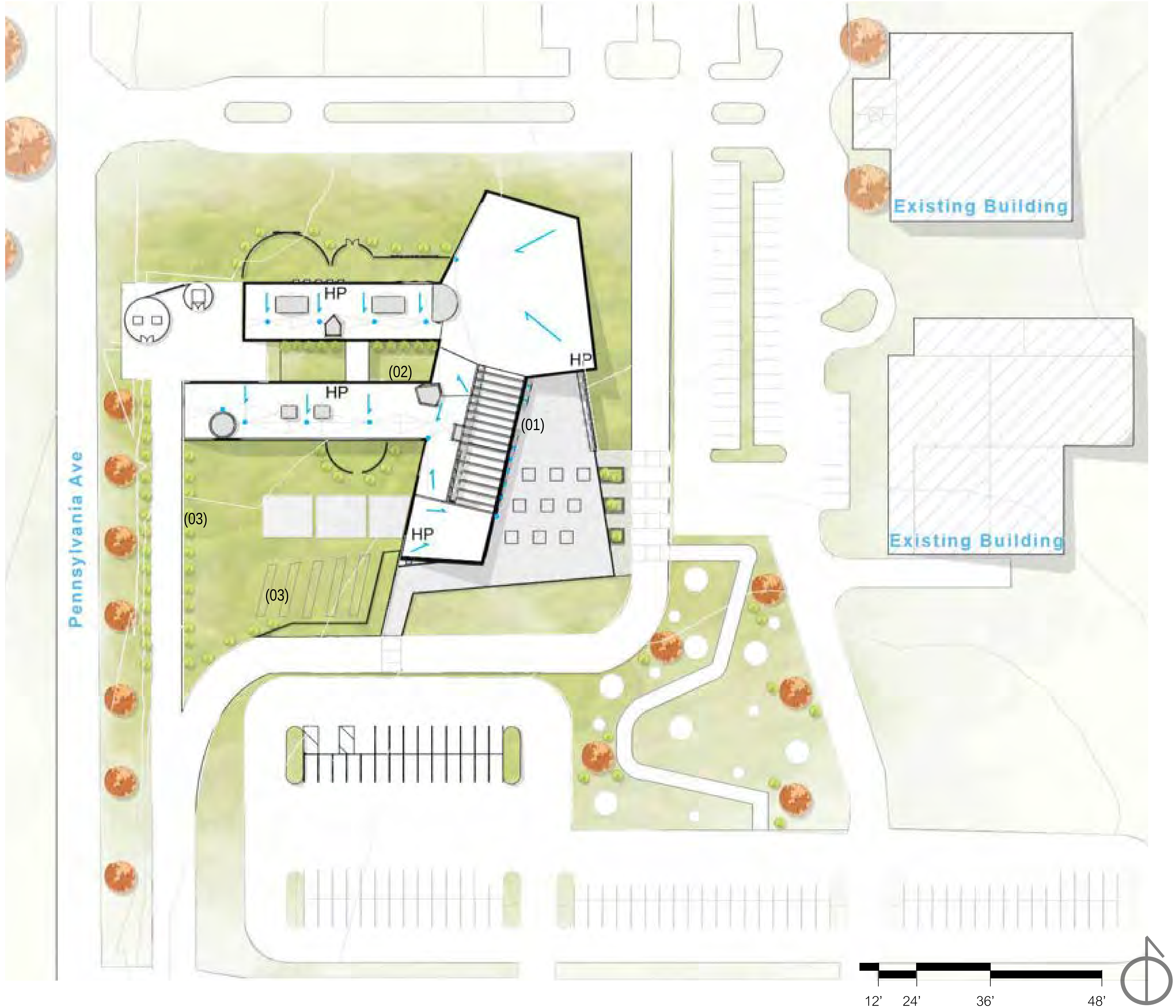


Rain Chains (01)



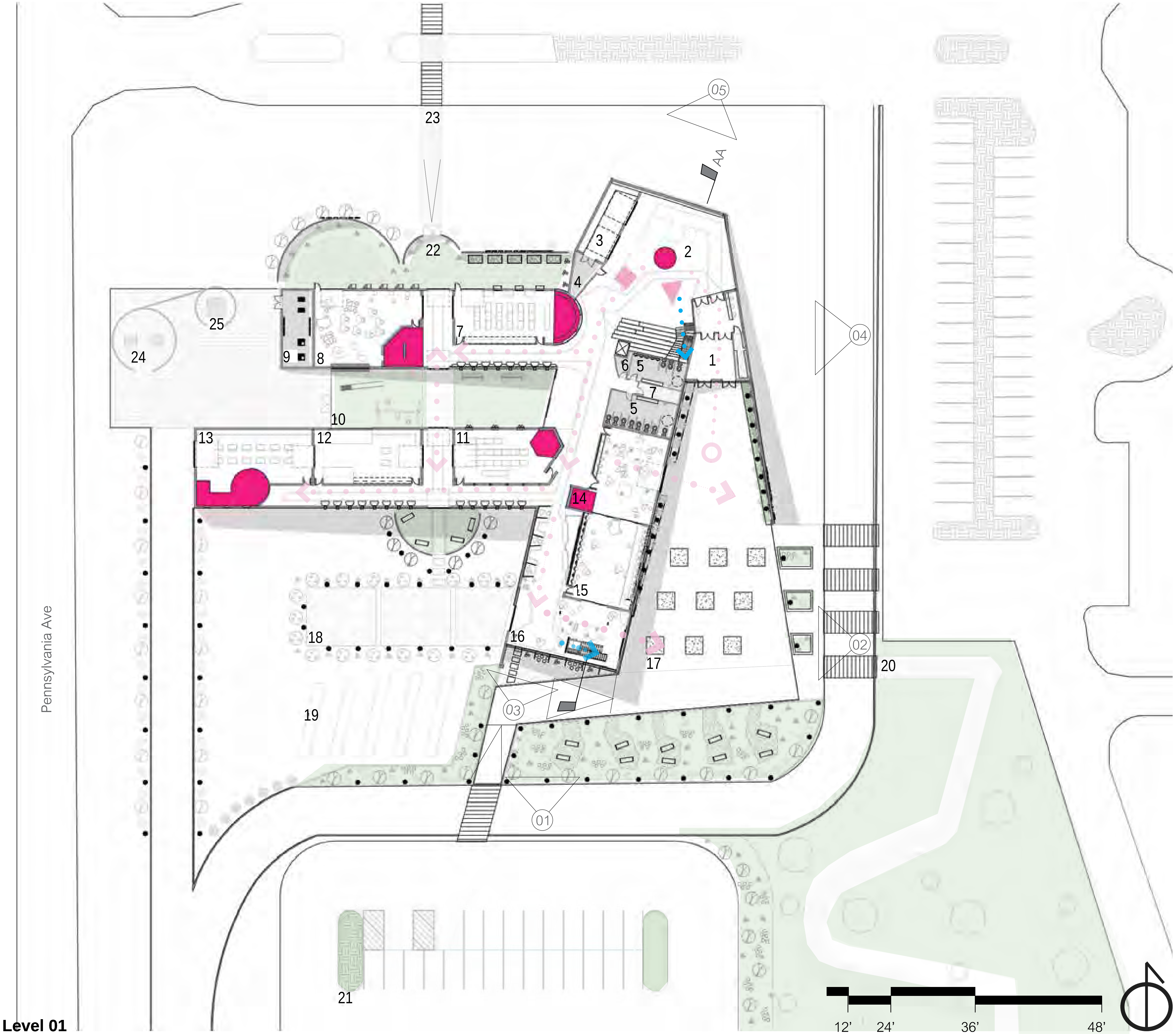
Collection Tables (02)

Bioswales (03)



FLOOR PLANS

1. Entry Loby
2. Gathering Space
3. Library
4. Storage
5. Restrooms
6. Mech | Storage
7. Teaching Kitchen
8. Art Studio
9. Mechanical Room
10. Outdoor Courtyard
11. Chemistry Lab
12. Woodshop
13. Woodworking Lab
14. Robot Lab
15. Computer Lab
16. Robot Testing Space
17. Robot Fighting Area
18. Robot Practice Space
19. Bioswales
20. Proposed Playspace
21. New Parking
22. Outdoor Breakout Space
23. Proposed Connection to North Plot
24. Trash Enclosure
25. Transformer

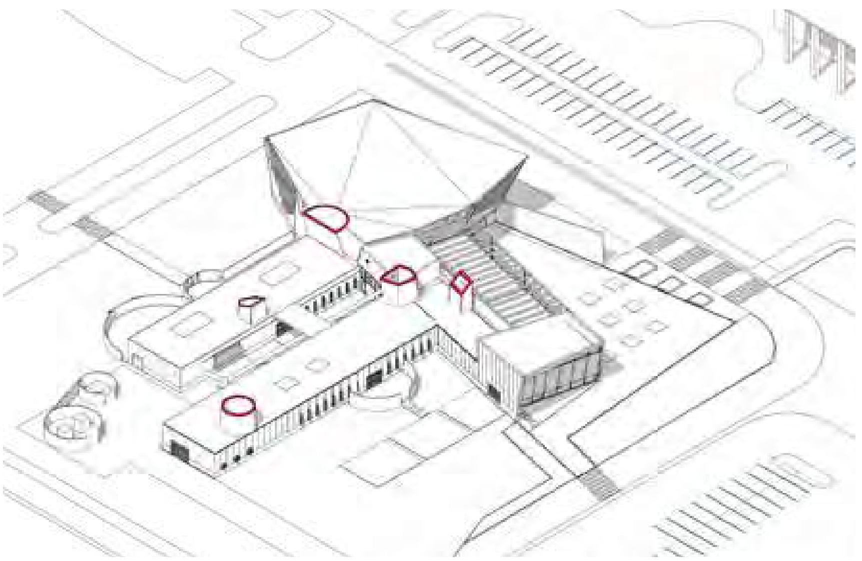


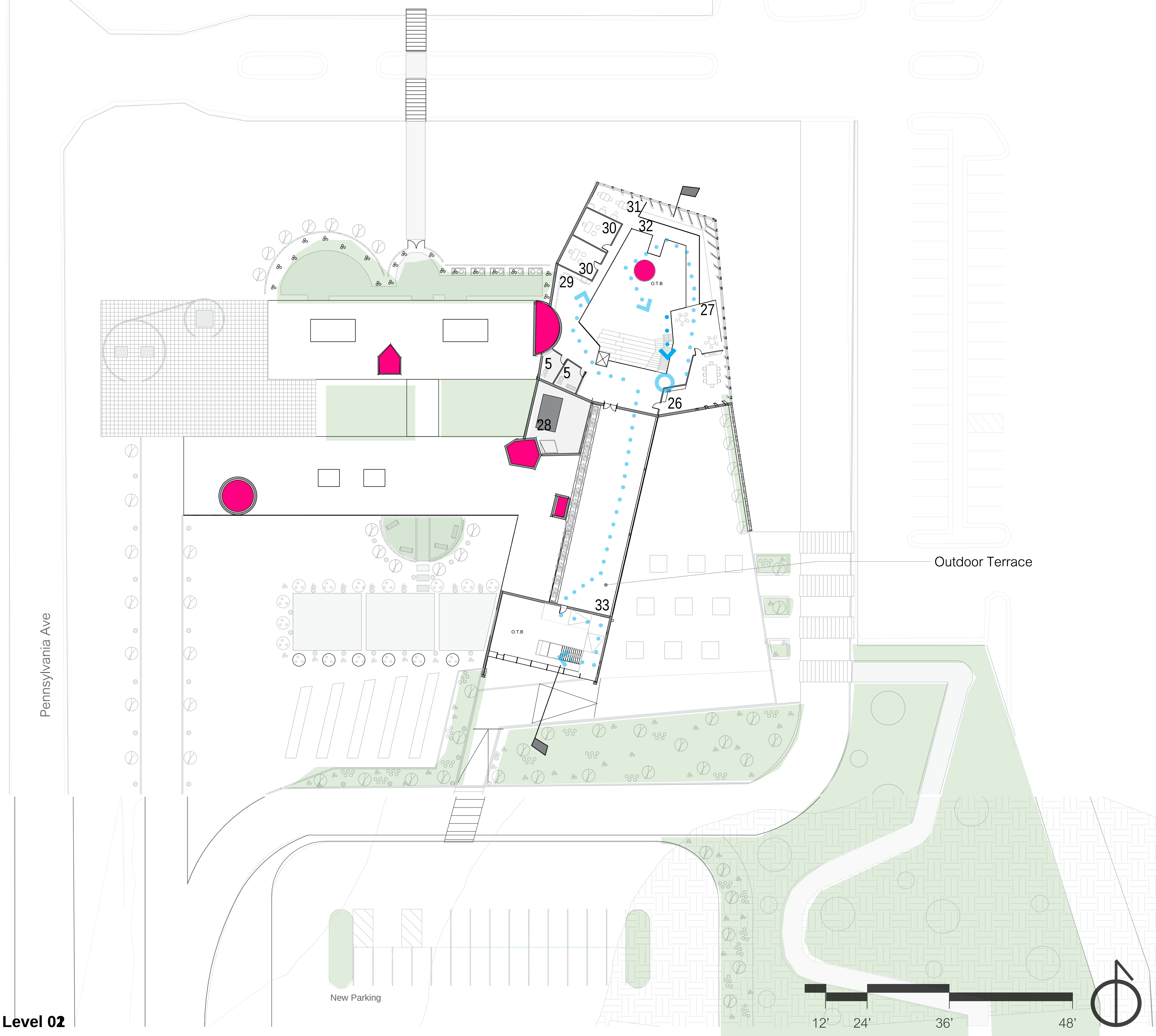
Level 01

DD

Courtyard View

FLOOR PLANS

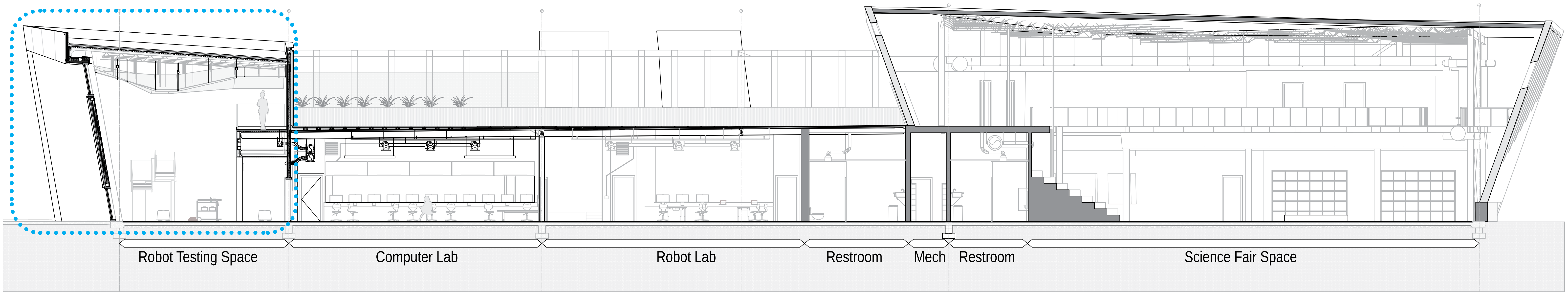




26. Board Room
27. Viewing Space
28. Fan Room
29. Lounge
30. Office
31. Open Office Space
32. Catwalk

Level 02

SECTION



Section AA

Focus Space R & U Values

Roof

Material	R-Value	
Outside Air	0.25	ASHRAE T1
Roof Membrane EDPM	0.33	ASHRAE T4
Vapor Barrier Permeable Felt	0.06	ASHRAE T4
4" Rigid Insulation Polyiso	25.0	Polyiso.org
Inside Air	0.92	ASHRAE T1

R-Value 26.6
U-Value 0.0377 < 0.039 OK

Slab On Grade

Material	R-Value	
Inside Air	0.92	ASHRAE T1
Terrazzo Floor Finish	0.08	ASHRAE T1
5" Concrete	0.5	IECC TC402.1.3
Vapor Barrier	0.06	ASHRAE T4

R-Value 1.56
U-Value 0.64 < 0.73 OK

Exterior Wall [Without Thermal Bridging]

Material	R-Value	
Outside Air	0.25	ASHRAE T1
2.5" Centria FWGX Panel W/ Foamed-in-placed polyisocyanurate	20	Centria
1" Air Cavity	2.32	ASHRAE T2
2" Rigid Insulation Polystyrene	2" x 5.0	ASHRAE T4
Vapor Barrier Permeable Felt	0.06	ASHRAE T4
1/2" Sheathing Gypsum	0.45	ASHRAE T4
6" Metal Stud 6" @ 24"	7.03	IECC TC402.1.4
6" Batted Cavity Insulation	0.45 x 19	ASHRAE T4
1/2" Gypsum Board	0.45	ASHRAE T4
Inside Air	0.68	ASHRAE T1

R-Value 49.89
U-Value 0.02004 < 0.064 OK

Exterior Wall [With Thermal Bridging]

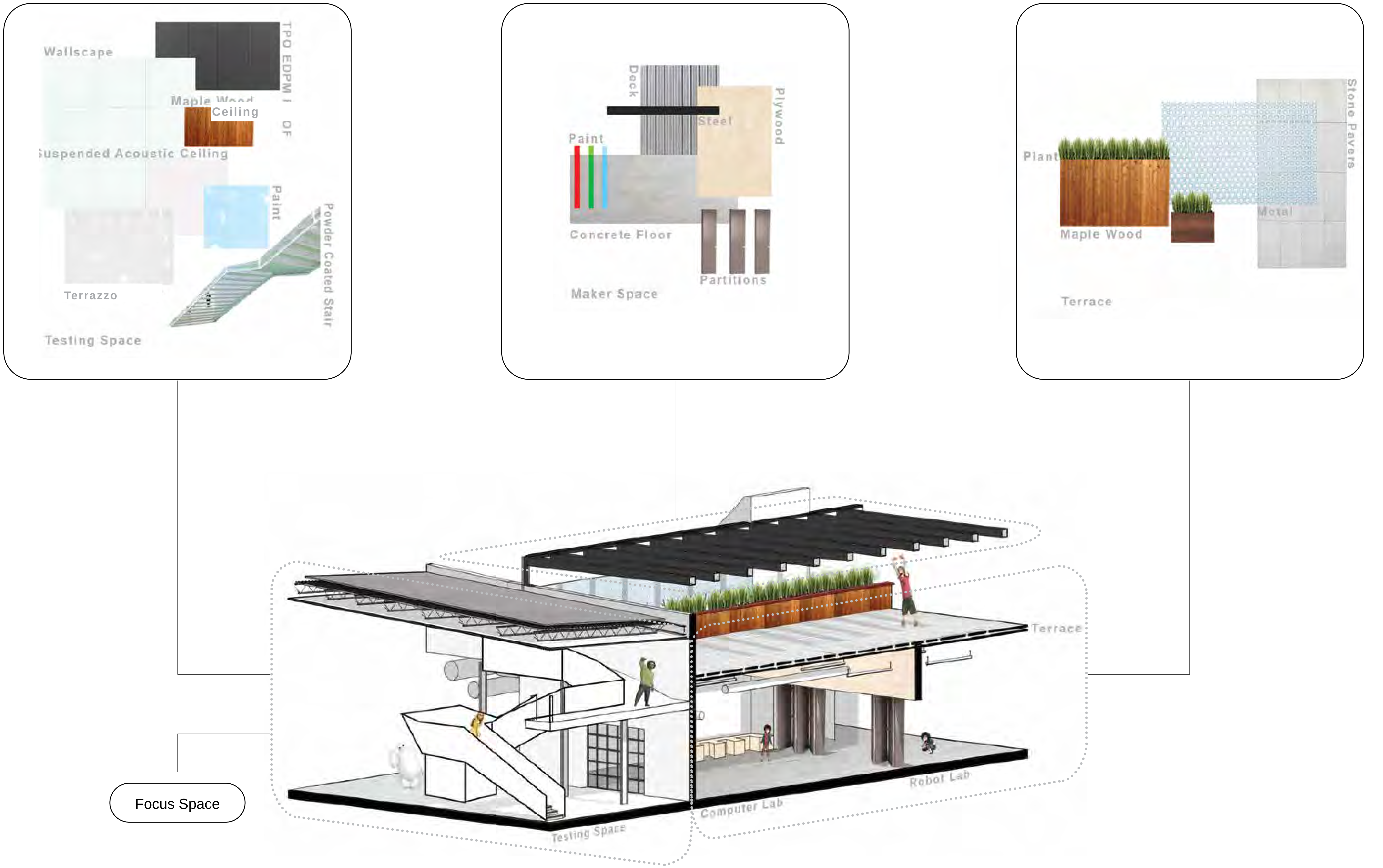
Material	R-Value	
Outside Air	0.25	ASHRAE T1
2.5" Metal Panel	16	Centria
1" Air Cavity	2.32	ASHRAE T2
2" Rigid Insulation Polystyrene	2" x 5.0	ASHRAE T4
Vapor Barrier Permeable Felt	0.06	ASHRAE T4
1/2" Sheathing Gypsum	0.45	ASHRAE T4
6" Metal Stud 6" @ 24"		IECC TC402.1.4
6" Batted Cavity Insulation	7.0	ASHRAE T4
1/2" Gypsum Board	0.45	ASHRAE T4
Inside Air	0.68	ASHRAE T1

