BREADTH STUDIES

ACOUSTICS

A reverberation time analysis was completed for the lounge on the first floor of the building. The lounge is a main circulation space for the building, but also a place for students to study and do homework, so improper acoustics can be detrimental to the atmosphere of the space. After analyzing the spaces alternative materials were chosen and the space was redesigned to maximize the acoustical balance.

ARCHITECTURE

The architectural breadth study is comprised of the south-facing façade on the first floor of the building. The sun shades, which help to control the daylight entering the space, were studied and alternative daylighting solutions were explored.

ACOUSTICS BREADTH

The student lounge in the Wheelock College Campus Center and Student Residence building is meant to be a place for students to be able to relax, do homework and study between classes and in the evening. It is also a main lobby and entrance space to the building, which conflict with the relaxed feeling it is supposed to convey.

The reverberation time, which is a measurement of the amount of time necessary for a sound to decay by 60 dB from its initial strength, is a good way to measure the quietness of a space. There are currently no building code requirements for a lounge space. The book *Architectural Acoustics* recommends a reverberation time between 0.8 and 1.1 seconds.

The formula for reverberation time is a function of the room volume and material absorption (in sabins). The material absorption depends on the amount of a particular material and the material's absorption coefficients (α). Since a material's absorption coefficient varies with the sound frequency, the reverberation time has to be calculated independently at each frequency. The formula for the reverberation time is defined as:

$T = 0.05*(V/a)$

T = reverberation time in seconds

V = volume in ft3

a = room absorption in sabins

MATERIALS AND FINISHES

Surface	Material	Absorption Coefficient					
		125 Hz	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
Floor 1	Carpet, heavy, on carpet	0.02	0.06	0.14	0.37	0.60	0.65
Floor 2	Glazed Tiles	0.01	0.01	0.01	0.02	0.02	0.02
Walls	Wood, ¼" thick with airspace behind	0.42	0.21	0.10	0.08	0.06	0.06
Doors	Wood, 1" thick with airspace behind	0.19	0.14	0.09	0.06	0.06	0.05
Ceiling 1	Gypsum board – ½" thick	0.29	0.10	0.10	0.10	0.07	0.02
Ceiling 2	Wood, ¼" thick with airspace behind	0.42	0.21	0.10	0.08	0.06	0.06
Ceiling 3	Acoustical Board, ¾" thick, suspended	0.76	0.93	0.83	0.99	0.99	0.94
Furniture	Fabric well-upholstered seats	0.19	0.37	0.56	0.67	0.61	0.59
Windows	Glass – Heavy	0.18	0.06	0.04	0.03	0.02	0.02
Stairs	Wood	0.15	0.11	0.10	0.07	0.06	0.07
Corridor Opening	Composite (Tile, Wood, ACT)	0.44	0.38	0.35	0.47	0.57	0.57

EXISTING DESIGN REVERBERATION TIMES

Surface	Surface Area – S	Absorption Coefficient					
		125 Hz	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
Floor 1	252 ft^2	5.04	15.12	35.28	93.24	151.20	163.80
Floor 2	2179 ft^2	21.79	21.79	21.79	43.58	43.58	43.58
Walls	946 ft^2	397.32	198.66	94.60	75.68	56.76	56.76
Doors	24 ft^2	4.56	3.36	2.16	1.44	1.44	1.20
Ceiling 1	563 ft^2	163.27	56.30	56.30	56.30	39.41	11.26
Ceiling 2	1868 ft^2	784.56	392.28	186.80	149.44	112.08	112.08
Ceiling 3	0 ft^2	0.00	0.00	0.00	0.00	0.00	0.00
Furniture	756 ft^2	143.64	279.72	423.36	506.52	461.16	446.04
Windows	1680 ft^2	302.40	100.80	67.20	50.40	33.60	33.60
Stairs	506 ft^2	75.90	55.66	50.60	35.42	30.36	35.42
Corridor Opening	402 ft^2	176.88	152.76	140.70	188.94	229.14	229.14
Room Volume V = 34,034 ft^3							
Room Absorption (sabins) $a = \sum S\alpha$		2075.36	1276.45	1078.79	1200.96	1158.73	1132.88
Reverberation Time (seconds) $T_{60} = 0.05*(V/a)$		0.82	1.33	1.58	1.41	1.47	1.50