R-Value 37.2
U-Value 0.0269 < 0.064 OK

DD

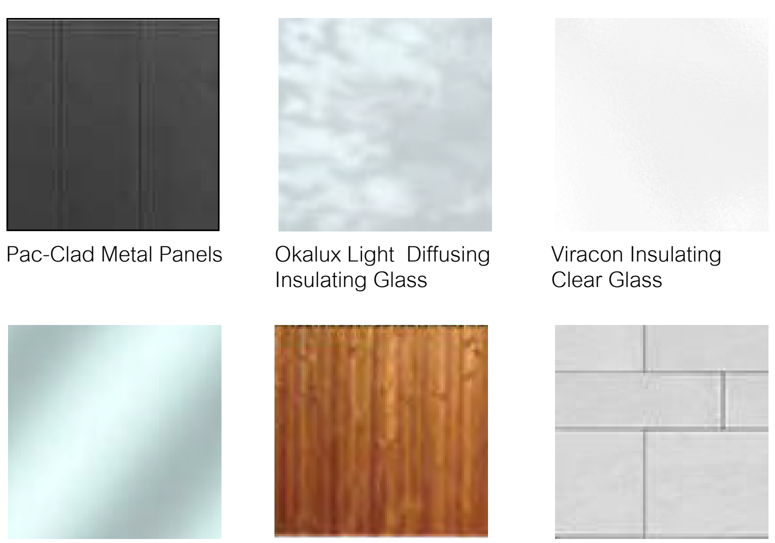
Focus Space Exterior

Materials Palette



ELEVATIONS

Elevation 01



Pac-Clad Metal Panels

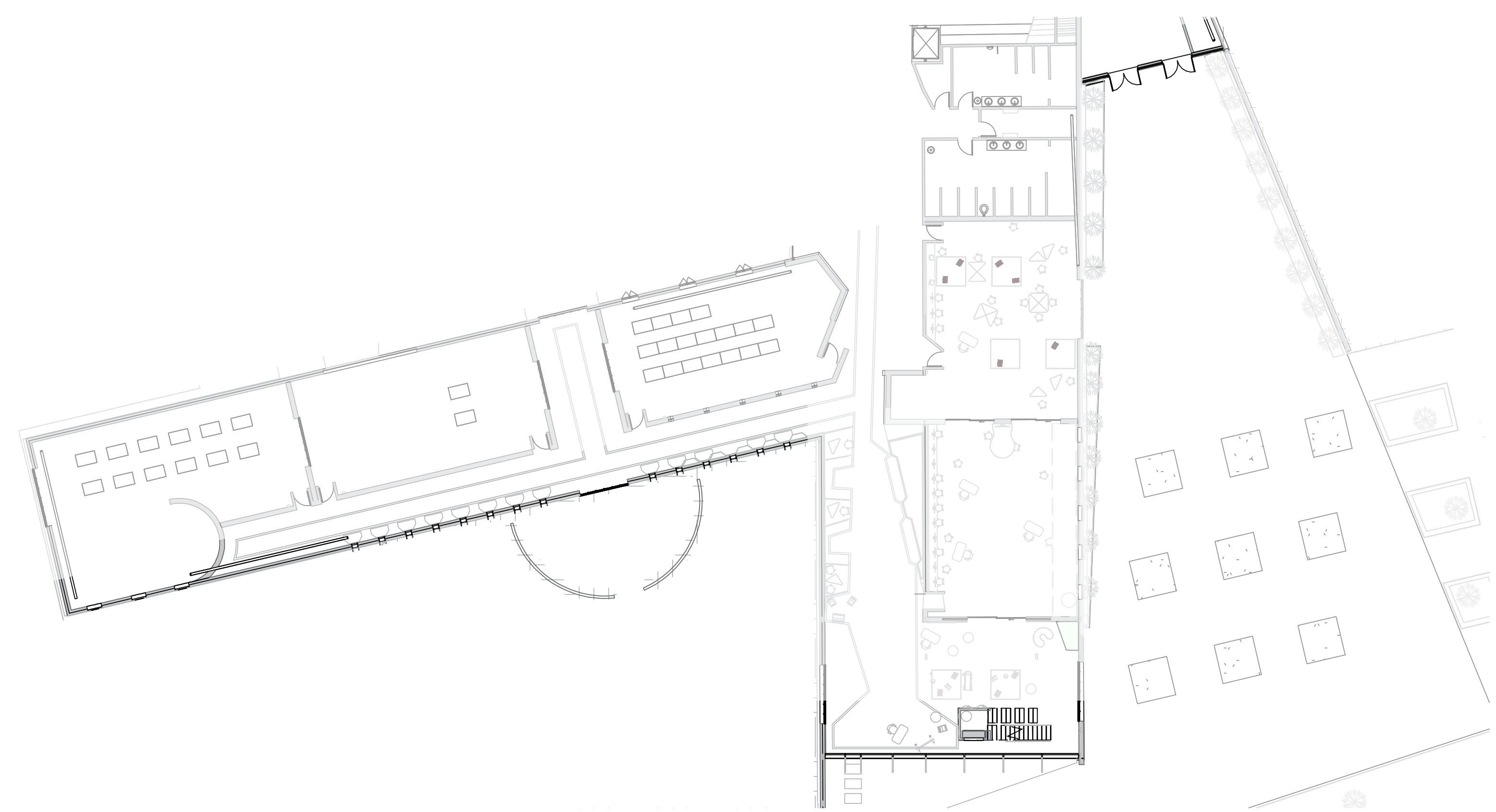
Okalux Light Diffusing Insulating Glass

Viracon Insulating Clear Glass

Reflective Glass Panel

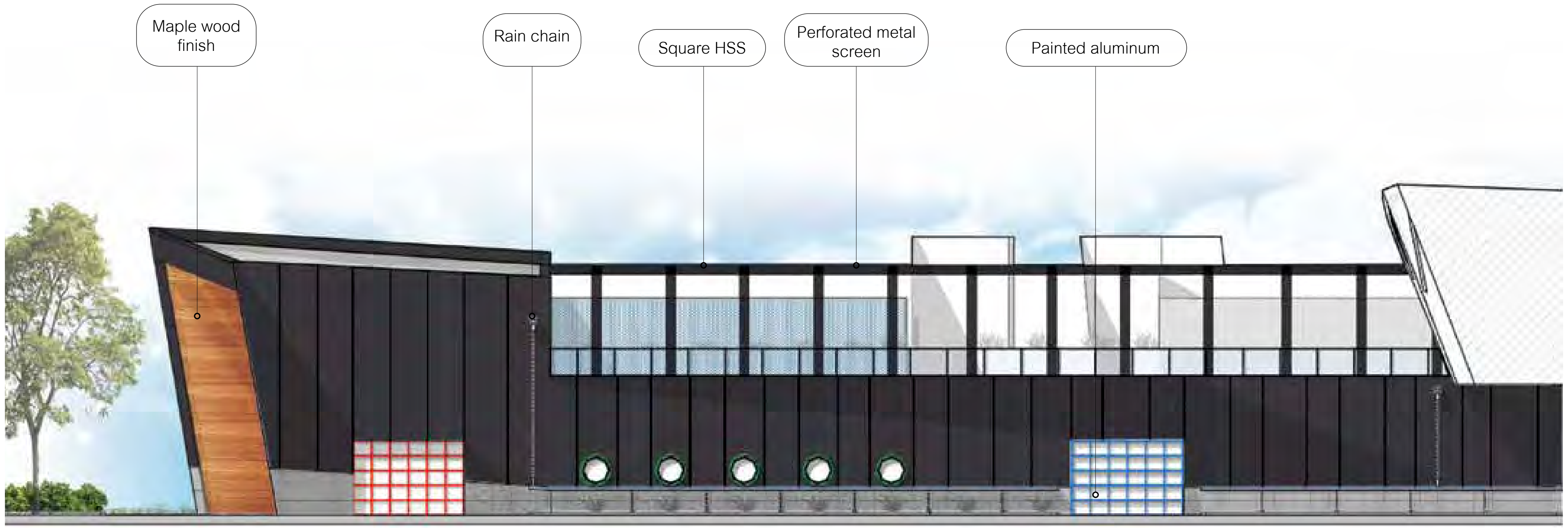
Mapel Wood

Equitone Fiber Cement Panels

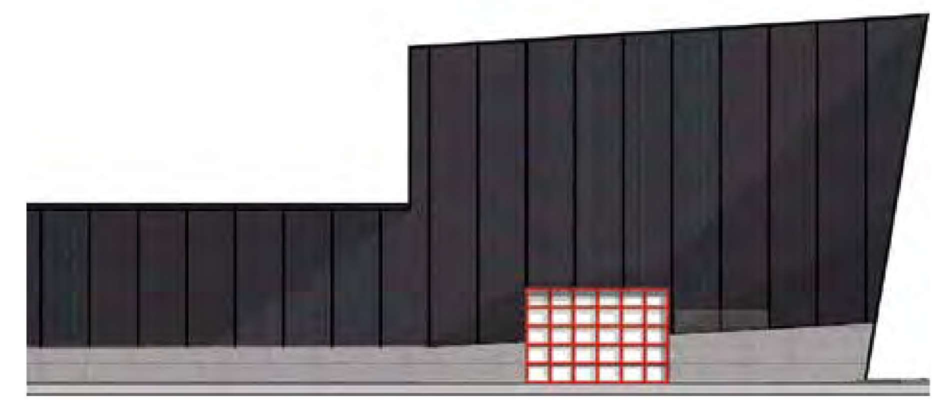


Level 01

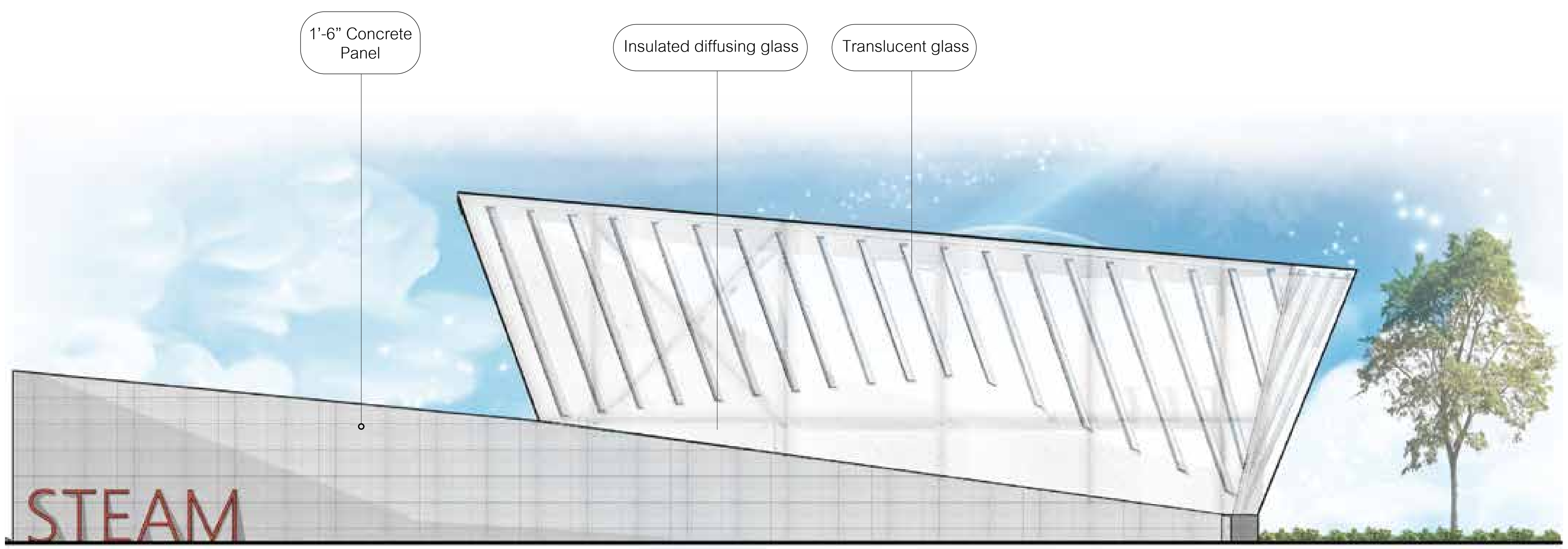
ELEVATIONS



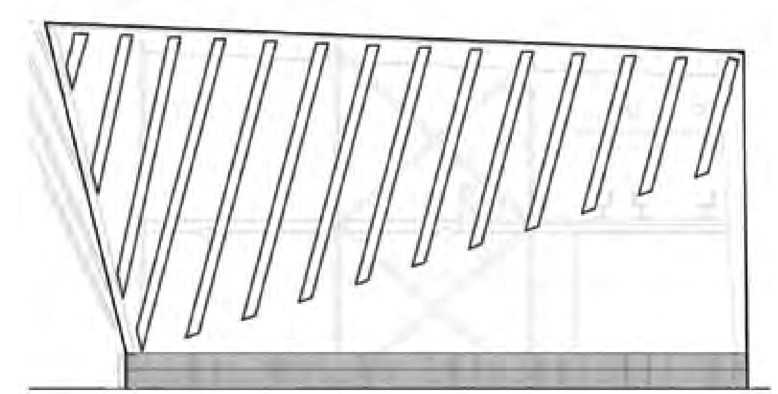
Elevation 02



Elevation 03

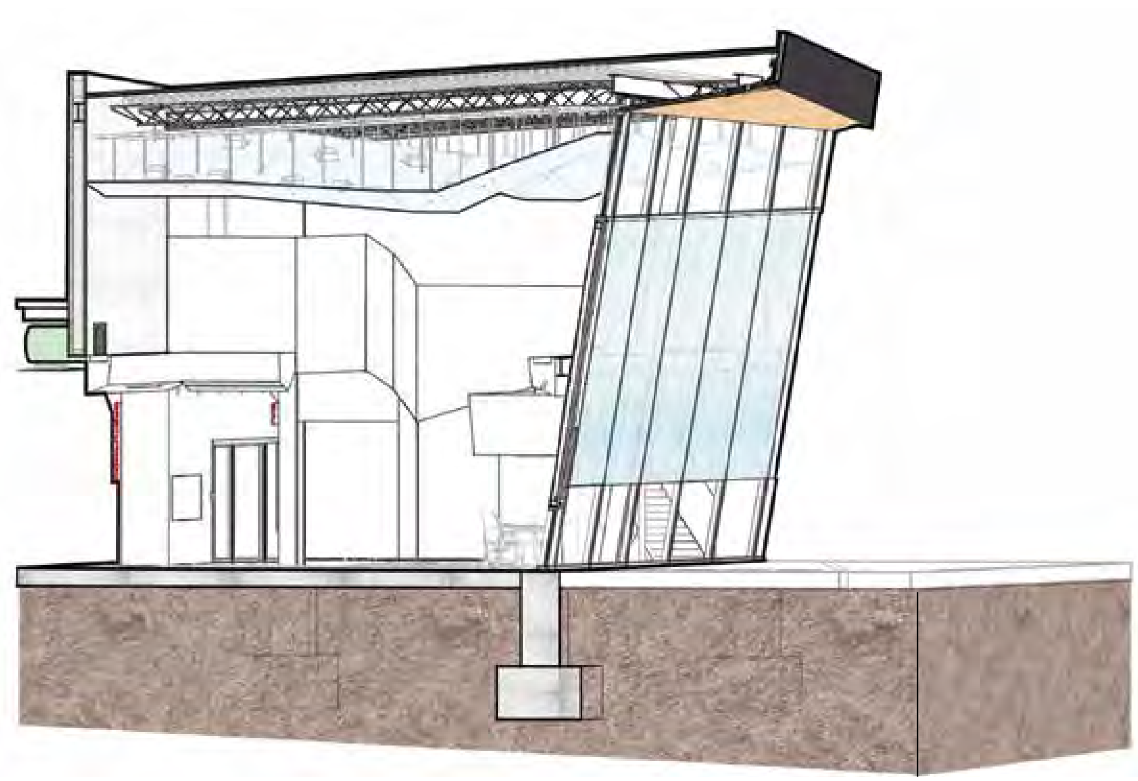


Elevation 04

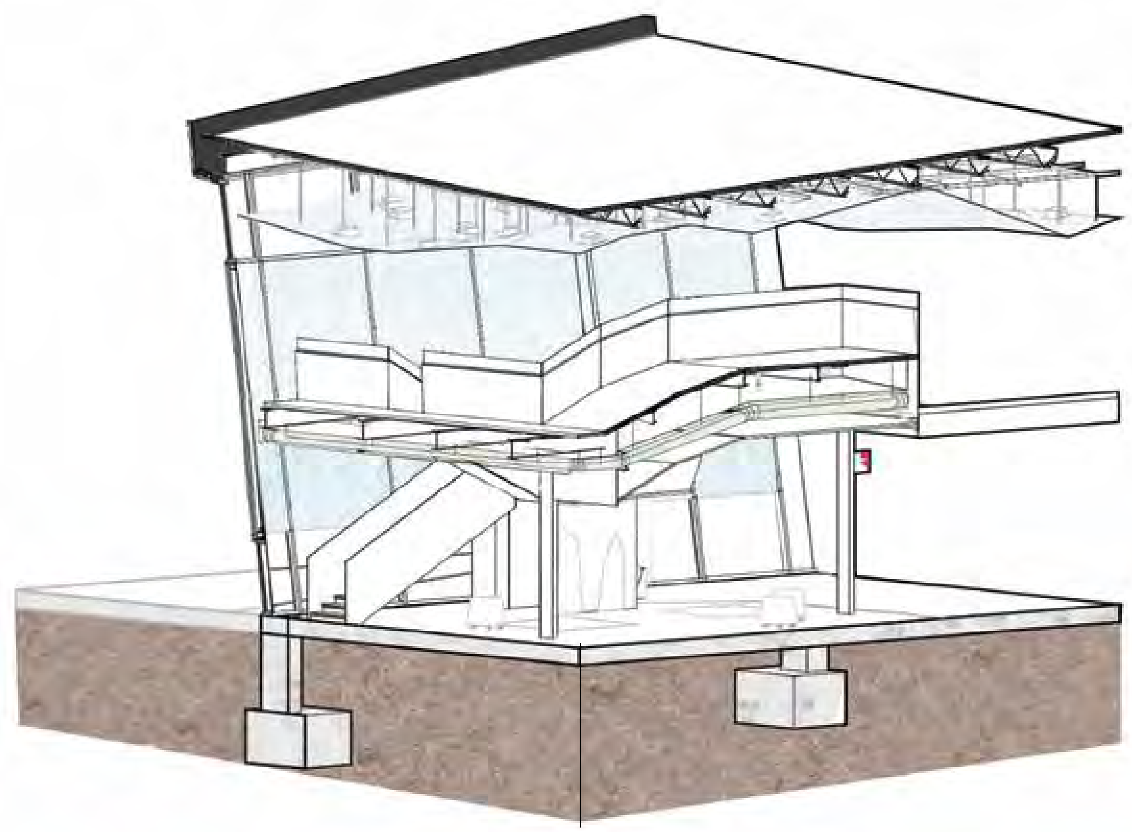


Elevation 05

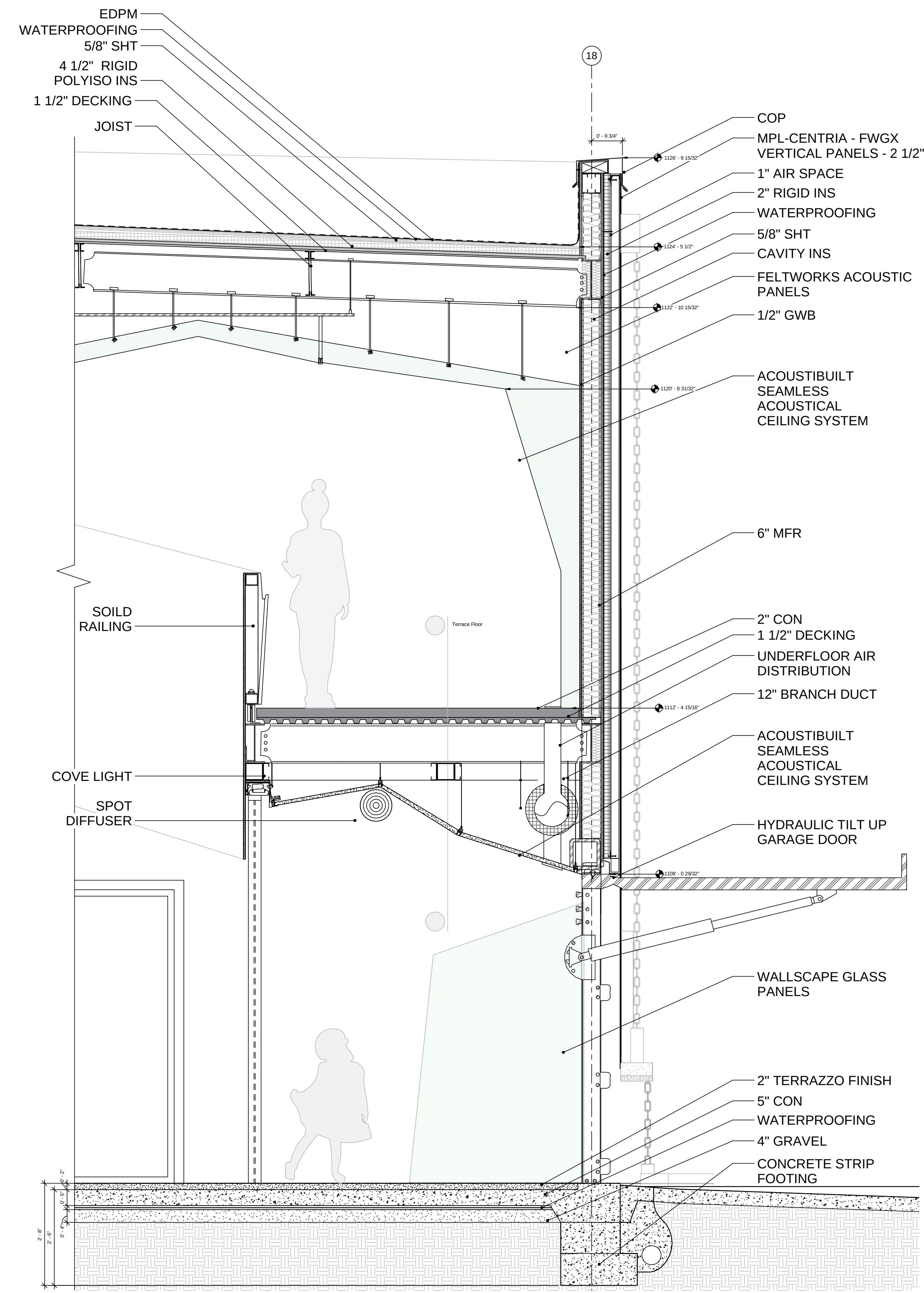
DETAILS



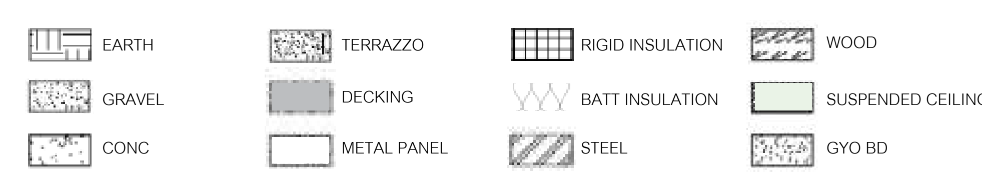
Suspended Ceiling



Under Floor Air Supply

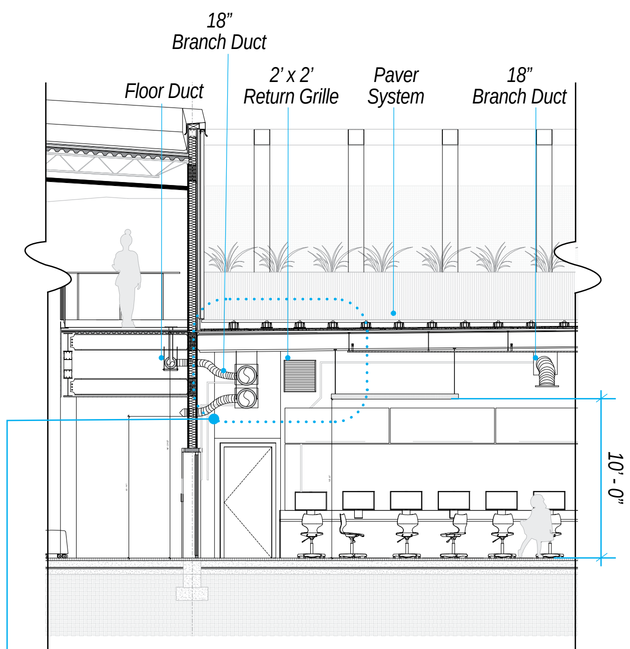


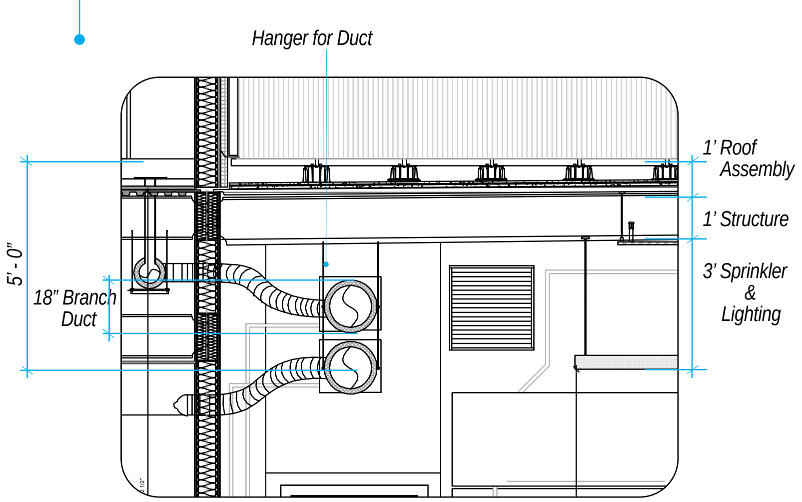
Wall Section



LIGHTING

Critical Section 01





Luminares

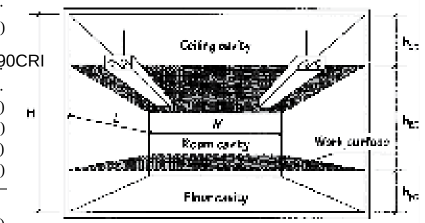
AVERAGE ILLUMINANCE WORKSHEET-ELECTRIC LIGHTING
[LUMEN METHOD-SIMPLIFIED]

Designer: Jacey Watson Space type: Lab/Gathering

PHOTOMETRIC DATA

IESNA Illuminance category: ....

IESNA Recommended illuminance (average): 40 (fc)
[*Refer to IESNA tables*]
Lamp type: PHG 9000LM LED HEF MARLR 50K 90CRI
Recommended spacing ratio Assume 0° & 90° = 1.0
Lumen output from one lamp (initial): 8124.5 (lumens)
Number of lamps per luminaire: 1 (lamps)
Fixture efficiency: 100 (%)
Lumen output from one luminaire: 8124.5 (lumens)



ROOM DESIGN

L = 52 (ft)
W = 30 (ft)
H = 27 (ft)
Ceiling cavity reflectance = CCR = 80 (%)
Room cavity reflectance (walls) = RCR = 50 (%)
Assumed floor cavity reflectance = FCR = **20** (%)

h_{CC} = 3 (ft)
h_{RC} = 21.5 (ft)
h_{FC} = 2.5 (ft)

SIZING OF THE SYSTEM

a. Effect of room geometry: Determine equivalent-square room length (W_{sq}), and the Room Cavity Ratio (RCR).

$W_{sq} = W + [(L-W) / 3]$ = 30 ft + [(52 ft - 30 ft) / 3] = 37.33 ft
RCR = $(10 \times h_{RC}) / W_{sq}$ = (10 * 21.5 ft) / 37.33 = 5.759

From manufacturer's data, obtain the Coefficient of Utilization (CU) of this luminaire in this space.

CU = 54.43% - Interpolated

b. Effect of maintenance conditions of the space and the system (includes ballast factor): Estimate LLF.
Light Loss Factor = **LLF** = Good conditions = (0.65) (Circle one)
Average conditions = 0.55
Poor conditions = 0.45

c. Calculate useful lumens from one luminaire (on the workplane):
Useful lumens from one luminaire = Lumen output from one luminaire x CU x LLF
= 8124.5* 0.54435 * 0.65 = 2874.67 lumens

d. Determine total lumens needed on the workplane:
Total lumens needed on the workplane = Recommended illuminance x area
= 40 fc * (52 ft * 30 ft) = 62400

e. Determine needed number of luminaires:
Number of luminaires = Total lumens needed on the workplane/useful lumens from one luminaire

Number of luminaires = 62400 lumens / 2874.67 lumens = 21.71 = 21 luminaires

Actual illumination level provided = 40 fc * (21 luminaires / 21.71 luminaires) = 38.7 fc
Light load = (21 luminaires * 54.76watts) / (30 ft * 52 ft) = 0.74 watts/SF < 0.97 watts/SF OK
Light load index = (0.74 watts/SF / 40 fc) =0.018 watts/SF fc
Area covered per luminaire = (52 ft * 30 ft) / 21uminaires = 74.29 SF/luminaire
System's overall efficiency = 100% * 54.43% * 0.65 = 35.4%

3/25/22, 10:12 AM PHG 9000LM HEF MALR 50K 90CRI

INDOOR PHOTOMETRIC REPORT
CATALOG: PHG 9000LM HEF MALR 50K 90CRI

AcuityBrands. HOLOPHANE

Test #: ISF 202781HP24
Test Lab: SCALED PHOTOMETRY
Catalog: PHG 9000LM HEF MALR 50K 90CRI
Description: PHG LED high bay, 9,000 lumens, high efficiency, Medium acrylic refractor, no reflector 5,000 K, 90 CRI
Series: PHG High Bay
Lamp Output: Total luminaire Lumens: 8124.5, absolute photometry *
Input Wattage: 54.76
Luminous Opening: Vertical Cylinder (Dia : 0.3M, H: 0.08M)
Cie Class: Direct
Nema Type: 7 X 7
Max Cd: 2,506.4 at Horizontal: 0°, Vertical: 2.5°
Spacing Criterion: @ 0 = 1.39 / @ 90 = 1.33

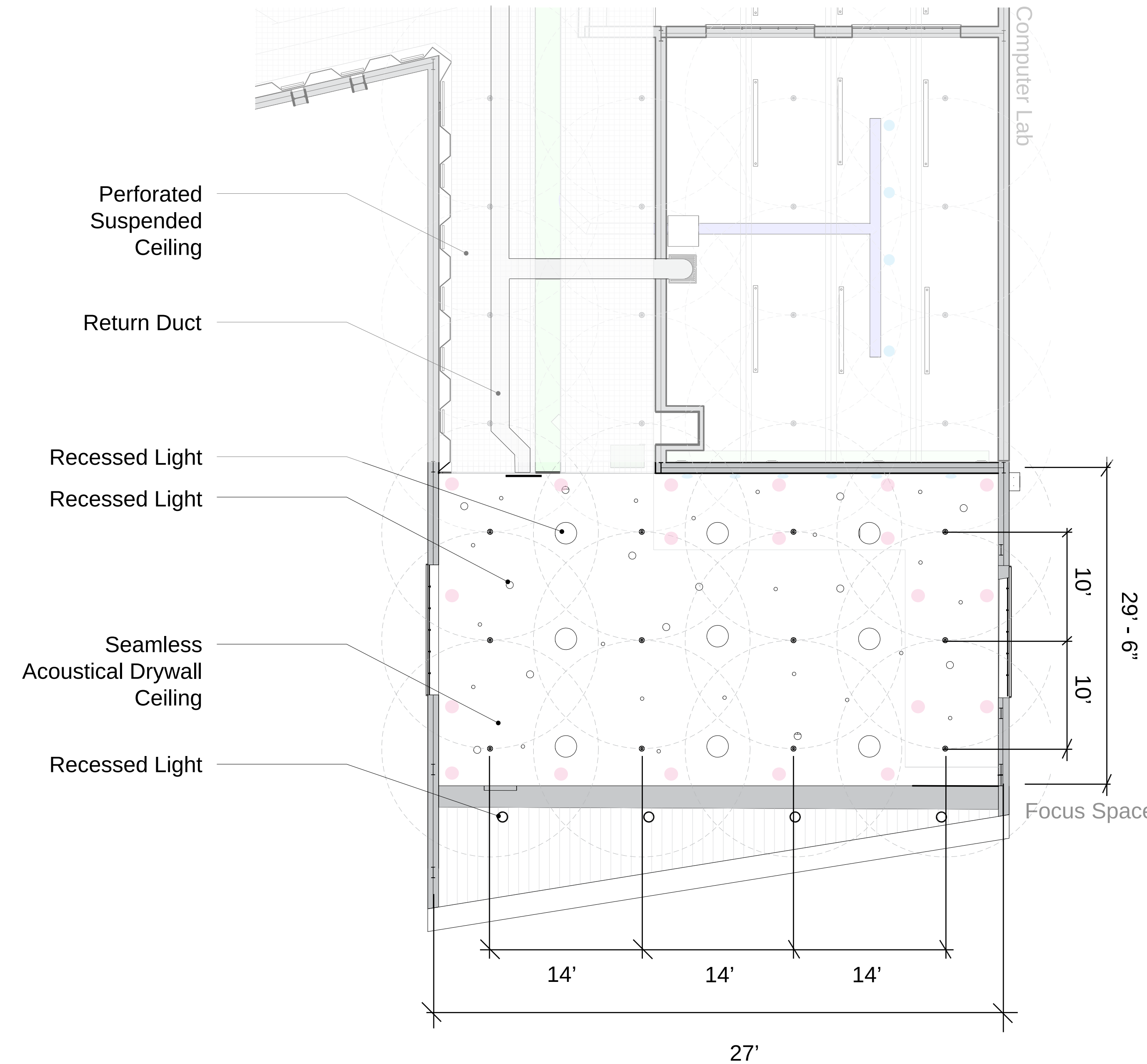
Zonal Lumen Summary

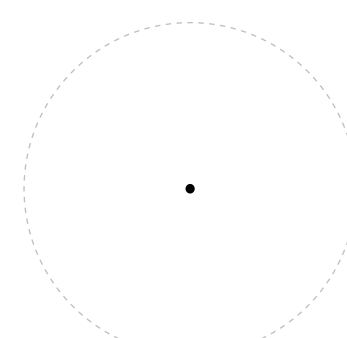
Zone	Lumens	% Luminaire
0-30	1,823.4	22.4%
0-40	3,088.0	38%
0-60	5,920.5	72.9%
60-90	2,051.7	25.3%
70-100	1,012.4	12.5%
90-120	138.7	1.7%
0-90	7,972.2	98.1%
90-180	152.4	1.9%
0-180	8,124.5	100%

Lumens Per Zone

Zone	Lumens	% Total	Zone	Lumens	% Total
0-10	220.4	2.7%	90-100	79.4	1%
10-20	631.6	7.8%	100-110	46.4	0.6%
20-30	971.4	12.0%	110-120	12.9	0.2%
30-40	1,264.6	15.6%	120-130	6.3	0.1%
40-50	1,445.0	17.8%	130-140	3.4	0%
50-60	1,387.5	17.1%	140-150	2.0	0%
60-70	1,118.6	13.8%	150-160	1.3	0%
70-80	674.3	8.3%	160-170	0.6	0%
80-90	258.8	3.2%	170-180	0.1	0%

Reflected Ceiling Plan





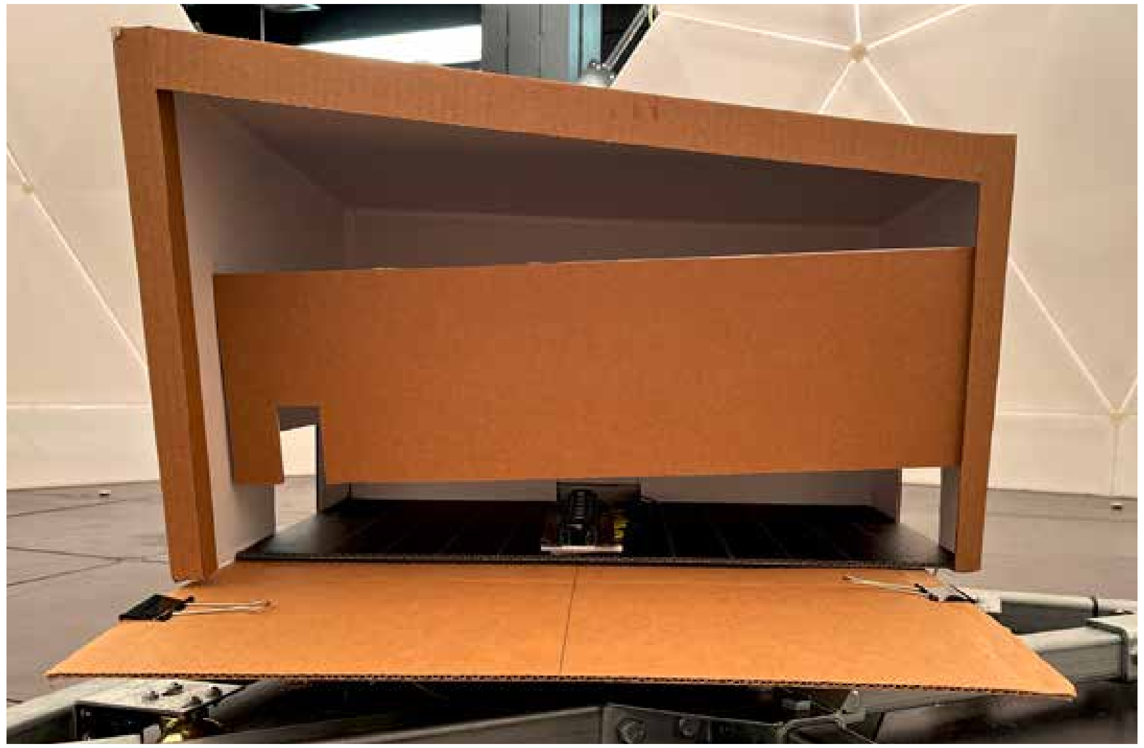
Sprinkler
Throw 10'

Diffusers
VAV Box
Return Grille
PHG Light

Pendant Light
Branch Duct
Main Duct
Recessed Lights

**Lights illuminate the ceiling utilizing ambient light within the space for an ephemeral feeling. Recessed star lights within dynamic ceiling plane and cove lights in balcony to light the lower workplane.*

DAYLIGHTING



Physical Model

1-5/16" (31.96mm) Laminated Insulating (Coating #4) Clear / VUE1-40

PERFORMANCE DATA

Transmittance	
Visible Light	39%
Solar Energy	15%
UV	<1%
Reflectance	
Visible Light-Exterior	13%
Visible Light-Interior	15%
Solar Energy	14%
NRFC U-Value	
Winter	0.28 (hr x sqft x °F)
Summer	0.25 (hr x sqft x °F)
Shading Coefficient	0.26
Relative Heat Gain	55Btu/(hr x sqft)
Solar Heat Gain Coefficient (SHGC)	0.22
LSG	1.77

Makeup

1/4" (6mm) clear
.060" (1.52mm) clear PVB
1/4" (6mm) clear with VUE-40
#4
1/2" (13.2mm) space - air filled
1/4" (6mm) clear

VIRACON®

ARCH 4263 / 5262
Space Use: Lab
Student Names: Jacey Watson

Daylighting lab test results

Sky Condition: Standard CIE Overcast Sky

Light Sensor #	Multiplier	Meter's Reading	Illumination level under artificial sky dome: lux	fc	sensor's serial number
1	2.9210	27.9	81 lux	7.6 fc	PH 8355
2	2.6310	22.3	63 lux	5.9 fc	PH 8356
3	2.8248	18.7	53 lux	4.9 fc	PH 8357
4	2.9378	16.7	49 lux	4.6 fc	PH 8358
5	2.9792	15.6	46 lux	4.3 fc	PH 8359
6	2.7992	16.5	46 lux	4.3 fc	PH 8360
7	2.9673	17.6	52 lux	4.9 fc	PH 8361
8	2.9431	15.8	47 lux	4.3 fc	PH 8362
(single sensor) 9	2.7651				
Outside (under dome)	2.7390	269.8	739 lux	68.7 fc	PH 8364

Measured outside illuminance = 68.7 fc

[NOTE]: This is the outside horizontal illuminance under the artificial sky dome in the lab, and not the standard illuminance at the location of your building

Daylight Factor for VT= 1.00
For models tested with glass or trace paper

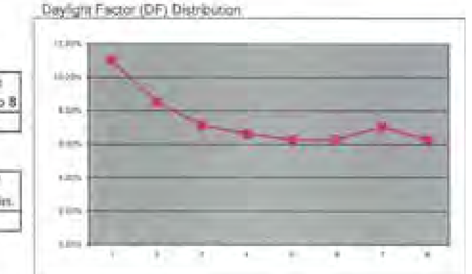
Daylight Factor
excluding effect of glass VT

Sensor	Daylight Factor for VT=1.00	Daylight Factor
1	11.03%	11.03%
2	8.54%	8.54%
3	7.15%	7.15%
4	6.64%	6.64%
5	6.29%	6.29%
6	6.29%	6.29%
7	7.07%	7.07%
8	6.29%	6.29%
(single sensor) # 9		

Average sens # 1 to 8: 7.41%

Ratio of Max. to Min.: 1.75

Daylight Factor (DF) Distribution



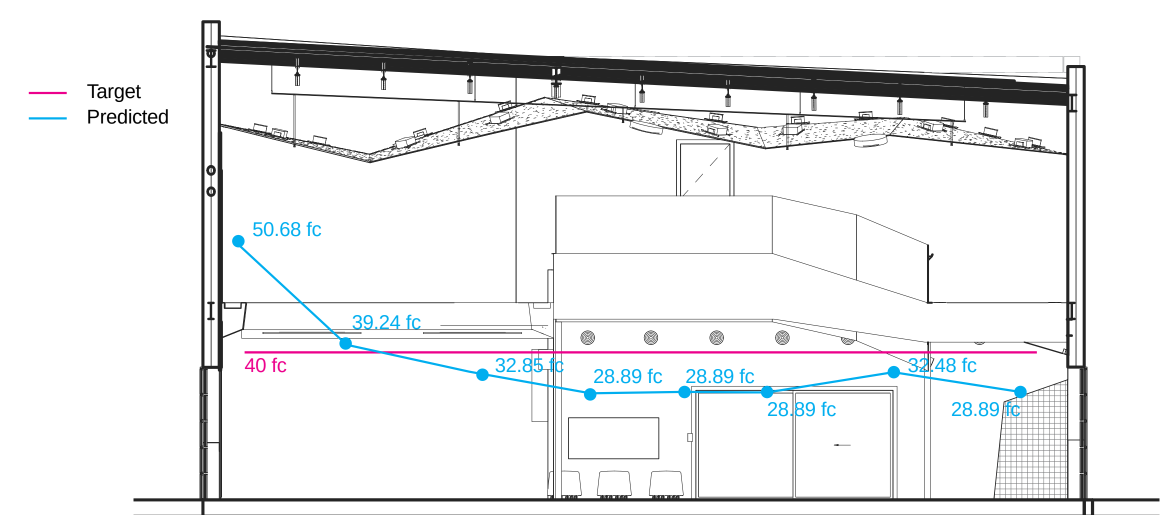
	1	2	3	4	5	6	7	8
Standard Illumination Level 2pm March / September 21st	1386	1386	1386	1386	1386	1386	1386	1386
Daylight Factor	0.1103	0.0854	0.0715	0.0664	0.0629	0.0629	0.0707	0.0629
VT Glass	.39	.39	.39	.39	.39	.39	.39	.39
M Glass	.85	.85	.85	.85	.85	.85	.85	.85
	50.68	39.24	32.85	28.89	28.89	28.89	32.48	28.89
Target	40	40	40	40	40	40	40	40