ACOUSTICS REDESIGN

After reviewing the reverberation time in the lounge, some alterations were made to the materials in the space. The 10 ft ceiling near the staircase will be switched from painted gypsum wall board to acoustical ceiling tile. The carpet will also be extended throughout the space, covering everything except the main walkway. By making these simple alterations, the reverberation time for the space has been greatly reduced and is much more conducive to speaking and conversations.

REDESIGN REVERBERATION TIMES

Surface	Surface Area – S	Absorption Coefficient					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Floor 1	1451 ft^2	29.02	87.06	203.14	536.87	870.60	943.15
Floor 2	980 ft^2	9.80	9.80	9.80	19.60	19.60	19.60
Walls	946 ft^2	397.32	198.66	94.60	75.68	56.76	56.76
Doors	24 ft^2	4.56	3.36	2.16	1.44	1.44	1.20
Ceiling 1	263 ft^2	76.27	26.30	26.30	26.30	18.41	5.26
Ceiling 2	1868 ft^2	784.56	392.28	186.80	149.44	112.08	112.08
Ceiling 3	300 ft^2	228.00	279.00	249.00	297.00	297.00	282.00
Furniture	756 ft^2	143.64	279.72	423.36	506.52	461.16	446.04
Windows	1680 ft^2	302.40	100.80	67.20	50.40	33.60	33.60
Stairs	506 ft^2	75.90	55.66	50.60	35.42	30.36	35.42
Corridor Opening	402 ft^2	176.88	152.76	140.70	188.94	229.14	229.14
Room Volume V = 34,034 ft^3							
Room Absorption (sabins) a = ∑Sα		2228.35	1585.4	1453.66	1887.61	2130.15	2164.25
Reverberation Time (seconds) $T_{60} = 0.05*(V/a)$		0.76	1.07	1.17	0.90	0.80	0.79

As apparent in the chart below, the reverberation times in the redesign are much closer to the recommended times than in the existing design. With just a few alterations, the sound quality in the student lounge has been improved dramatically.

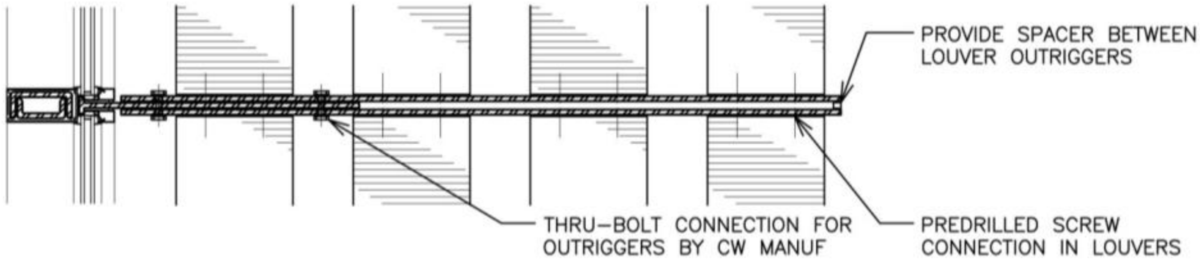
	Reverberation Time (seconds)					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000Hz
Target	0.8 to 1.1	0.8 to 1.1	0.8 to 1.1	0.8 to 1.1	0.8 to 1.1	0.8 to 1.1
Existing Design	0.82	1.33	1.58	1.42	1.47	1.50
Redesign	0.76	1.07	1.17	0.90	0.80	0.79

ARCHITECTURE BREADTH

Natural light is an integral part of building and lighting design. Having light during the day can decrease energy expenses by allowing occupants to turn off electric lights, as well as help to maintain the natural circadian rhythms in our bodies. While it is important to have a building with sufficient daylight, it is also important to have means to control the amount of daylight entering a certain space. During the summer, illuminance from the sun can reach up to 7000 fc, more than 300 times the amount of light needed for most spaces. In addition to an abundance of light, uncontrolled daylight can cause unwanted solar heat gain, damage fabrics and artwork and cause uncomfortable glare for occupants.