Predicted Illumination Level Calculation [Average]:

$IL_{predicted} = IL_{standard} \times DF \times VT_{glass} \times M_{glass}$

$IL_{predicted} = 1386 \times 0.0741 \times 0.39 \times 0.85$

$= 34.05$ FC



eQuest

Current Design

MOTB-open office DOE-2.2-50a 4/04/2022 15:44:06 BDL RUN 1

REPORT- SS-G Zone Loads Summary for Perimeter Th Zone (G.N1) WEATHER FILE- Oklahoma CityOK TMY2

MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000	31	24	43.F	38.F	0.000	-4.774	9	16	12.F	10.F	-24.723	120.	0.563
FEB	0.00000	28	24	36.F	34.F	0.000	-4.401	1	11	23.F	21.F	-24.579	107.	0.541
MAR	0.00000	31	1	53.F	48.F	0.000	-4.030	23	12	44.F	39.F	-24.473	118.	0.545
APR	0.00000	30	1	52.F	46.F	0.000	-3.376	2	11	30.F	27.F	-24.404	118.	0.536
MAY	0.03865	24	17	93.F	75.F	4.161	-1.544	1	9	52.F	47.F	-24.054	116.	0.495
JUN	0.55537	27	17	90.F	80.F	8.858	-0.396	3	8	59.F	54.F	-21.514	108.	0.458
JUL	1.60688	26	17	99.F	73.F	10.651	-0.021	5	8	62.F	56.F	-6.798	116.	0.479
AUG	2.55325	15	8	84.F	73.F	15.532	0.000	31	1	70.F	64.F	0.000	119.	0.494
SEP	1.37681	4	17	96.F	71.F	11.657	-0.025	28	9	55.F	50.F	-5.990	110.	0.535
OCT	0.53143	9	16	96.F	66.F	10.998	-0.287	25	8	44.F	38.F	-11.330	122.	0.546
NOV	0.03094	25	16	75.F	60.F	3.545	-1.629	9	10	39.F	34.F	-24.111	111.	0.546
DEC	0.00376	5	16	70.F	52.F	1.409	-3.070	18	9	15.F	13.F	-24.252	120.	0.544
TOTAL	6.697						-23.554						1385.	
MAX						15.532						-24.723		0.563

MOTB-open office DOE-2.2-50a 4/04/2022 15:44:06 BDL RUN 1

REPORT- SS-G Zone Loads Summary for Interior Th Zone (G.S2) WEATHER FILE- Oklahoma CityOK TMY2

MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000	31	24	43.F	38.F	0.000	-2.412	9	17	11.F	9.F	-11.195	132.	0.500
FEB	0.00000	28	24	36.F	34.F	0.000	-2.228	1	10	22.F	21.F	-11.128	120.	0.500
MAR	0.00000	31	1	53.F	48.F	0.000	-2.110	5	10	41.F	36.F	-11.030	134.	0.500
APR	0.00000	30	1	52.F	46.F	0.000	-1.799	2	10	27.F	24.F	-11.086	138.	0.500
MAY	0.00000	31	1	67.F	63.F	0.000	-0.920	13	8	54.F	53.F	-10.954	138.	0.500
JUN	0.09256	27	17	90.F	80.F	2.825	-0.258	3	8	59.F	54.F	-9.153	128.	0.500
JUL	0.57535	15	8	78.F	69.F	4.648	-0.014	5	8	62.F	56.F	-4.273	138.	0.500
AUG	1.09241	15	8	84.F	73.F	8.421	0.000	31	1	70.F	64.F	0.000	139.	0.500
SEP	0.54763	16	8	71.F	66.F	5.365	-0.012	28	9	55.F	50.F	-3.413	127.	0.500
OCT	0.10415	9	16	96.F	66.F	2.899	-0.143	7	8	57.F	55.F	-6.965	138.	0.500
NOV	0.00000	30	24	36.F	31.F	0.000	-0.874	21	8	34.F	32.F	-11.009	122.	0.500
DEC	0.00000	31	24	43.F	39.F	0.000	-1.693	18	10	20.F	17.F	-11.060	132.	0.500
TOTAL	2.412						-12.463						1586.	
MAX						8.421						-11.195		0.500

Baseline

MOTB-open office DOE-2.2-50a 4/04/2022 15:11:57 BDL RUN 1

REPORT- SS-G Zone Loads Summary for Perimeter Th Zone (G.N1) WEATHER FILE- Oklahoma CityOK TMY2

MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.06675	30	15	62.F	49.F	8.778	-8.759	22	16	16.F	14.F	-57.602	188.	0.814
FEB	0.00226	12	16	53.F	43.F	1.492	-7.015	1	9	22.F	21.F	-56.329	169.	0.794
MAR	0.05134	29	16	84.F	58.F	9.005	-5.743	23	10	41.F	37.F	-55.404	188.	0.798
APR	0.13496	24	17	85.F	69.F	10.531	-4.482	2	9	27.F	25.F	-55.747	189.	0.789
MAY	0.83822	24	17	93.F	75.F	17.720	-1.736	13	9	54.F	53.F	-48.150	187.	0.746
JUN	2.16099	22	16	94.F	80.F	22.439	-0.497	4	8	56.F	54.F	-32.936	176.	0.708
JUL	3.95258	26	16	100.F	73.F	27.518	-0.058	5	8	62.F	56.F	-16.093	187.	0.729
AUG	5.76312	27	16	100.F	76.F	33.591	0.000	31	1	70.F	64.F	0.000	192.	0.745
SEP	3.30758	23	16	88.F	69.F	35.183	-0.154	28	9	55.F	50.F	-24.373	175.	0.788
OCT	2.08457	9	16	96.F	66.F	32.740	-0.930	25	8	44.F	38.F	-37.468	192.	0.800
NOV	0.62218	6	16	62.F	47.F	19.239	-3.244	21	9	38.F	35.F	-54.949	175.	0.799
DEC	0.26112	3	15	74.F	51.F	15.209	-5.254	6	9	36.F	30.F	-55.241	188.	0.798
TOTAL	19.246						-37.871						2205.	
MAX						35.183						-57.602		0.814

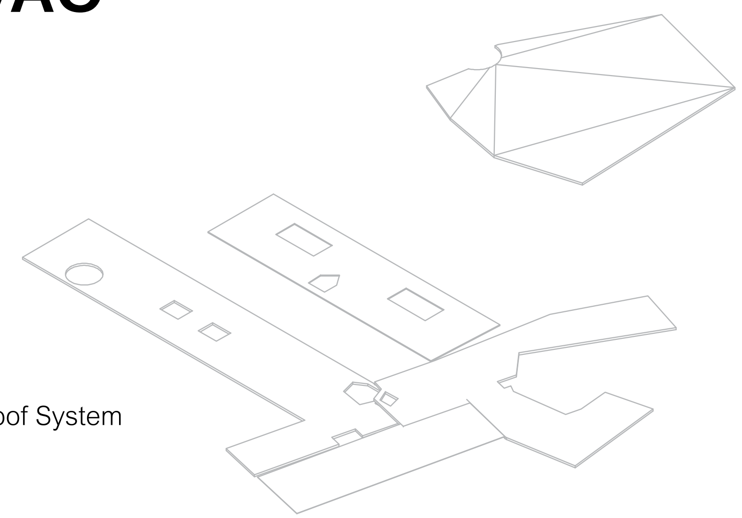
MOTB-open office DOE-2.2-50a 4/04/2022 15:11:57 BDL RUN 1

REPORT- SS-G Zone Loads Summary for Interior Th Zone (G.S2) WEATHER FILE- Oklahoma CityOK TMY2

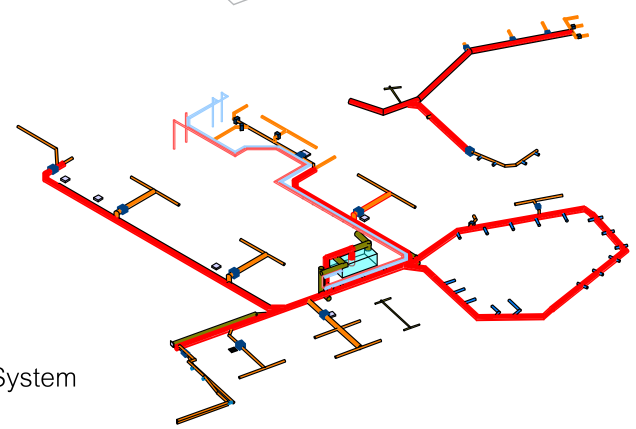
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000	31	24	43.F	38.F	0.000	-2.312	9	17	11.F	9.F	-11.351	133.	0.501
FEB	0.00000	28	24	36.F	34.F	0.000	-2.078	1	8	23.F	22.F	-11.170	120.	0.501
MAR	0.00000	31	1	53.F	48.F	0.000	-1.887	12	8	42.F	37.F	-11.109	134.	0.501
APR	0.00000	30	1	52.F	46.F	0.000	-1.528	13	9	47.F	46.F	-11.105	138.	0.501
MAY	0.00253	24	17	93.F	75.F	0.823	-0.686	3	8	51.F	49.F	-11.109	138.	0.501
JUN	0.21591	22	9	83.F	75.F	4.234	-0.218	4	8	56.F	54.F	-9.782	128.	0.501
JUL	0.67558	15	8	78.F	69.F	7.595	-0.028	5	8	62.F	56.F	-8.343	138.	0.501
AUG	1.13952	15	8	84.F	73.F	9.009	0.000	31	1	70.F	64.F	0.000	139.	0.501
SEP	0.53143	16	8	71.F	66.F	6.941	-0.050	28	9	55.F	50.F	-9.098	127.	0.501
OCT	0.12754	9	16	96.F	66.F	3.260	-0.279	22	8	42.F	38.F	-10.585	138.	0.501
NOV	0.00031	18	16	72.F	56.F	0.134	-0.916	22	8	35.F	34.F	-11.152	122.	0.501
DEC	0.00000	31	24	43.F	39.F	0.000	-1.638	18	8	13.F	12.F	-11.114	133.	0.501
TOTAL	2.693						-11.620						1588.	
MAX						9.009						-11.351		0.501

Focus Space Interior

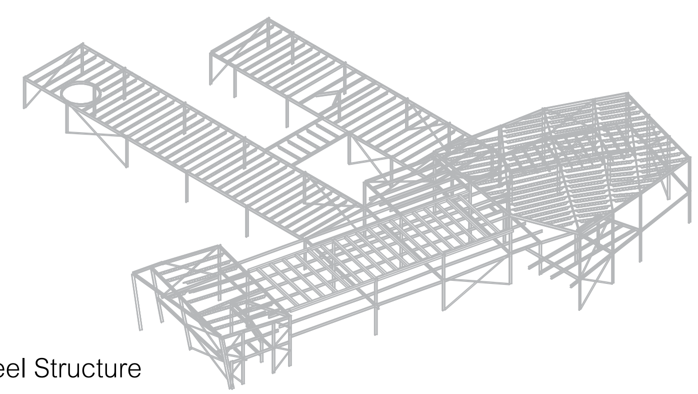
HVAC



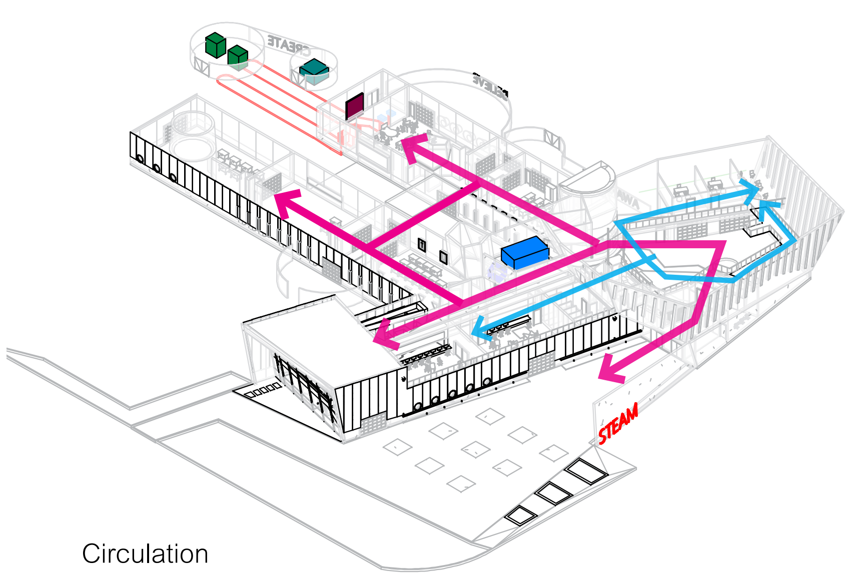
Roof System



HVAC System



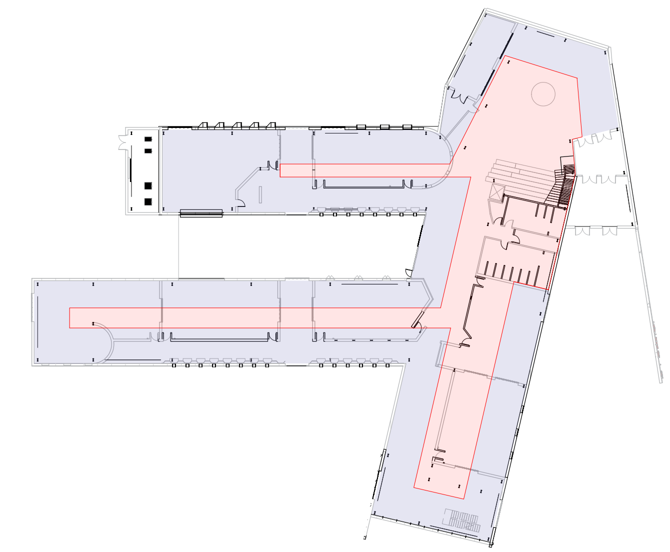
Steel Structure



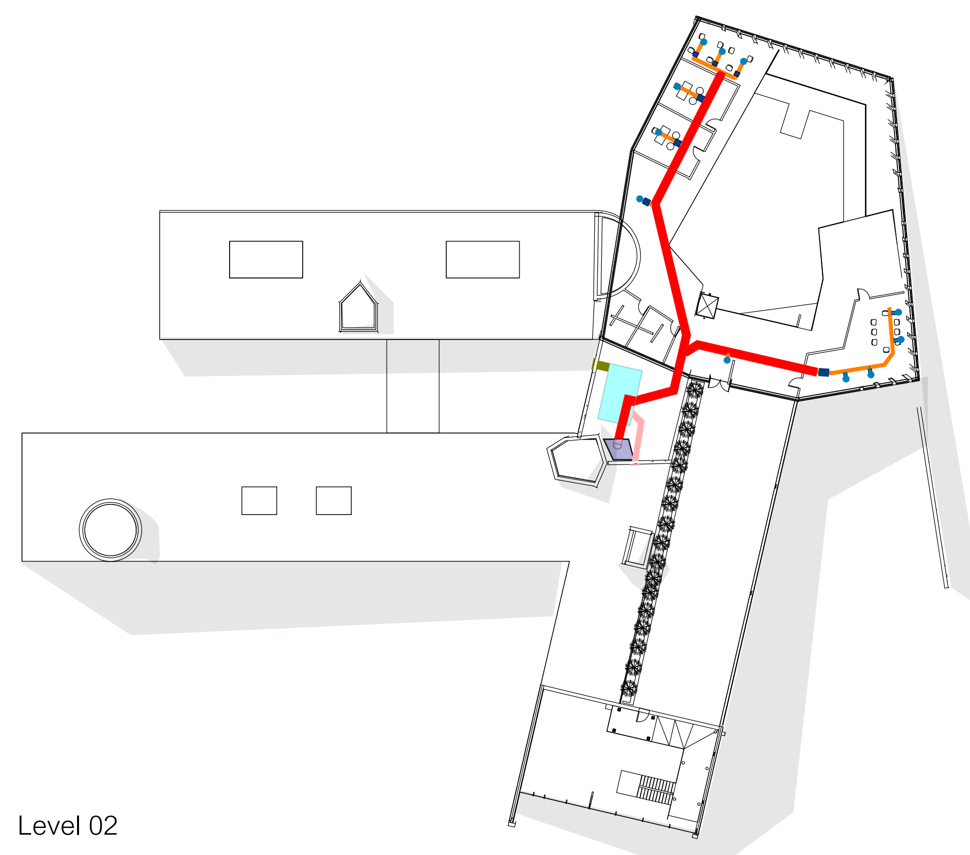
Circulation

HVAC Coordination

Level 01



Thermal Zoning



Level 02

Duct Work

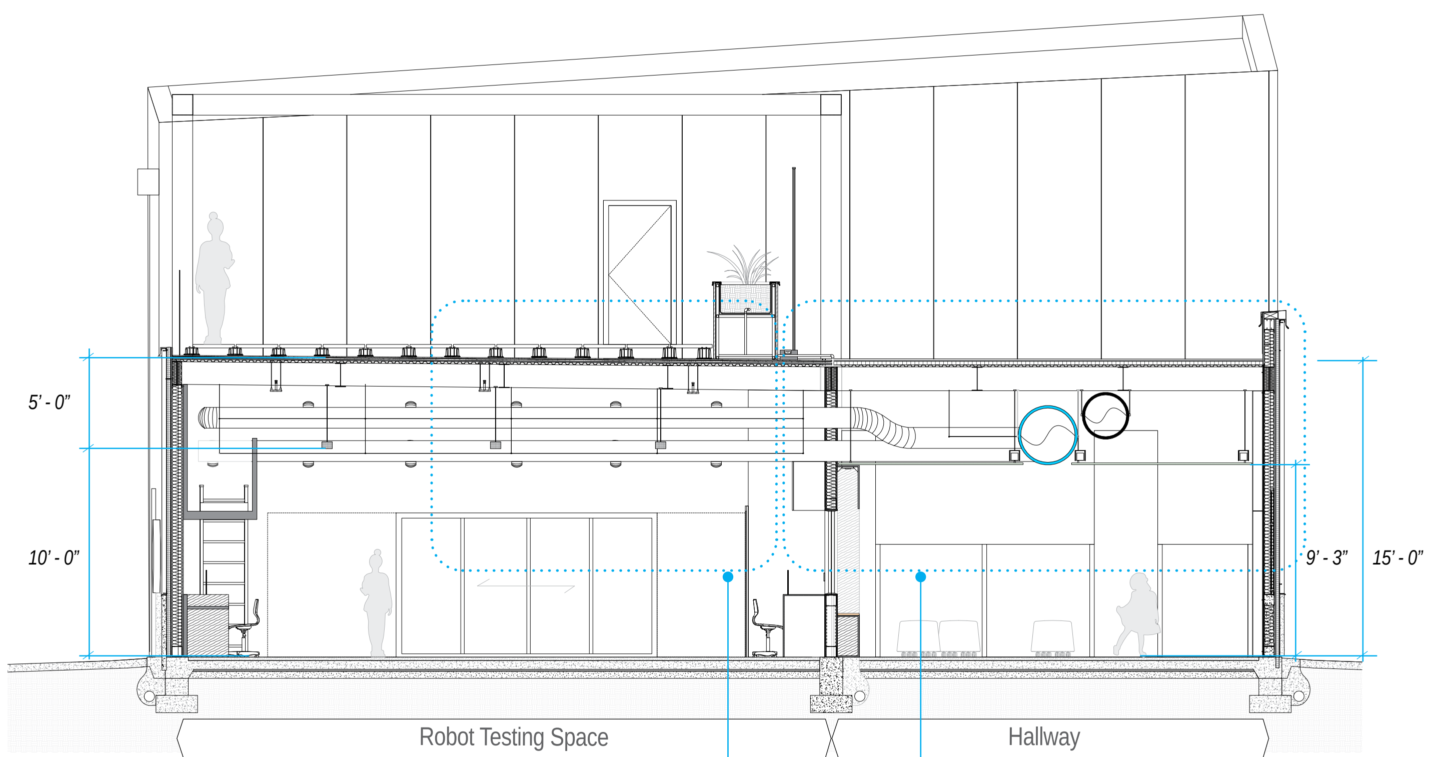
Key Systems :

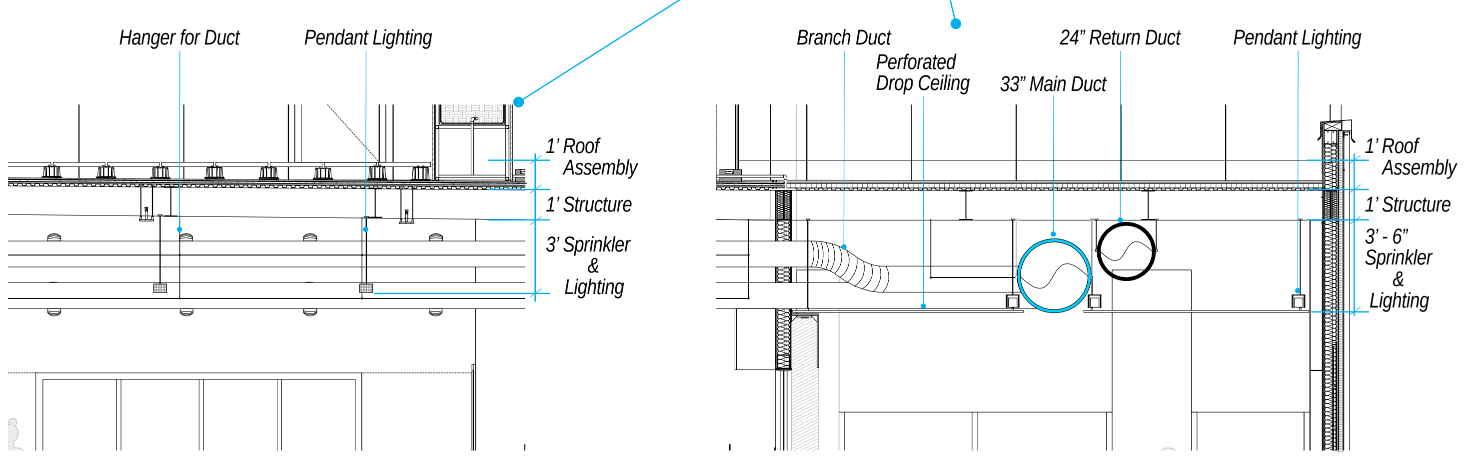
- Supply Duct
- Branch Duct
- Return Duct
- VAV Box
- Diffusers
- AHU
- Mechanical Chase

Systems integrated to the design through utilization of color, following the circulation paths, and reflecting off the light colored materials throughout the hallways

HVAC

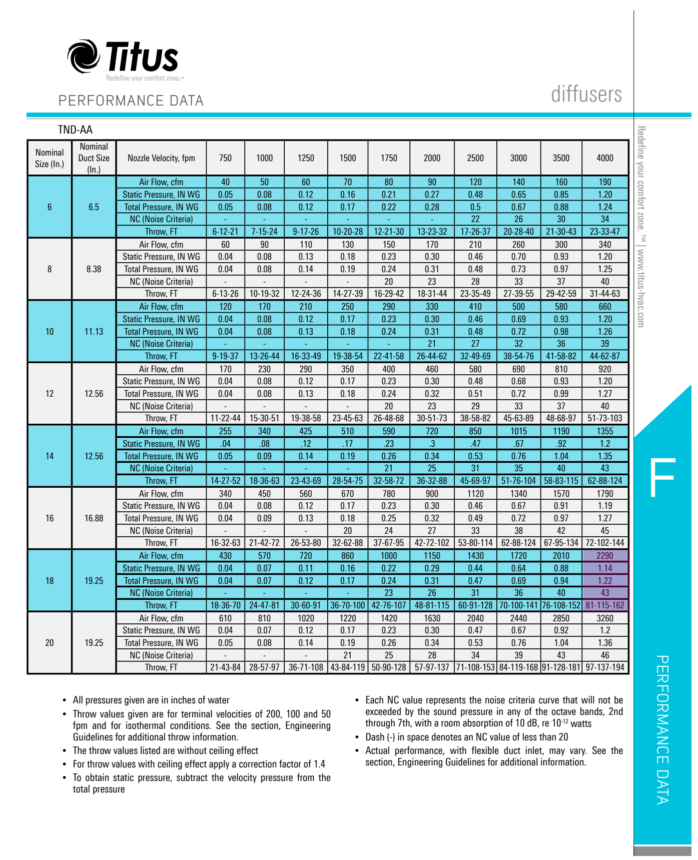
Critical Section 02





Wall Diffusers

Interior : 1.29 CFM/SF x 1560 SF Focus Space = 2,012.4 CFM Needed



Titus

PERFORMANCE DATA

diffusers

TND-AA

Nominal Size (In.)	Nominal Duct Size (In.)	Nozzle Velocity, fpm	750	1000	1250	1500	1750	2000	2500	3000	3500	4000
6	6.5	Air Flow, cfm	40	50	60	70	80	90	120	140	160	190
		Static Pressure, IN WG	0.05	0.08	0.12	0.16	0.21	0.27	0.48	0.65	0.85	1.20
		Total Pressure, IN WG	0.05	0.08	0.12	0.17	0.22	0.28	0.5	0.67	0.88	1.24
		NC (Noise Criteria)	-	-	-	-	-	-	22	26	30	34
		Throw, FT	6-12-21	7-15-24	9-17-26	10-20-28	12-21-30	13-23-32	17-26-37	20-28-40	21-30-43	23-33-47
8	8.38	Air Flow, cfm	60	90	110	130	150	170	210	260	300	340
		Static Pressure, IN WG	0.04	0.08	0.13	0.18	0.23	0.30	0.46	0.70	0.93	1.20
		Total Pressure, IN WG	0.04	0.08	0.14	0.19	0.24	0.31	0.48	0.73	0.97	1.25
		NC (Noise Criteria)	-	-	-	-	20	23	28	33	37	40
		Throw, FT	6-13-26	10-19-32	12-24-36	14-27-39	16-29-42	18-31-44	23-35-49	27-39-55	29-42-59	31-44-63
10	11.13	Air Flow, cfm	120	170	210	250	290	330	410	500	580	660
		Static Pressure, IN WG	0.04	0.08	0.12	0.17	0.23	0.30	0.46	0.69	0.93	1.20
		Total Pressure, IN WG	0.04	0.08	0.13	0.18	0.24	0.31	0.48	0.72	0.98	1.26
		NC (Noise Criteria)	-	-	-	-	-	21	27	32	36	39
		Throw, FT	9-19-37	13-26-44	16-33-49	19-38-54	22-41-58	26-44-62	32-49-69	38-54-76	41-58-82	44-62-87
12	12.56	Air Flow, cfm	170	230	290	350	400	460	580	690	810	920
		Static Pressure, IN WG	0.04	0.08	0.12	0.17	0.23	0.30	0.48	0.68	0.93	1.20
		Total Pressure, IN WG	0.04	0.08	0.13	0.18	0.24	0.32	0.51	0.72	0.99	1.27
		NC (Noise Criteria)	-	-	-	-	20	23	29	33	37	40
		Throw, FT	11-22-44	15-30-51	19-38-58	23-45-63	26-48-68	30-51-73	38-58-82	45-63-89	48-68-97	51-73-103
14	12.56	Air Flow, cfm	255	340	425	510	590	720	850	1015	1190	1355
		Static Pressure, IN WG	.04	.08	.12	.17	.23	.3	.47	.67	.92	1.2
		Total Pressure, IN WG	0.05	0.09	0.14	0.19	0.26	0.34	0.53	0.76	1.04	1.35
		NC (Noise Criteria)	-	-	-	-	21	25	31	35	40	43
		Throw, FT	14-27-52	18-36-63	23-43-69	28-54-75	32-58-72	36-32-88	45-69-97	51-76-104	58-83-115	62-88-124
16	16.88	Air Flow, cfm	340	450	560	670	780	900	1120	1340	1570	1790
		Static Pressure, IN WG	0.04	0.08	0.12	0.17	0.23	0.30	0.46	0.67	0.91	1.19
		Total Pressure, IN WG	0.04	0.09	0.13	0.18	0.25	0.32	0.49	0.72	0.97	1.27
		NC (Noise Criteria)	-	-	-	20	24	27	33	38	42	45
		Throw, FT	16-32-63	21-42-72	26-53-80	32-62-88	37-67-95	42-72-102	53-80-114	62-88-124	67-95-134	72-102-144
18	19.25	Air Flow, cfm	430	570	720	860	1000	1150	1430	1720	2010	2290
		Static Pressure, IN WG	0.04	0.07	0.11	0.16	0.22	0.29	0.44	0.64	0.88	1.14
		Total Pressure, IN WG	0.04	0.07	0.12	0.17	0.24	0.31	0.47	0.69	0.94	1.22
		NC (Noise Criteria)	-	-	-	-	23	26	31	36	40	43
		Throw, FT	18-36-70	24-47-81	30-60-91	36-70-100	42-76-107	48-81-115	60-91-128	70-100-141	76-108-152	81-115-162
20	19.25	Air Flow, cfm	610	810	1020	1220	1420	1630	2040	2440	2850	3260
		Static Pressure, IN WG	0.04	0.07	0.12	0.17	0.23	0.30	0.47	0.67	0.92	1.2
		Total Pressure, IN WG	0.05	0.08	0.14	0.19	0.26	0.34	0.53	0.76	1.04	1.36
		NC (Noise Criteria)	-	-	-	21	25	28	34	39	43	46
		Throw, FT	21-43-84	28-57-97	36-71-108	43-84-119	50-90-128	57-97-137	71-108-153	84-119-168	91-128-181	97-137-194

- All pressures given are in inches of water
- Throw values given are for terminal velocities of 200, 100 and 50 fpm and for isothermal conditions. See the section, Engineering Guidelines for additional throw information.
- The throw values listed are without ceiling effect
- For throw values with ceiling effect apply a correction factor of 1.4
- To obtain static pressure, subtract the velocity pressure from the total pressure
- Each NC value represents the noise criteria curve that will not be exceeded by the sound pressure in any of the octave bands, 2nd through 7th, with a room absorption of 10 dB, re 10^{-12} watts
- Dash (-) in space denotes an NC value of less than 20
- Actual performance, with flexible duct inlet, may vary. See the section, Engineering Guidelines for additional information.

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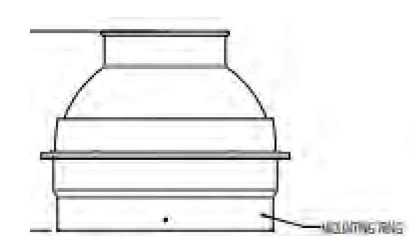
F

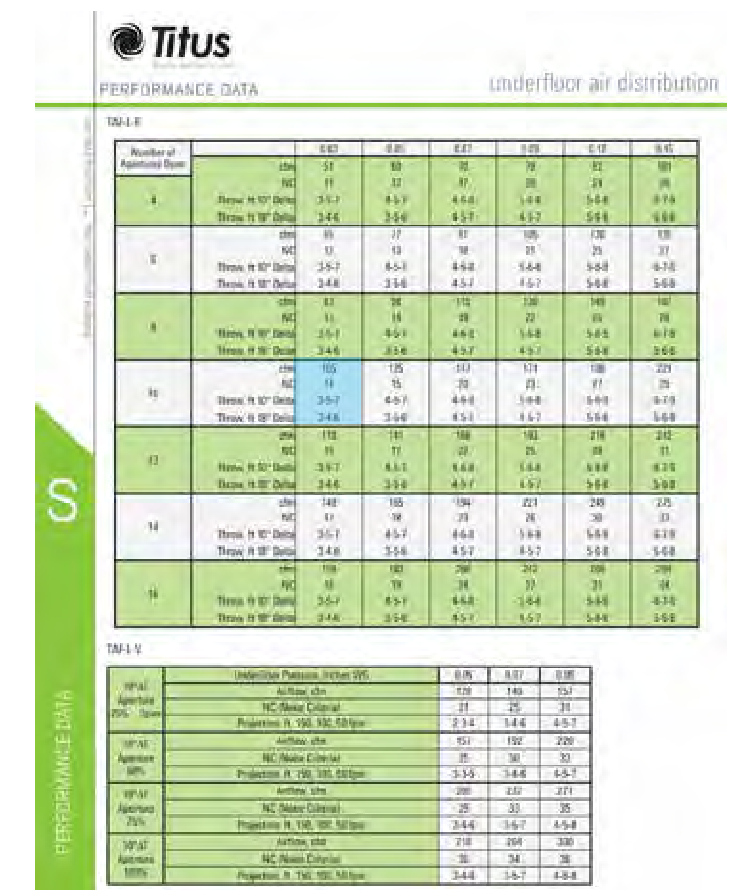
PERFORMANCE DATA



Floor Diffusers

Perimeter : 2.39 CFM/SF x 437.7 SF Balcony Space = 1,046.103 CFM needed

10 openings x 105 CFM = 1,050 CFM > 1,046.103 CFM OK



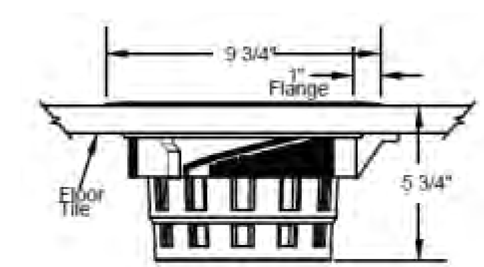
Titus

PERFORMANCE DATA

underfloor air distribution

S

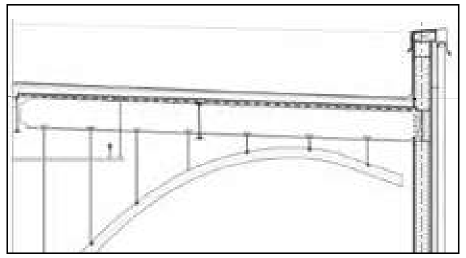
PERFORMANCE DATA



DD

Computers Lab

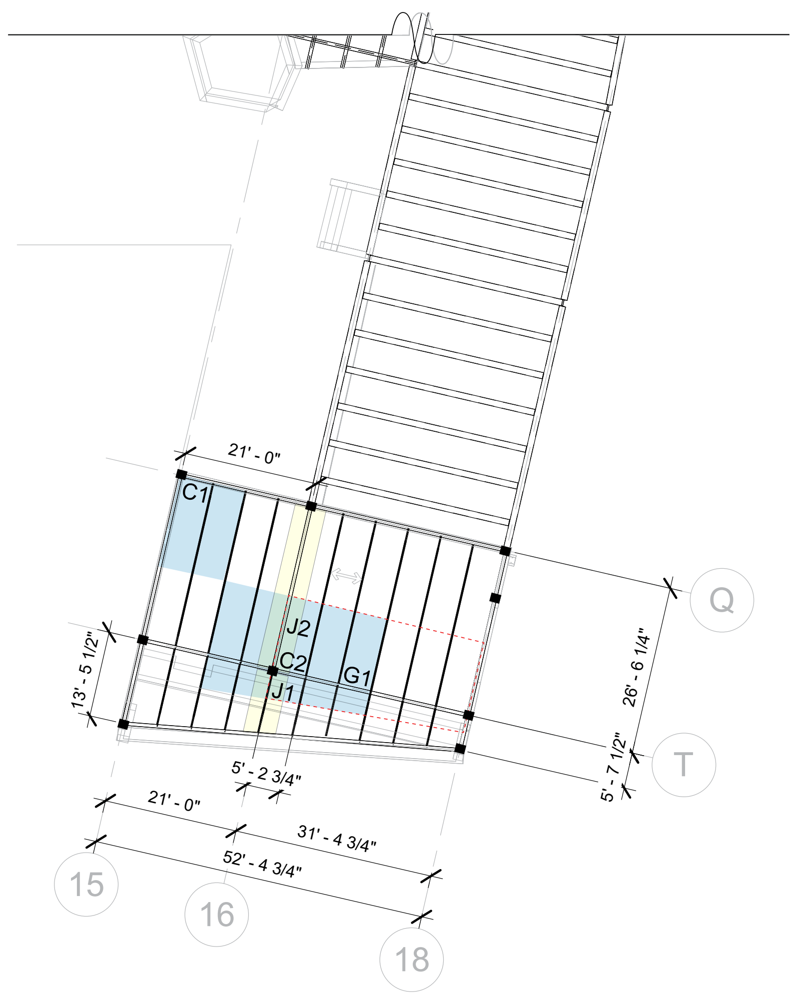
ROOF CALCULATIONS



1. **Roof**

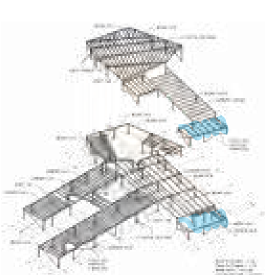
Structure	4,0psf
Metal Decking	2.0psf
Rigid Polyiso Insulation	3.0 psf
Roofing System	7.0psf
Finish Ceiling [Acoustic Fiber]	3.0psf
Mech, Elec, Plumb	4.0psf
Sprinklers	3.0psf
Metal Paneling	15.0psf
Collateral	1.0psf
Dead Load	42psf
[IBC 2021 T1607.1] Live Load	20psf

W service = 42psf + 20psf = 62psf
W u = 1.2 (42) + 1.6 (20) = 52.4psf



Tributary Width

Beam   Girder   Column



1. **Check Deck/ Slab**

S.I. Load= Dead - Slab + Live
= 42psf- 2psf + 20psf
=60psf
Span : 6' (conservative)

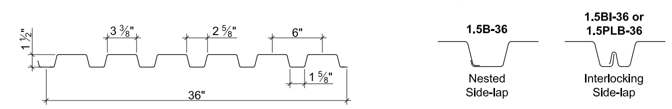
Vulcraft 1.5B-36/1.5Bl-36/1.5PLB-36
Deck
73psf > 60psf   OK

1.5B ROOF DECKS

- **1.5B-36 Deck used with Side-lap Screws**
- **1.5BI-36 Deck used with TSWs or BPs**
- **1.5PLB-36 Deck used with PunchLok® II System**

1.5B-36/1.5BI-36/1.5PLB-36 ROOF DECKS
GRADE 50 STEEL

Nominal Dimensions



Section Properties

Deck Gage	Deck Weight w_{dd} (psf)	Base Metal Thickness t (in.)	Yield Strength F_y (ksi)	Effective Moment of Inertia at Service Load $I_d = (2I_e+I_g)/3$: I_d+ (in⁴/ft)	I_d- (in⁴/ft)	Effective Section Modulus at F_y = 50 ksi: S_e+ (in³/ft)	S_e- (in³/ft)	Design Moment: $øM_n$+ (lb-ft/ft)	$øM_n$- (lb-ft/ft)	Vertical Web Shear $øV_n$ (lb/ft)
22	1.6	0.0295	50	0.155	0.178	0.169	0.179	634	671	4035
20	2.0	0.0358	50	0.197	0.217	0.224	0.229	840	859	4874
19	2.3	0.0418	50	0.239	0.257	0.266	0.278	997	1042	5666
18	2.6	0.0474	50	0.277	0.290	0.306	0.318	1148	1193	6398
16	3.3	0.0598	50	0.364	0.367	0.393	0.402	1474	1508	7996

Design Reactions at Supports Based on Web Crippling, $øR_n$ (lb/ft)

Deck Gage	Bearing Length of Webs — One-Flange Loading, End Bearing 1½"	2"	3"	4"	One-Flange Interior Bearing 3"	4"	Two-Flange Loading, End Bearing 1½"	2"	3"	4"	Two-Flange Interior Bearing 3"	4"
22	1235	1357	1563	1706	2204	2383	1289	1389	1556	1672	2728	2966
20	1763	1932	2215	2408	3164	3406	1949	2093	2333	2497	3960	4286
19	2344	2562	2927	3169	4222	4527	2702	2893	3213	3426	5324	5740
18	2954	3221	3669	3959	5334	5699	3515	3754	4156	4417	6762	7265
16	4525	4915	5568	5967	8206	8709	5681	6043	6651	7023	10487	11191

Standard Features

- ASTM A653 SS GR50 Min., with G60 or G90, white or gray primer optional
- ASTM A1008 SS GR50 Min. with gray primer
- Standard lengths – 6'-0" to 42'-0"
- IAPMO UES ER-0652, UL, and FM Listed
- Tables conform to ANSI/SDI RD-2017

Optional Features

- Inquire regarding cost and lead times for:
  - -Short cuts < 6'-0"
  - -Sheet Lengths > 42'-0"
  - -Alternative metallic and painted finishes
- Web Perforated Acoustical Versions

Deck Gage	Spans	Criteria	Span (ft-in.) 2'-0"	3'-0"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"
22	Single	$øW_n$	1267	563	317	203	141	103	79	63	51	42	35
		L/240	1270	376	159	81	47	30	20	14	10	8	6
	Double	$øW_n$	1240	575	329	212	148	109	83	66	54	44	37
		L/240	3514	1041	439	225	130	82	55	39	28	21	16
	Triple	$øW_n$	1502	708	407	263	184	136	104	82	67	55	46
		L/240	2754	816	344	176	102	64	43	30	22	17	13
20	Single	$øW_n$	1679	746	420	269	187	137	105	83	67	56	47
		L/240	1614	478	202	103	60	38	25	18	13	10	7
	Double	$øW_n$	1572	732	419	271	189	139	107	84	68	57	48
		L/240	4283	1269	535	274	159	100	67	47	34	26	20
	Triple	$øW_n$	1898	900	519	336	235	173	133	105	85	71	59
		L/240	3357	995	420	215	124	78	52	37	27	20	16
19	Single	$øW_n$	1994	886	499	319	222	163	125	98	80	66	55
		L/240	1958	580	245	125	73	46	31	21	16	12	9
	Double	$øW_n$	1894	886	508	328	229	169	129	102	83	69	58
		L/240	5073	1503	634	325	188	118	79	56	41	30	23
	Triple	$øW_n$	2281	1087	628	407	285	210	161	128	104	86	72
		L/240	3976	1178	497	254	147	93	62	44	32	24	18

LRFD

SELECT : 1.5B-36 Deck

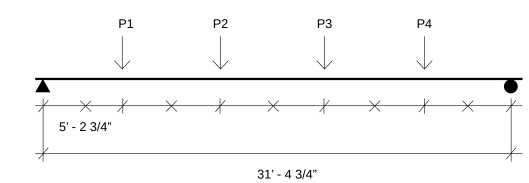
1. **Joist 01**

Length : 9' - 3 1/4" = 10' (conservative)
Wu = 1.2D + 1.6L
=1.2(42psf) + 1.6920psf) =82.4psf
Total Load = 82.4psf x 5' - 3" (trib width) = 432.6 plf

JOIST DESIG.	TOTAL LOAD (ASD)	LOAD for L/360 DEFL.	TOTAL LOAD (LRFD)	JOIST WEIGHT (lbs/ft)	MAX CHORD WIDTH (IN)	BRIDG. (H/X/EX)
10' LENGTH						
10K1	550	550	825	5.1	4	1/0/0
11' LENGTH						
10K1	550	542	825	5.1	4	1/0/0
12' LENGTH						