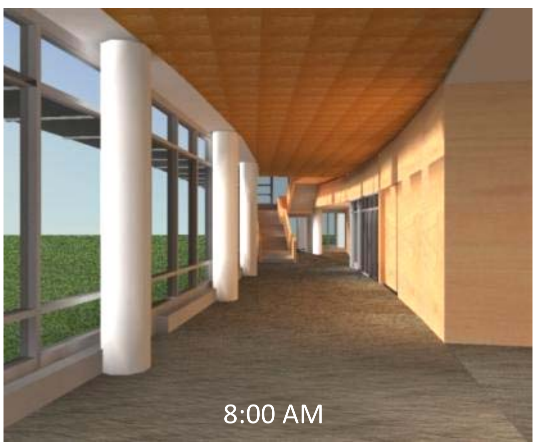
This study evaluates the effectiveness of daylight control in the student lounge. The space was designed with exterior sun shades to reduce the amount of sunlight entering the space during the day, which was modeled and rendered with AGI 32 software. Additional studies were performed with a sheer shading system and a Kalwall system installation. A comparative analysis will be performed on all systems, and each solution will be evaluated based on its effectiveness.

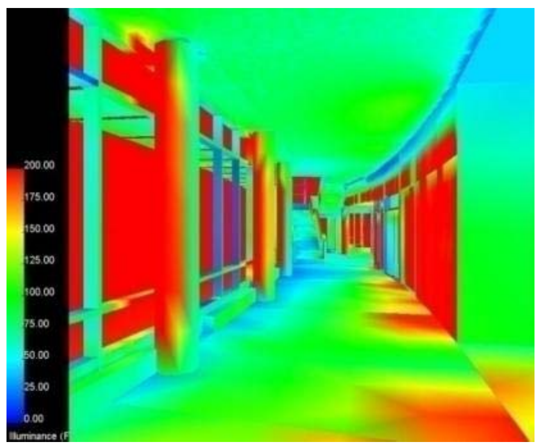
Daylight level calculations were performed on the student lounge at various times throughout the day. December 21, 2009 was chosen as the day to calculate because it is the winter solstice, where the sun is the lowest in the sky and therefore the most likely to cause glare issues for occupants. The analysis for all three solutions was performed at 8:00 AM, 10:00 AM, 12:00 PM, 2:00 PM and 4:00 PM with a clear sky.

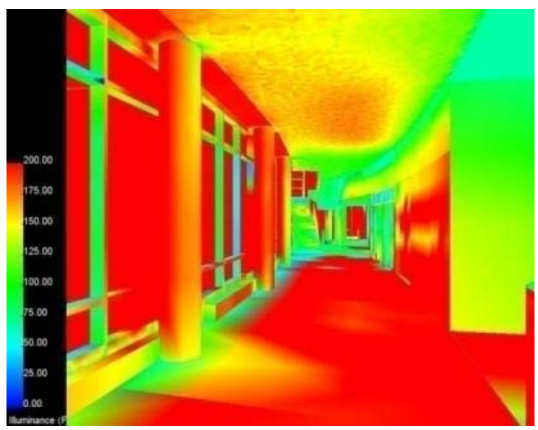


The image above is the plan view of the solar shade connection system.

The sun shades installed on the building extend 4'-6" from the building and are mounted 10'-0" above the ground. They are made of perforated metal strips. The idea of the sun shades are to block out the sun when it is most likely to cause glare during the day. They allow an unobstructed view to the scenery outside while protecting occupants from harsh direct sunlight and glare during the day. The images below are RGB and Pseudo-color renderings to show the amount of illuminance in the space.