JOIST DESIG.	TOTAL LOAD (ASD)	LOAD for L/360 DEFL.	TOTAL LOAD (LRFD)	JOIST WEIGHT (lbs/ft)	MAX CHORD WIDTH (IN)	BRIDG. (H/X/EX)
19' LENGTH (continued)						
16K5	550	455	825	7.7	5	1/0/0
18LH02	748	748	1122	9.7	5	1/0/0
18LH03	833	833	1250	10.5	5	1/0/0
18LH05	1093	1093	1640	12.9	5	1/0/0

SELECT : 10K1



1. **GIRDER 01**

Length : 31' - 4 3/4"
Load = Distance x (1.2D + 1.6L)
= 5' 2 3/4" x (1.2(42psf) + 1.6(20psf) = 430.952plf

Factored:

P1 : 430.952 x (4.625' + 13.26') = 7.71 k
P2 : 430.952 x (4.21' + 13.26') = 7.53 k
P3 : 430.952 x (3.75' + 13.26') = 7.33 k
P4 : 430.952 x (3.3' + 13.26') = 7.14 k
P5 : 430.952 x (2.92' + 13.26') = 6.97 k

36.68 k

Service:

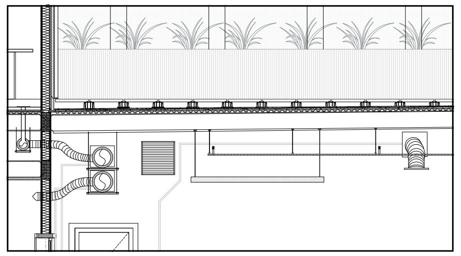
P1 : [(42+20) x 5' -2 3/4"] x (4.625' + 13.26') = 5.79 k
P2 : (62 x 5.23') x (4.21' + 13.26') = 5.66k
P3 : (62 x 5.23') x (3.75' + 13.26') = 5.52k
P2 : (62 x 5.23') x (3.3' + 13.26') = 5.37k
P2 : (62 x 5.23') x (2.92' + 13.26') =5.25k

27.59 k

*Moment Control
[T3-22 Case 3&4]
+M = APL = [0.33 x (7.71) x *31' -4 3/4")] + [(0.5) x (7.71) x (31' -4 3/4")] = 200.91 kft
-M = bPL = [(7.71) x (31' 4 3/4") + [(7.71) x (31' 4 3/4")] =484.12 *CONTROL
[T3-10]
1st Dash : W16x67
2nd Dash : W12x87
3rd Dash : W14X82
Solid Line : W21x62

SELECT : W21x62

FLOOR CALCULATIONS



1. **Floor**

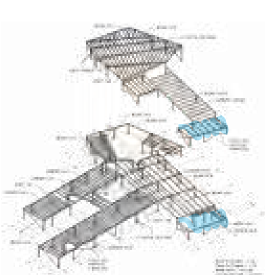
Conc | Metal Decking	63.0psf
Structure *[3.5" Conc w/ 3" deck]*	8.0psf
Finish Flooring *[Stone Pavers]*	9psf
Rigid Insulation 3"	4.5psf
Mech, Elec, Plumb	4.0psf
Sprinklers	3.0psf
Collateral	3.0psf
Metal Paneling	15.0psf
Dead Load	109.5psf
[IBC 2021 T1607.1] Live Load	100psf

W service = 109.5psf + 100psf = 209.5psf
W u = 1.2 (109.5) + 1.6 (100) = 291.4psf

Terrace Space

Tributary Width

Beam | Girder | Column



1. **Check Deck/ Slab**

Pre- Composite:
Dead Load Floor : 63psf
Live Load : 20psf

Post Composite:
Dead Load Floor : 109.5psf
Live Load : 100psf

Wu = 1.2D + 1.6L
=1.2 (63) + 1.6 (20) = 107.6psf

Slab Selection :

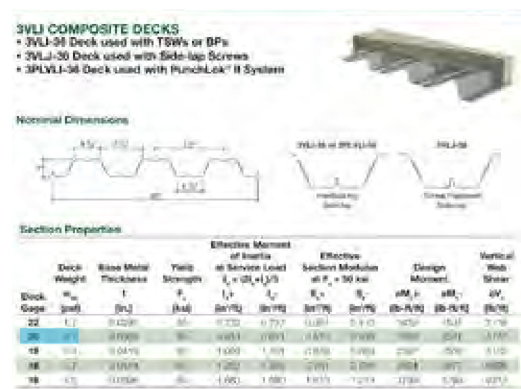
Wu = 1.2D + 1.6L
=1.2 (109.5) + 1.6 (100) = 291.4psf

Fire Code Requirements
6.5" Slab | 3" Deck +3.5" Concrete

Maximum Unshored Span
3vLI = 10' - 4" > 7' - 10 1/4"

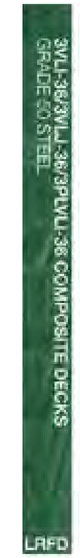
S.I. Load= Dead - Slab + Live
= 109.5psf- 71psf = 38.5psf
=100psf + 38.5psf = 138.5psf
Span : 8' (conservative)

Vulcraft 3VLI 20 Deck Reinforced 6x6 -W2.1xW2.1
938psf > 138.5psf OK



Total Slab Depth (in.)	Cover Depth (in.)	Theoretical Concrete Volume (yd³/100 ft²)	Min. A, for T&S (in.²)	WWR
Light Weight Concrete (110 pcf)				
5	2	1.08	0.028	6x6-W1.4xW1.4
5½	2½	1.23	0.028	6x6-W1.4xW1.4
6	3	1.39	0.028	6x6-W1.4xW1.4
6¼	3¼	1.47	0.029	6x6-W2.1xW2.1
6½	3½	1.54	0.032	6x6-W2.1xW2.1
7½	4½	1.77	0.038	6x6-W2.1xW2.1

SELECT : 3VLI Composite Deck with Reinforced 6x6-W2.1xW2.1 6 1/2"



1. **Beam 01**

Loads During Construction:
DL : 71psf
LL : 20psf
Mu= 1.2D + 1.6L = 1.2(71psf) + 1.6(20psf) = 117.2 psf

2. **Loads After Construction:**
DL : 109.5psf
LL : 100psf
Mu= 1.2D + 1.6L = 1.2(109.5psf) + 1.6(100psf) = 291.4 psf

Pre-Composite Condition:
Wu(floor) = (7' -10 1/4") x (117.2psf) = 920.51 = 0.921klf

Moment [T3-23]
Mu = wl^2 / 8 = ((0.921 x (39.83')^2) / 8 = 182.64kft

[AISC EQN 3-2]
Mu = ΦFyZx
Zx= Mu / ΦFy = (182.64kft x 12") / (0.9) x (50ksi) = 48.703in^3

Select:

	[T3-2] Zx (in^3)	[T3-2] Ix (in^4)	[T3-2] ΦVn (k)
W16x31	54.0	375	131
W14x34	54.6	340	120
W18x35	66.5	510	159
W16x40	73.0	518	146
W18x40	78.4	612	169
W21x44	95.4	843	217

Deflection:
DL = (7' - 10 1/4") X (71psf) = 0.55765 klf
[T3-23] Δmax = 5WL / 384EI
W21x44 -> [(5) x (0.55765 klf / 12") x (39.83' x 12") ^4 / (384 x 29000 x 843) = 1.29

(39.83' x 12") / 360 = 1.327 > 1.29 OK -> Select W21x44 pre-composite condition

3. **Composite Condition :**
Wu = (7.85') x (291.4psf = 2.29 klf

Moment [T3-23]
Mu = wl^2 / 8 = ((2.29 x (39.83')^2) / 8 = 454.19kft

Effective Width, bE : min | 1/8 (39.83') = 4.98' 3.93' + 12" (to edge of slab) = 4.93'
| 1/2 (7.85') = 3.93'

Trial A [T1-1 W21x44]
a = Asfy / 0.85f'cbE = (13 in^2) x (50ksi) / (0.85 x 4ksi x (4.93' x 12") = 3.23"

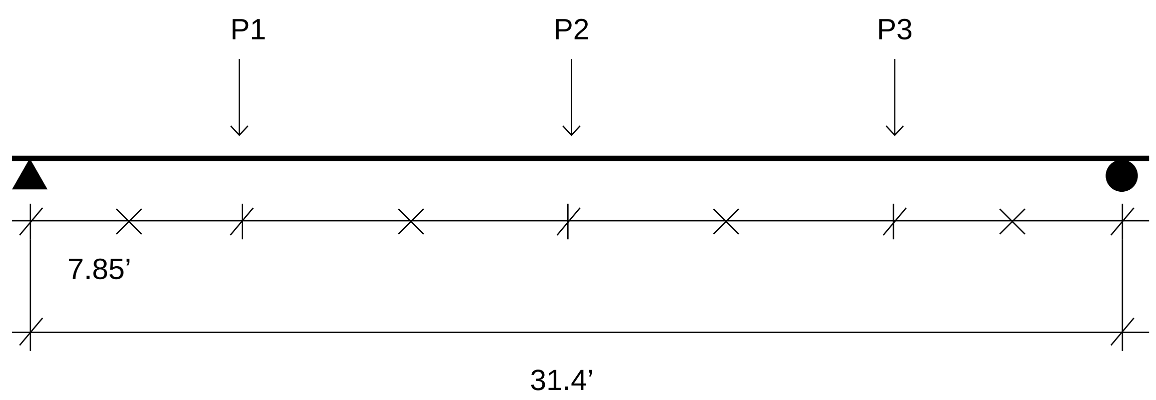
Actual A [T3-19]
Y=5"
AboveBFL (4)
Above 454.19 kft
W21x44 -> Mn= 647 > 454.19 OK
Qn= 431 k
a = Qn / (0.85 x f'c x bE) = 431 / (0.85 x 4 ksi x (4.93 ' x 12") = 2.143"
2.143" < 3.23 " OK

Actual Y:
Y2 = 6.5" - (2.143" / 2) = 5.43" > 5" OK

Shear [T3-2] :
Vu= wl/2 = (2.29klf x 39.83') / 2 = 45.62 k
W21x44 -> ΦVn = 217k > 45.61 OK

Deflection:
w = 100 psf x (7.85') = 0.785 klf
W21x44 I=2060 in^4 [T3-20]
Δmax = (5wl^4) / 284EI = (5 x 0.785 klf x (39.83^4)) / (384 x 29000 x 2060in^4) x 1728 = 0.74"
39.83' x 12" / 360 = 1.327" > 0.74" OK

SELECT : W21x44



1. **Girder 02**

2. **Pre-Composite Condition:**
Loads During Construction:
DL : 71psf x (31.4’ + 35.60’) x 7.85’ = 37.34 k
LL : 20psf x (31.4’ + 35.60’) x 7.85’ = 10.52 k

Load Combination
1.2D + 1.6L = 1.2(37.34k) + 1.6(10.52) = 61.64 k
D + L = 37.34 + 10.52 = 47,86 k

Moment [T3-22a]
Mu = P x L = 61.64 k x 7.85’ = 483.87kft

[AISC EQN 3-2]
Mu = ΦFyZx
Zx= Mu / ΦFy = (483.87kft x 12”) / (0.9) x (50ksi) = 129.032in^3

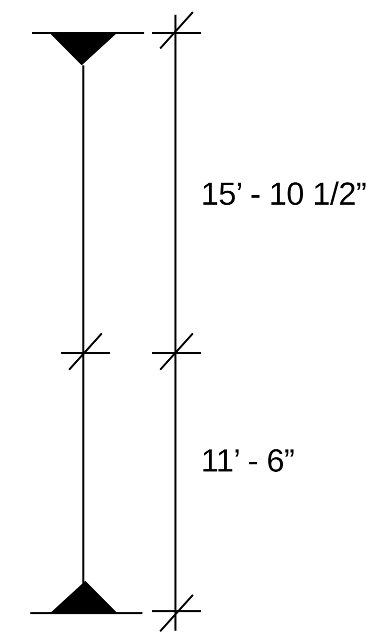
	[T3-2] Zx (in^3)	[T3-2] Ix (in^4)	[T3-2] ΦVn (k)
Select:			
W21x55	134	1140	234
W21x62	144	1330	252
W24x62	153	1550	306
W21x68	160	1480	272
W24x68	177	1830	295
W24x76	200	2100	315

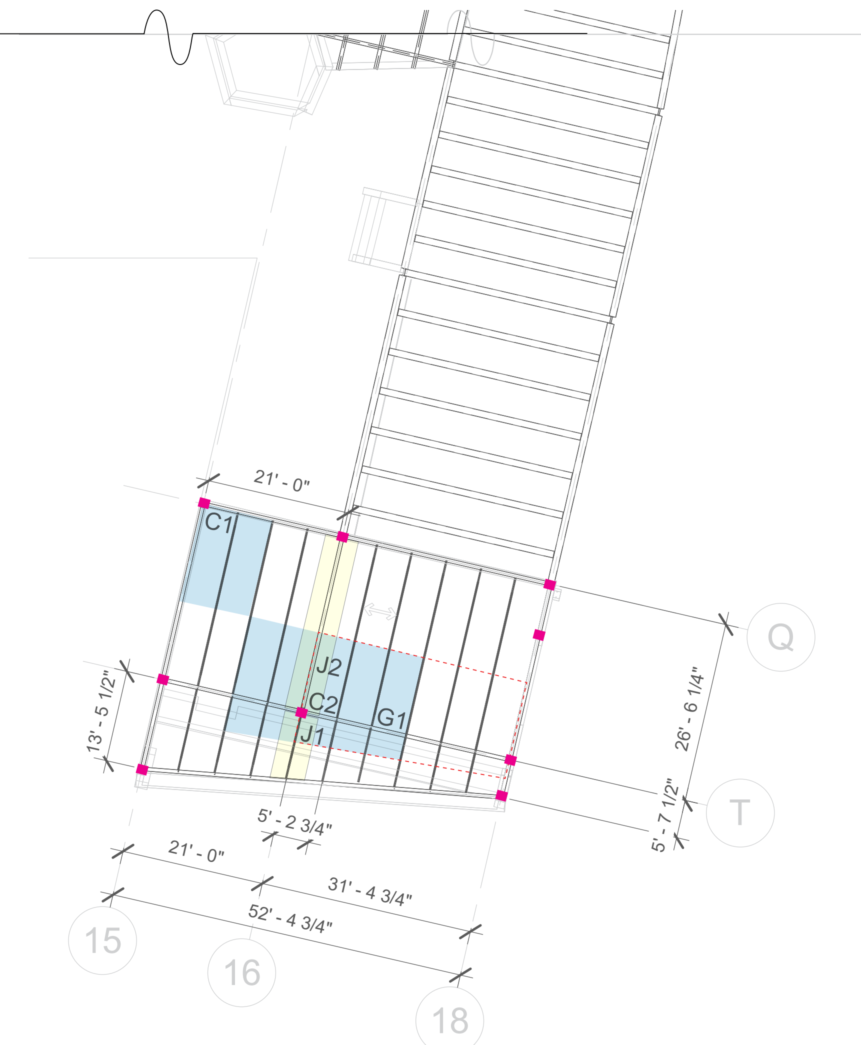
Deflection:
[T3-22a] Δmax = 0.05 x P x L^3 / EI
W24x68 -> [(0.05) x (37.34k/ft) x (31.4”)^3] / (2900ksi x 1830in^4) x 1728 = 1.88”

(31.4’’ x 12”) / 240 = 1.57 < 1.88 -> Camber 80% = 1.88” x (0.8) = 1.51 < 1.57 OK

Select W24x68 with a 1.5” Camber

SELECT : W24x68 with a 1.5” Camber





1. **Column 01**

Exterior
Trib Area = 10’ 6” x 13’ 4 1/4” = 140.22 ft^2
Mu = 1.2(42psf) + 1.6 (20psf) = 82.4psf
Exterior Wall x2 = 1.2 (15psf) = 18sf = 36psf
A= (10.5’ x 19.625’) + (13.35’ x 19.625’) = 468.06

K=1 Pinned at Top and Bottom
L= 13’ - 10 1/2”
KL = 13’ - 10 1/2”

Supporting Roof = p = (140.22 ft^2 x 82.4psf) + (468.06 x 36 psf) = 28.4 k

Select [T4-1a]

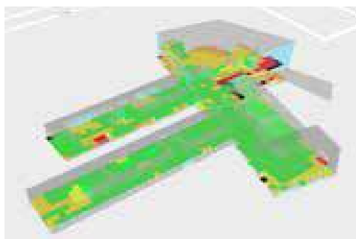
W8x31	Pn =28.4k < ΦPn 230k
W10x33	Pn =28.4k < ΦPn 233k
W12x40	Pn =28.4k < ΦPn 281k

SELECT : W8x31

CARBON FOOTPRINT

Heating Load: Heating load remains higher. To resolve this issue, we will increase the size of openings and remove some of the shading devices.

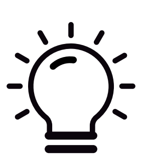
Lighting: To reduce the lighting load we will looking into better incorporated diffused light wells that can be incorporated with the HVAC coordination with the space. Having operable door to the exterior will also help increase the natural light filtering through.



53% sDA **37%** ASE

System Type	VAV w/ Reheat, with GSHP
Integrated Part Load Value	Constant Speed Screw Chiller
Heating System COP	4.5
Cooling System COP	6
Heat Recovery System	Heat-Pipes
Fan Flow Control Factor	Variable Speed
Specific Fan Power	Central Mechanical Ventilation With Hea
Ventilation Type	Mechanical
People Outdoor Air Rate (CFM/Person)	10
Area Outdoor Air Rate (CFM/ft²)	0.18
Infiltration (CFM/ft²)	0.03
Ventilation Calculation Type	Ventilation Rate Procedure
Building Energy Management System	Advanced
Ventilation Control	Demand Control
Exhaust Recirc. %	Exhaust Air Recirculation 60%
DHW Gen.	Heat Pump
Hot Water Distribution System	Taps Within 3 Meters Of Heat Generatio
Domestic Hot Water Demand (gal/yr)	90000
Pump Control for Cooling	All Other Cases
Pump Control for Heating	All Other Cases

AIA Framework for Design Excellence



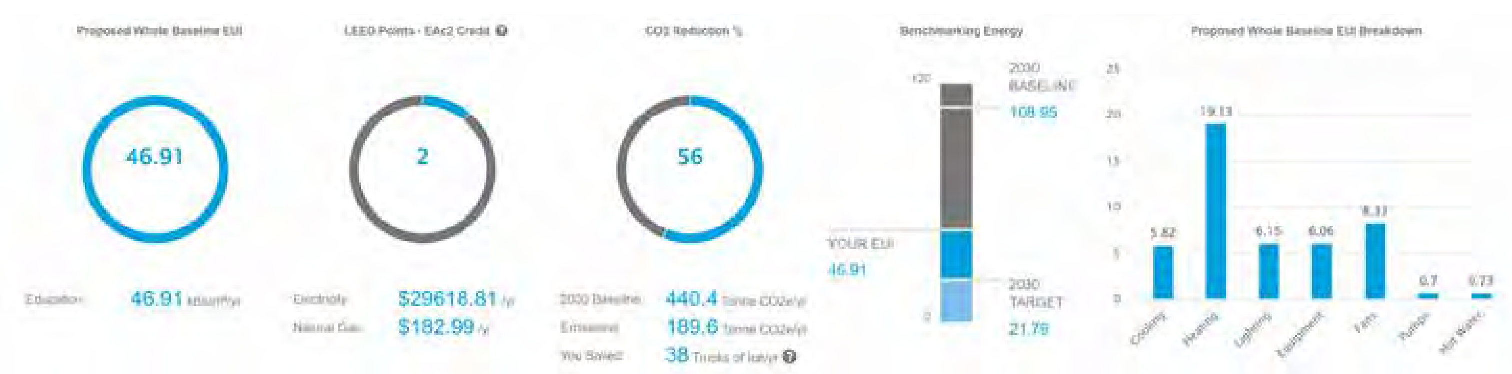
Design for energy

Good design reduces energy use and eliminates dependence on fossil fuels while improving building performance, function, comfort, and enjoyment.

Model A: 100% Code Compliant

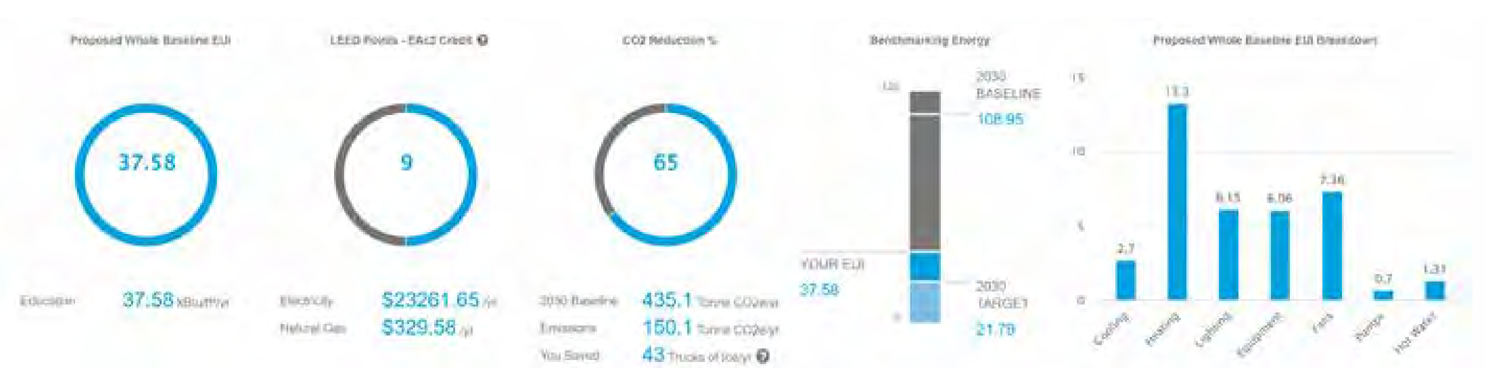
15.5% sDA **14.5%** ASE

Model B: Improved Design

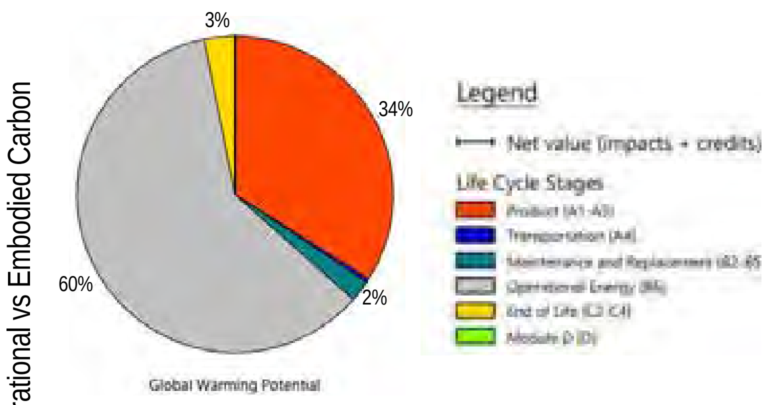


53% sDA **37%** ASE

Model C: Improved Design + Equipment



01 : Operational vs Embodied Carbon



operational : 60%
embodied : 34%

02 : Calculated Carbon Footprint

Row Labels	Sum of Global Warming Potential Total (kgCO2eq)	SF
Cast-in-place concrete, lightweight structural concrete, 3000 psi	16,226.07	10.38
Cast-in-place concrete, structural concrete, 5000 psi	6,170.63	3.95
Precast concrete slab	22,162.74	14.18
05 - Metals	**31,686.18**	**20.27**
Aluminum, sheet	6,628.28	4.24
Aluminum, square tube	126.46	0.08
Stair, steel plate	1,768.73	1.13
Steel, bar joist	1,279.70	0.09
Steel, C-stud metal framing with insulation	1,659.42	0.82
Steel, deck	5,985.06	3.83
Steel, round tubing	3,692.97	2.37
Steel, W section (wide flange shape)	10,545.57	6.75
06 - Wood/Plastics/Composites	**-1,326.84**	**-0.85**
Ornamental wood	-42.54	-0.03
Plywood, exterior grade	-1,284.29	-0.82
07 - Thermal and Moisture Protection	**5,746.25**	**3.68**
Fluid applied elastomeric air barrier	1,366.57	0.87
Polyurethane (PUR), board	4,379.68	2.80
08 - Openings and Glazing	**15,813.42**	**10.12**
Aluminum mullion system	670.48	0.43
Curtainwall System (including glazing)	9,978.83	6.38
Spandrel, glass, insulated	5,164.11	3.04
09 - Finishes	**3,522.50**	**2.25**
Fiberglass mat gypsum sheathing	1,595.15	1.02
Fluoropolymers	43.73	0.03
Wall board, gypsum	1,883.62	1.21
Operational Electricity	**87,894.49**	**56.23**
Operational Electricity	87,894.49	56.23
Operational Heating	**99,090.56**	**63.39**
Operational Heating	99,090.56	63.39
Grand Total	**286,986.00**	**183.61**

183.61 global warming potential per SF

DD

Aerial View Day Time

DD

Aerial View Night Time

Are you ready to invent and present?

The Glue

SPR2022 | ARCH4216 | Honors

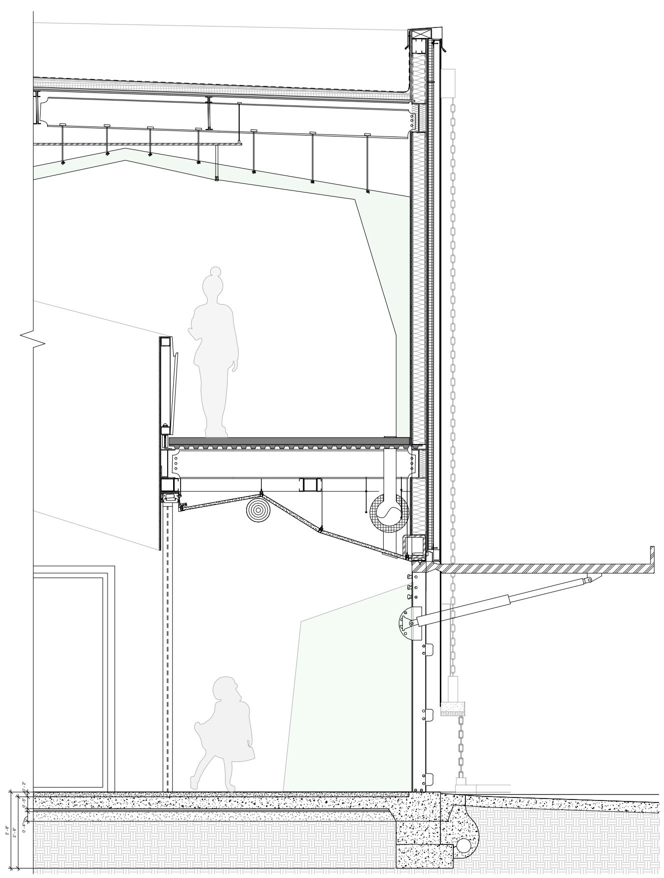
Jacey Watson

Avoiding the Thermal Glue

When trying to compute a building's total global warming potential, architects must first consider all the potential decisions that come within each material down to the thermal breaks in windows. Wall assemblies in themselves can be custom, standard, or a combination of both. The Thermal Envelope Calculator is a tool that breaks down typical details on buildings and provides various assemblies that hold different R and U values which can be crucial when looking at the overall efficiency of the building. The Thermal Envelope Calculator is user-friendly and begins with a diagram that expands into clickable spots that explode into very detailed 3D sections that provide the R and U values of the assemblies and the materials that are within. The website goes further as you can custom search for requirements and more personalized details. In the end, it allows the user to view what their total effective U value is for all their assemblies, total heat flow, and total area of opaque vs clear field assemblies.1 Knowing the importance of the Thermal Envelope Calculator is dandy but, truly understanding thermal bridging is the first step to mitigating it.

The mitigation of thermal bridging is the glue between the paper, the thing that brings all the items of a project together. It affects the MEP systems and their sizing, the structural integration with the design, overall energy consumption, and the overall embodied carbon. Without thermal bridging, there might be a possibility to have a net 0 building. However, the environment that architects create buildings in speaks for itself and all there is left to do is mitigate. Thermal bridging although is what connects most decisions in the DD phase of designing is the thing that breaks apart the thermal envelope of the building. The thermal envelope keeps the conditioned and unconditioned areas of the building separate however when clear field assembly thermal bridging or interface thermal bridging occurs there is an unfortunate moment in the wall assembly where the heat or cold from the outside seeps into the interior of the building. This is where mitigating thermal bridging becomes the glue, as decisions on insulation, MEP sizing, and structural placement connect.

Through the semester of ARCH4216, I began my journey with some research on thermal bridging and typical R values of wall assemblies. I further developed a greater understanding of what thermal bridging was with my team of four. Through this research, I began the SD phase by constructing the form of the building with little thought about thermal bridging. Just keep in mind to consider thicker walls for more insulation and a general ventral layout for the fan room. There was still an unclear understanding of materiality which left the wall assembly to be low in R and U values. Through the Design Development and Construction Documentation phase of the project, the wall section below, reveals the rendition to mitigate thermal bridging through my critical section. The resultant R-value of the wall was R-30 due to the selection of metal panels that had internal insulation adding an R-value of 20 to the total wall assembly.



1. "Thermal Envelope." Thermal Envelope. BC Housing, 2020. https://thermalenvelope.ca/.

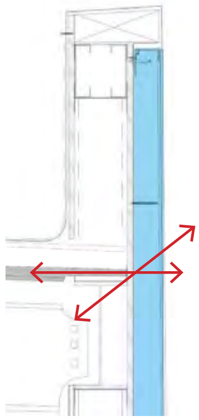
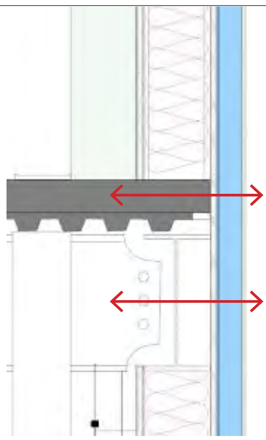
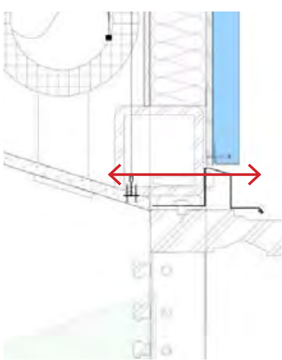
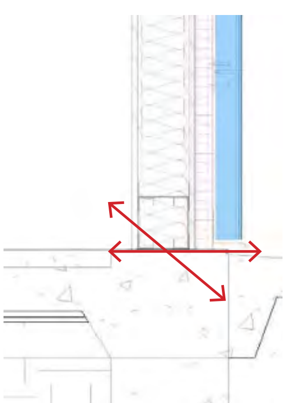
Overview

Through the design process, there are clear changes that occurred with the building envelope to mitigate thermal bridging.

In the Schematic Design Phase, floor slabs broke the envelope, and insulation was not properly placed creating an overall poor linear transmittance and contribution to overall heat flow in the assembly. Through the Design Development phase, the structure was fixed in accordance with the thermal envelope, and insulation was placed properly to mitigate the thermal bridging of the metal stud walls. The next few pages reveal the changes that were made throughout the project and how important it is for the efficiency of the building to mitigate thermal bridging.

Schematic Design Phase

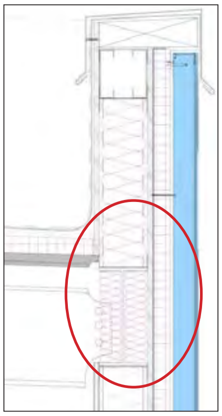
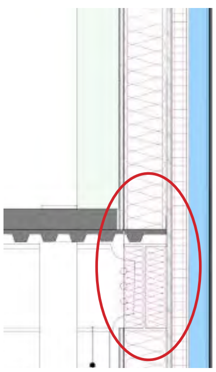
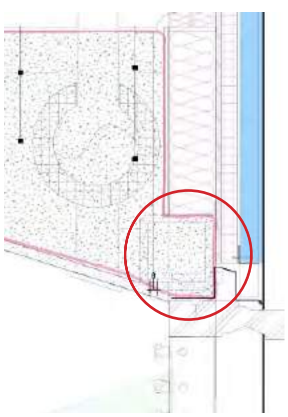
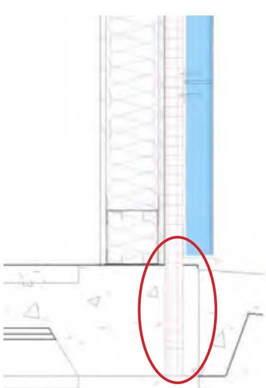
No specific materials were selected and a generalized 1' wall was utilized on the exterior. The structure interupts the wall assembly with no measures taken to acount for the added clear field assembly thermal heaat gain. Overall a poor job at mitigating thermal bridging.

		R value	U value	Descpription
roof at wall		R-1.56	0.64	No insulation was utilized in the parapet. The steel girders also are unprotected from the exchange of heat flow causing a direct connection to the interior thermal envelope.
intermediate		R-20.2	0.05	The slab extends to the edge of the exterior envelope transferring heat into the building. No continuous insulation is provided therefore breaking the thermal envelope.
garage door at wall		R-27.2	0.037	No insulation is located at the jamb of the door. Large steel supports for the tilt-up garage door absorb heat and transfer it inside by the underfloor HVAC system.
slab at grade		R-1.56	0.64	Since slab on grade is continuous there the heat absorbed by the exterior concrete transfers into the building's interior increasing the cooling load.

↔ Thermal Bridging

Design Developement | Construction Documentation Phase

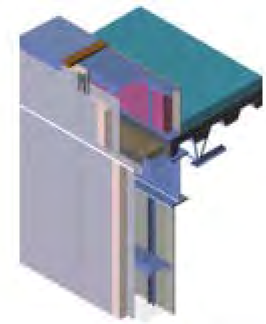
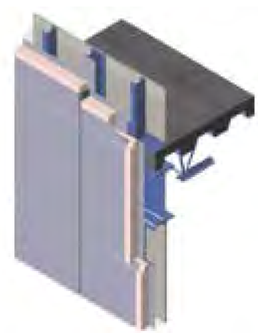
Specific materials selected with higher R and U values. Batt insulation is placed in line where there is a higher risk of thermal bridging. Continuous insulation is added to create a wall assembly that contains an R vaule of R-30. Overall a moderate job at mitigating thermal bridging.

		R value	U value	Descpription
roof at wall		R-26.6	0.0377	Batt insulation is added in between the girders to mitigate the thermal bridging. The insulation on the roof is extended to align with the batt insulation within the wall.
intermediate		R-49.89	0.020	Insulation continues through the wall. Continuous insulation is put behind the metal panel. An insulated metal panel was selected to add extra insulating values to the wall assembly.
garage door at wall		R-32.2	0.031	Spray foam is utilized around the jambs of the doors for further insulation.
slab at grade		1.56	0.64	Continuous insulation is continued down into the ground stopping with the spread footings to mitigate the thermal bridging between the exterior and interior slab.

Mitigation

Thermal Envelope Calculator

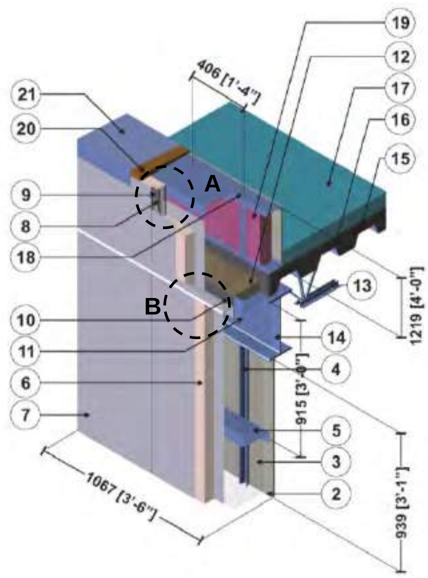
Taking the wall section a step futher, specific condiations and details are calulated utilizing the thermal envelope calulator to grasp a stronger sense of the reality of thermal bridging.

		R value	U value	O.H.F	Descpription
roof at wall		R-21	0.198 W/m^2K	29.0%	Batt insulation will be added to the wall assembly to increase the R-value to R-31.
intermediate		R-21	0.052 W/m^2K	4.30%	A higher R-value is noted in the DD phase due to the type of metal panel selected. There will be insulation on the inside of the panels as well including the continuous insulation to increase the R-value.
window to wall		R-16.8	1.32 W/m^2K	12.9%	There should be an exploration in more detail of thermal breaks for windows, consider utilizing less conductive materials for mullions to further increase the thermal resistivity of the window to wall condition.
slab at grade		R-42	0.095 W/m^2K	53.9%	Insulation penetrates into the ground to protect the interior slab from thermal bridging.

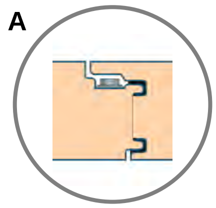
O.H.T : Overall Heat Flow

Detail 6.4.1

Vertical Insulated Metal Panel – Steel Roof Deck with Open Web Steel Joist & Parapet Intersection

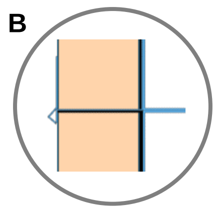


A



Vertical Joint

B



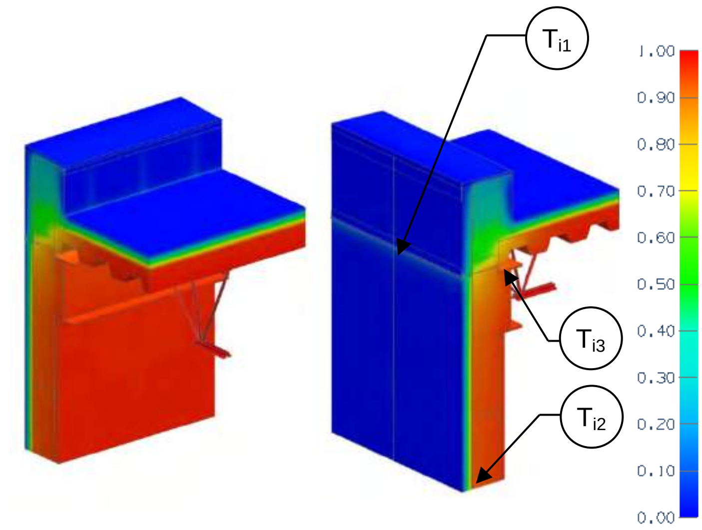
Horizontal Joint

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.6 to R-0.7 (0.11 RSI to 0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Cavity	-	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	Hat Tracks @ 16" o.c.	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Z-Girts with 1 1/2" Flange	16 Gauge	430 (62)	-	489 (7830)	0.12 (500)
6	Polyisocyanurate Insulation	3" (76)	0.143 (0.02)	R-21.0 (3.70)	1.8 (28)	0.29 (1220)
7	Steel Facer Skin	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Sealant	-	2.4 (0.35)	-	-	-
9	#14 Steel Fasteners	1/4" (6) Ø	314 (45)	-	489 (7830)	0.12 (500)
10	Steel Flashing & Trim	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
11	Steel Angle	16 Gauge	430 (62)	-	489 (7830)	0.12 (500)
12	Semi-Rigid Insulation	-	0.28 (0.04)	-	4.5 (72)	0.17 (710)
13	Open Web Steel Joist	-	314 (45)	-	489 (7830)	0.12 (500)
14	Steel Beam (W410)	-	314 (45)	-	489 (7830)	0.12 (500)
15	Steel Deck	1/16" (2)	314 (45)	-	489 (7830)	0.12 (500)
16	Concrete Topping	6" (152)	6.3 (0.9)	-	120 (1920)	0.20 (850)
17	Roof Insulation	4" (102)	-	R-20 (3.5 RSI)	1.8 (28)	0.29 (1220)
18	3 5/8" x 1 5/8" Steel Studs with Track	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
19	Parapet Insulation	-	0.29 (0.042)	R-12 (2.1 RSI)	0.9 (14)	0.17 (710)
20	Wood Block	5/8" (16)	0.69 (0.10)	-	27.8 (445)	0.45 (1880)
21	Flashing & roof finish materials are incorporated into exterior heat transfer coefficient.					
22	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 6.4.1

Vertical Insulated Metal Panel - Steel Roof Deck with Open Web Steel Joist & Parapet Intersection



View from Interior View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-2.2 (0.39 RSI) + exterior insulation
Transmittance / Resistance without anomalies	U_r, R_r, U_w, R_w	"clear field" U- and R-values for: r = insulated roof w = steel stud wall assembly with horizontal z girts
Transmittance / Resistance	U, R	U and R-values for the overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per length of parapet

[1]Assumptions and limitations for surface temperatures identified in ASHRAE 1365-RP

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Insulated Panel 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_w ft²·hr·°F / Btu (m² K / W)	U_w Btu/ft² ·hr ·°F (W/m² K)
R-21.0 (3.70)	R-23.2 (4.09)	R-21.4 (3.80)	0.047 (0.27)

Base Assembly - Roof

Roof Exterior Insulation 1D R-Value (RSI)	R_r ft²·hr·°F / Btu (m² K / W)	U_r Btu/ft² ·hr ·°F (W/m² K)
R-20 (3.52)	R-21.9 (3.86)	0.046 (0.26)

Parapet Transmittance

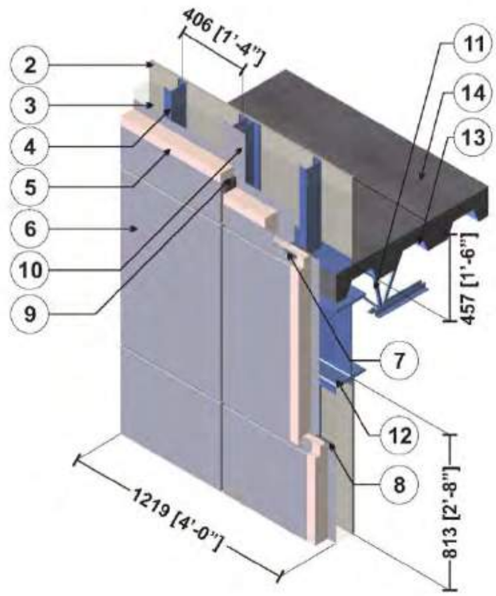
Insulated Panel 1D R-Value (RSI)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft ·hr ·°F (W/m K)
R-21.0 (3.70)	R-9.5 (1.68)	0.105 (0.60)	0.283 (0.489)

Temperature Indices

T_{i1}	0.71	Min T on interior panel face, at bolts, underneath support girt and semi-rigid insulation
T_{i2}	0.91	Max T on interior panel face, away from roof and joints
T_{i3}	0.84	Min T on interior surfaces, at roof and joist

Detail 6.2.2

Horizontal Insulated Metal Panel – Corrugated Slab Intersection with I-beam – Open Web Steel Joist and Steel Stud Backup Wall



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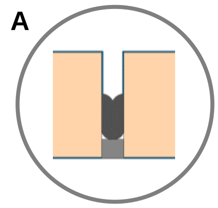
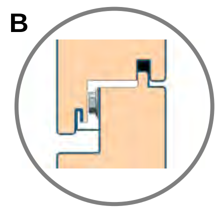