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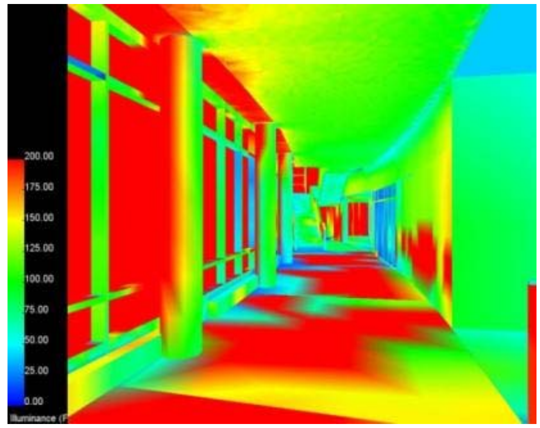
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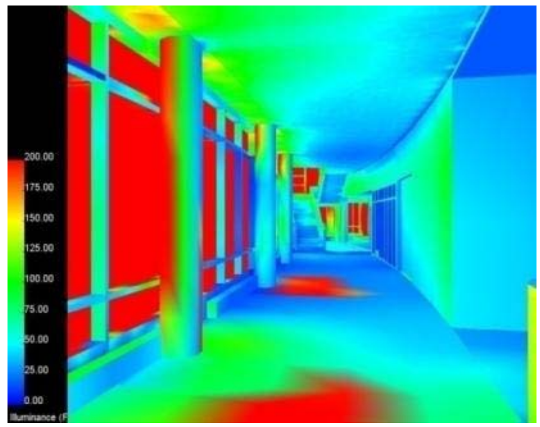
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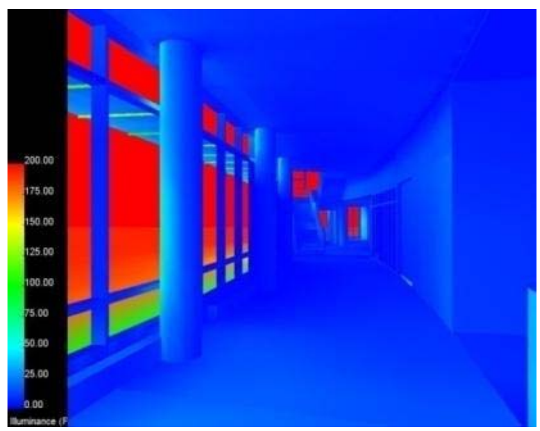
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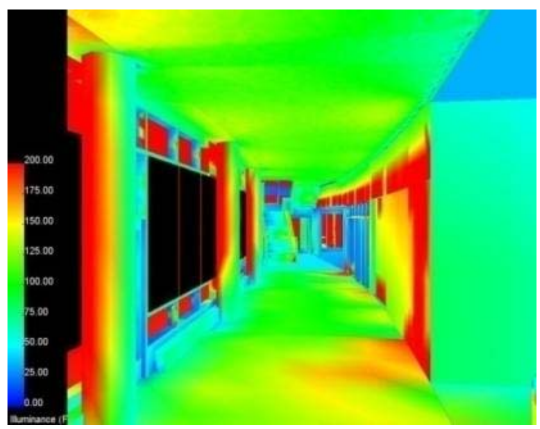
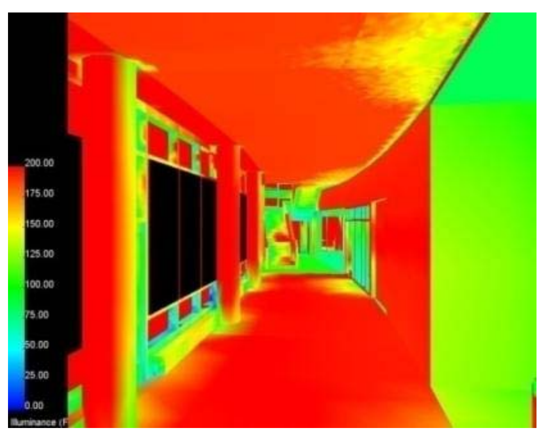
SHEER SHADE ANALYSIS

The above image is a commercial installation of a Lutron sheer shading system.