Vertical Joint

B



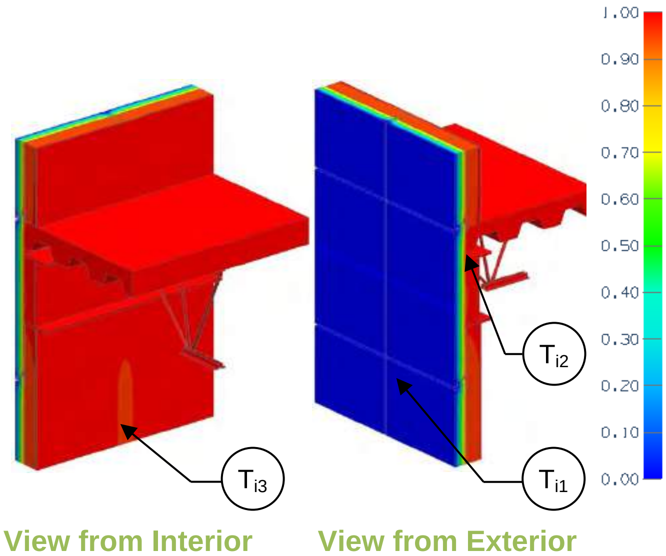
Horizontal Joint

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.6 to R-0.9 (0.11 RSI to 0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	-	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" x 1 5/8" Steel Studs (16" o.c.)	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Polyisocyanurate Insulation	3" (76.2)	0.143 (0.02)	R-21.0 (3.70)	1.8 (28)	0.29 (1220)
6	Steel Facer Skin	24 Gauge	430 (62)	-	489 (7830)	0.12 (500)
7	#14 Steel Fasteners	1/4" (6) Ø	314 (45)	-	489 (7830)	0.12 (500)
8	Sealant	-	2.4 (0.35)	-	-	-
9	Gasket	1 1/3" (33)	0.966 (0.14)	-	-	-
10	Steel Plate	20 Gauge	430 (62)	-	489 (7830)	0.12 (500)
11	Open Web Steel Joist	-	314 (45)	-	489 (7830)	0.12 (500)
12	Steel Beam (W410)	-	314 (45)	-	489 (7830)	0.12 (500)
13	Steel Deck	1/16" (1.6)	314 (45)	-	489 (7830)	0.12 (500)
14	Concrete Topping	6" (152)	6.3 (0.9)	-	120 (1920)	0.20 (850)
15	Exterior Film[1]	-	-	R-0.2 (0.03 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 6.2.2

Horizontal Insulated Metal Panel Corrugated Slab Intersection with I-beam – Open Web Steel Joist and Steel Stud Backup Wall



Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	Nominal thermal resistance value of panel and backup wall
Transmittance / Resistance without anomalies	U_o, R_o	"clear wall" U and R-value
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per length of slab

[1]Assumptions and limitations for surface temperatures identified in ASHRAE 1365-RP

Nominal (1D) vs. Assembly Performance Indicators

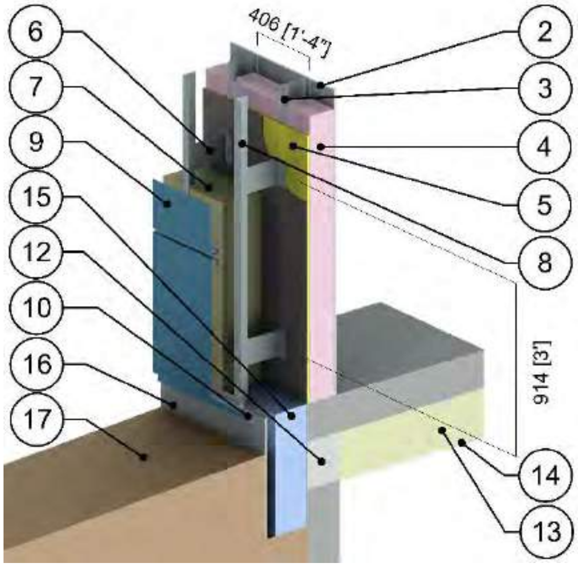
Insulated Panel 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft ·hr ·°F (W/m K)
R-21.0 (3.70)	R-23.2 (4.09)	R-19.5 (3.43)	0.052 (0.29)	R-16.3 (2.87)	0.061 (0.35)	0.016 (0.027)

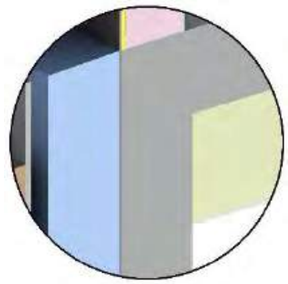
Temperature Indices

T_{i1}	0.87	Min T on interior panel face, at bolts and joint intersection, away from slab
T_{i2}	0.97	Max T on interior panel face, at I-Beam
T_{i3}	0.95	Min T on interior surfaces, at steel studs, away from I-Beam

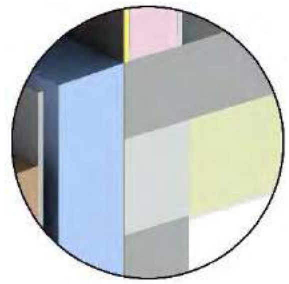
Detail 5.8.3

Exterior and Interior Insulated 6″ x 1 5/8” Steel Stud (16″ o.c.) Wall Assembly with FRP Vertical Brackets and Rail System Supporting Metal Cladding and R19 Batt Insulation in Stud Cavity – At-Grade Foundation Wall Intersection





Scenario A - Without Thermal Break



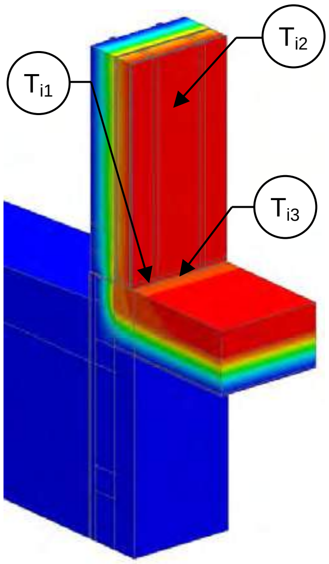
Scenario B - With Thermal Break

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.7 to R-0.9 (0.12 to 0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	6” x 1 5/8” Steel Studs with Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Fiberglass Batt Insulation	6” (152)	0.32 (0.046)	R-19 (3.35 RSI)	0.9 (14)	0.17 (710)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	FRP Bracket	-	4.9 (0.70)	-	110 (1760)	-
7	Exterior Mineral Wool Insulation	10” (254)	0.24 (0.034)	R-42 (7.40 RSI)	4.5 (72)	0.20 (850)
8	Vertical Aluminum L-Rail	0.09” (2.2)	1110 (160)	-	171 (2739)	0.22 (900)
9	Metal Cladding with 1/2" vented airspace incorporated into exterior heat transfer coefficient					
10	Aluminum Flashing	18 Gauge	1110 (160)	-	171 (2739)	0.22 (900)
11	Concrete Foundation	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
12	Foundation Thermal Block	8” (203)	0.20 (0.029)	R-40 (7.04 RSI)	1.8 (28)	0.29 (1220)
13	Slab Insulation	10” (254)	0.24 (0.034)	R-42 (7.40 RSI)	4.5 (72)	0.20 (850)
14	Gypsum Thermal Protection Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
15	Below Grade Rigid Insulation	8” (203)	0.20 (0.029)	R-40 (7.04 RSI)	1.8 (28)	0.29 (1220)
16	Cement Protection Board	1/2" (13)	12.5 (1.8)	-	140 (2250)	0.20 (850)
17	Soil	-	15.6 (2.25)	-	-	-
18	Exterior Film[1]	-	-	R-0.2 to R-0.7 (0.03 to 0.12 RSI)	-	-

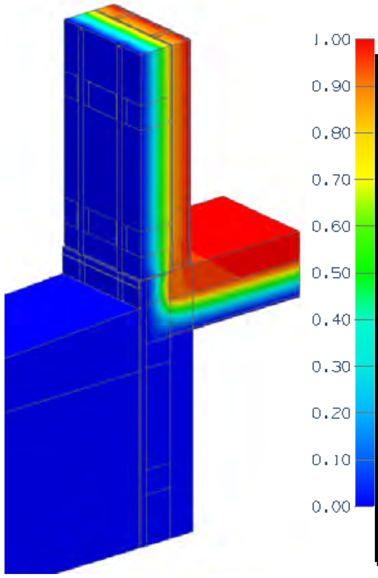
[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Detail 5.8.3

Exterior and Interior Insulated 6″ x 1 5/8” Steel Stud (16″ o.c.) Wall Assembly with FRP Vertical Brackets and Rail System Supporting Metal Cladding and R19 Batt Insulation in Stud Cavity – At-Grade Foundation Wall Intersection



View from Interior



View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-21.3 (3.75 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o	“clear wall” U- and R-value without slab and shelf angle
Transmittance / Resistance	U, R	U- and R-values for overall assembly
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of foundation

[1]Assumptions and limitations for surface temperatures identified in ASHRAE 1365-RP

Scenario

Scenario	
A	Without Thermal Break
B	With Thermal Break

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-42.0 (7.40)	R-63.3 (11.15)	R-48.3 (8.51)	0.021 (0.12)

Foundation Linear Transmittance

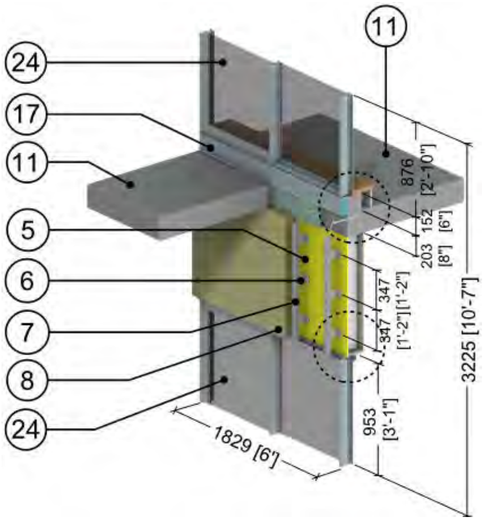
Scenario	Exterior Insulation 1D R-Value (RSI)	R ft²·hr·°F / Btu (m² K / W)	U Btu/ft² ·hr ·°F (W/m² K)	ψ Btu/ft ·hr·°F (W/m K)
A	R-42.0 (7.40)	R-7.2 (1.26)	0.140 (0.79)	0.271 (0.468)
B	R-42.0 (7.40)	R-13.6 (2.39)	0.074 (0.42)	0.058 (0.101)

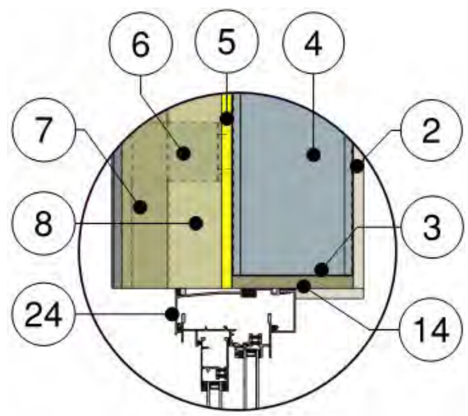
Temperature Indices

	A	B	
T_{i1}	0.65	0.88	Min T on interior sheathing surface at slab intersection, at studs
T_{i2}	0.75	0.75	Min T on interior sheathing surface away from slab, between studs at clips
T_{i3}	0.75	0.92	Min T on floor, at drywall intersection

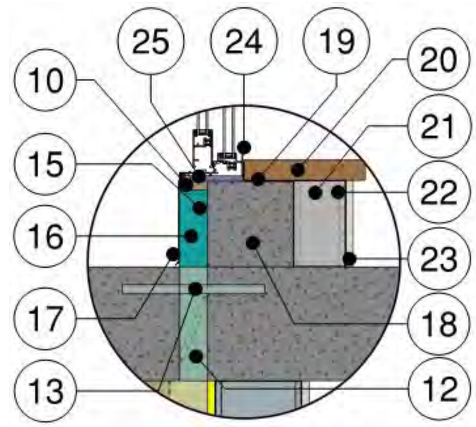
Detail 9.1.20

Exterior Insulated 2” x 6” Steel Stud (16” o.c.) Wall Assembly with Vertical Clips (24” o.c.) Supporting Cladding and Sliding Door – Structural Thermal Break at Concrete Balcony and Curb Intersection





Head Detail



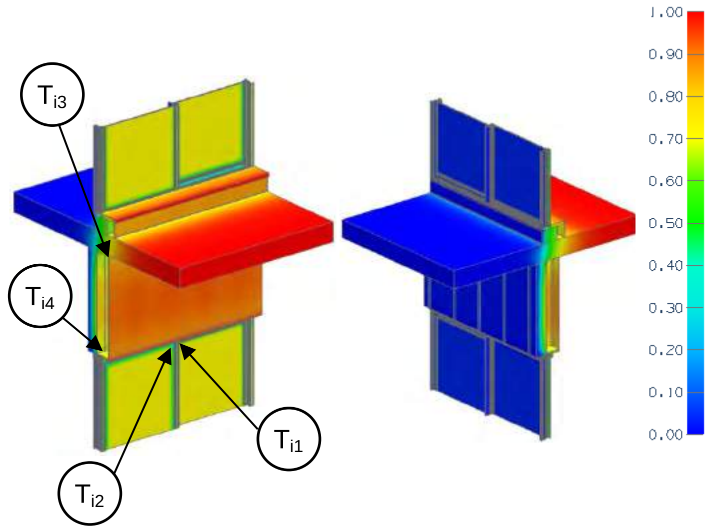
Sill Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft^2·hr·°F (W/m K)	Nominal Resistance hr·ft^2·°F/Btu (m^{2}K/W)	Density lb/ft^3 (kg/m^3)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.6 to R-1.1 (0.11 to 0.20 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	2” x 6” Steel Studs with Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	6” (152)	-	R-0.9 (0.16 RSI)	-	0.24 (1000)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Thermally Isolated Aluminum Bracket	0.09” (2.2)	-	-	-	-
7	Vertical Aluminum L-girt	0.09” (2.2)	1340 (193)	-	169 (2700)	0.22 (900)
8	Exterior Mineral Wool Insulation	Varies	0.24 (0.034)	R-4.2 to R-21 (0.74 to 3.70 RSI)	-	-
9	Generic Cladding with 1/2" (13 mm) vented air space is incorporated into exterior heat transfer coefficient					
10	Wood Buck	5/8” (16)	0.69 (0.10)	-	31 (500)	0.45 (1880)
11	Concrete Slab	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
12	Structural Thermal Break	2” (51)	0.53 (0.076)		-	-
13	#5 Steel Rebar	5/8” (16) Ø	347 (50)	-	489 (7830)	0.12 (500)
14	Wood Liner	1/2" (16)	0.69 (0.10)	-	31 (500)	0.45 (1880)
15	Steel Support Angle	1/4" (6)	430 (62)	-	489 (7830)	0.12 (500)
16	XPS Curb Insulation	2” (51)	0.02 (0.029)	R-10 (1.76 RSI)	1.8 (28)	0.29 (1220)
17	Aluminum Flashing	18 Gauge	1110 (160)	-	171 (2739)	0.22 (900)
18	Concrete Curb	8” (203)	12.5 (1.8)	-	140 (2250)	0.20 (850)
19	Steel Back Angle	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
20	Wood Sill	1 1/2" (38)	0.69 (0.10)	-	31 (500)	0.45 (1880)
21	3 5/8” x 1 5/8” Steel Studs with Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
22	Air in Stud Cavity	3 5/8” (92)	-	R-0.9 (0.16 RSI)	-	0.24 (1000)
23	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
24	Thermally broken aluminum sliding door[2], double glazed IGU U_{IGU} = 0.32 BTU/hr·ft^2·°F (1.82 W/m^{2}K)					
25	Polyamide Shim	1/2" (10)	1.73 (0.25)	-	-	-
26	Exterior Film[1]	-	-	R-0.2 to R-0.7 (0.03 to 0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation
[2]The thermal conductivity of air spaces within framing was found using ISO 100077-2

Detail 9.1.20

Exterior Insulated 2” x 6” Steel Stud (16” o.c.) Wall Assembly with Vertical Clips (24” o.c.) Supporting Cladding and Sliding Door – Structural Thermal Break at Concrete Balcony and Curb Intersection



View from Interior   View from Exterior

Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1D}	R-3.2 (0.56 RSI) + exterior insulation
Transmittance / Resistance without Anomaly	U_o, R_o, U_g	U- and R-value for o = “clear wall” g = glazed sliding door, including framing
Transmittance / Resistance	U_s, R_s, U_t, R_t	U and R-values for s = balcony slab + curb t = combined glazing, wall + slab
Surface Temperature Index	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Exterior Insulation 1D R-Value (RSI)	R_{1D} ft²·hr·°F / Btu (m² K / W)	R_o ft²·hr·°F / Btu (m² K / W)	U_o Btu/ft² ·hr ·°F (W/m² K)
R-4.2 (0.74)	R-7.4 (1.30)	R-6.9 (1.22)	0.144 (0.82)
R-8.4 (1.48)	R-11.6 (2.04)	R-9.8 (1.72)	0.102 (0.58)
R-12.6 (2.22)	R-15.8 (2.78)	R-12.0 (2.11)	0.083 (0.47)
R-16.8 (2.96)	R-20.0 (3.52)	R-14.5 (2.55)	0.069 (0.39)
R-21.0 (3.70)	R-24.2 (4.26)	R-16.7 (2.95)	0.060 (0.34)

Base Assembly – Glazed Door

$U_{centre\ of\ glass}$ Btu/ft² ·hr ·°F (W/m² K)	U_g Btu/ft² ·hr ·°F (W/m² K)
0.321 (1.82)	0.552 (3.13)

Balcony Transition Transmittance

Exterior Insulation 1D R-Value (RSI)	R_t ft²·hr·°F / Btu (m² K / W)	U_t Btu/ft² ·hr ·°F (W/m² K)	Ψ Door Head Btu/ft ·hr ·°F (W/m K)	Ψ Door Sill Btu/ft ·hr ·°F (W/m K)	Ψ Balcony Btu/ft ·hr ·°F (W/m K)
R-4.2 (0.74)	R-2.5 (0.44)	0.399 (2.26)	0.145 (0.251)	0.065 (0.112)	0.094 (0.163)
R-8.4 (1.48)	R-2.6 (0.46)	0.386 (2.19)	0.161 (0.279)		0.144 (0.249)
R-12.6 (2.22)	R-2.6 (0.46)	0.382 (2.17)	0.154 (0.267)		0.193 (0.333)
R-16.8 (2.96)	R-2.6 (0.47)	0.378 (2.15)	0.176 (0.305)		0.200 (0.346)
R-21.0 (3.70)	R-2.7 (0.47)	0.376 (2.14)	0.181 (0.313)		0.218 (0.377)

Balcony Only

R_s ft²·hr·°F / Btu (m² K / W)	U_s Btu/ft² ·hr ·°F (W/m² K)
R-12.4 (2.18)	0.081 (0.46)
R-8.1 (1.43)	0.123 (0.70)
R-6.1 (1.07)	0.165 (0.94)
R-5.8 (1.03)	0.171 (0.97)
R-5.4 (0.94)	0.187 (1.06)

Temperature Indices

	R4.2	R8.4	R12.6	R16.8	R21.0	
T_{i1}	0.13	0.13	0.13	0.13	0.13	Min T on window frame at centre mullion of sliding door
T_{i2}	0.44	0.44	0.44	0.44	0.44	Min T on window glass at 30 mm away from sight edge at fixed glazing
T_{i3}	0.84	0.84	0.84	0.84	0.84	Min T on slab at wall ceiling
T_{i4}	0.50	0.48	0.49	0.50	0.50	Min T on sheathing at sliding door head

Conclusion

In conclusion, good design is a response to a problem, and in this case, thermal bridging is pinned as the "bad guy."
Thermal bridging is the thing that should be avoided but in turn, becomes the thing that adheres all the other elements together to become a sophisticated and efficient system. Through the utilization of hand calculations computer in SD, it becomes clear how simplified the process of determining the R and U value of wall assemblies becomes.

Through the Thermal Envelope Calculator, the user is able to view the breakdown of all of the materials within the given condition selected. They are also able to take those items to values to computer their own project-specific details. By computing the conditions in the thermal envelope calculator, I am able to further see where the issues of thermal bridging occur and how the heat flow of the assemblies fan out. From the SD phase, there was an increase in the overall insulation utilized to increase the R-value. Comparing the thermal envelope calculations to the DD phase, further exploration of how the materials attached to the facade are necessary. Although the inclusion of thermal bridging with nails and hat channels is low, it is still a factor that contributes to the overall heat flow of the thermal envelope. Placing a thin sheet of plastic insulation at the point at which the nail penetrates the metal stud can become a buffer area for thermal bridging. Since there is low glazing throughout most of the exterior walls of my building, focusing on breaking the bridge at the slab on grade appears to be the most pressing issue with the thermal envelope. Mitigation occurs through the use of continuous insulation and extending the insulation horizontally to align with the vertical insulation.

After calculating the R and U values of my critical section by hand, although it is proven to be useful to make sure there is a clear understanding as to how the wall assembly gets assembled, I believe that by also utilizing the thermal envelope calculator you are able to get even more precise and accurate with the decisions that are made to mitigate thermal bridging.

The Thermal Envelope Calculator Process1
To begin the process of computing these details, the first step is to go to https://thermalenvelope.ca

The next step is to click on collections, then start your own project.

From there you go to the database and select on the module which condition you are looking at.

After you filter the search list, you are able to select the condition review their properties, and then click add to add it to the project created.

Once all of the assemblies are added to the project you are able to download all of their information on the list scenarios tab.

From there you can input how much of that assembly you have and find the overall heat flow contribution of each.

You can also compare the varying scenarios added and their effectiveness to mitigate thermal bridging by clicking the compare the scenarios tab.

1. "Thermal Envelope." Thermal Envelope. BC Housing, 2020. https://thermalenvelope.ca/.