An alternative solution to the metal sun shades are an interior sheer shading system. A motor controlled sheer shading system offers many benefits, such as blocking harmful UV rays from entering the space. Also, the shades can be retracted on overcast days and when the sun is not shining directly into the space. A clear view to the outside is not necessary due to the parking lot behind the building. The shades are assumed to have a 50% transmittance.



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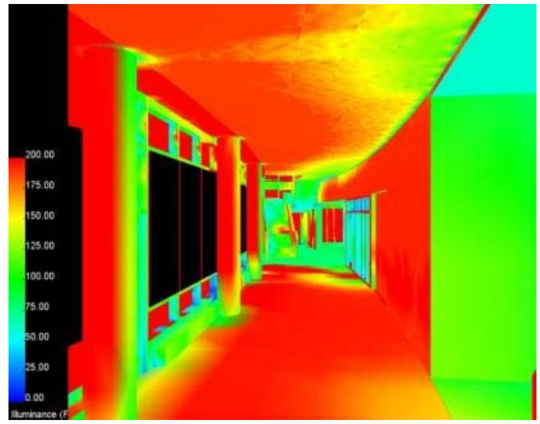
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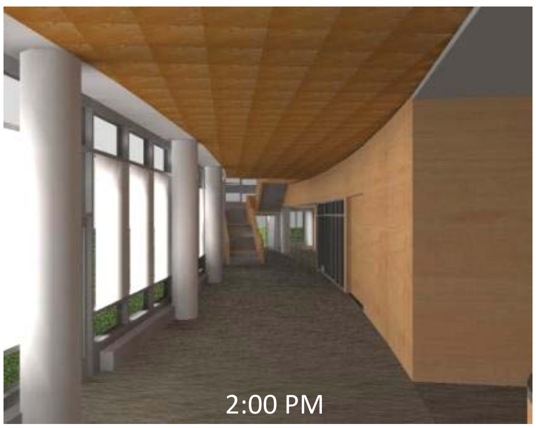
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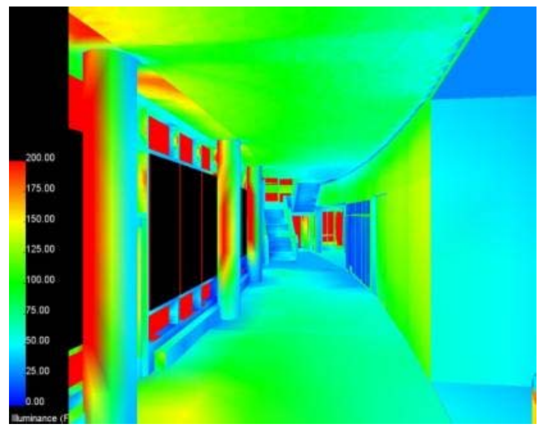
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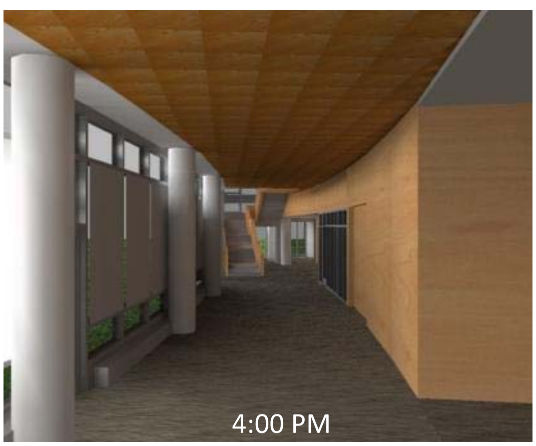
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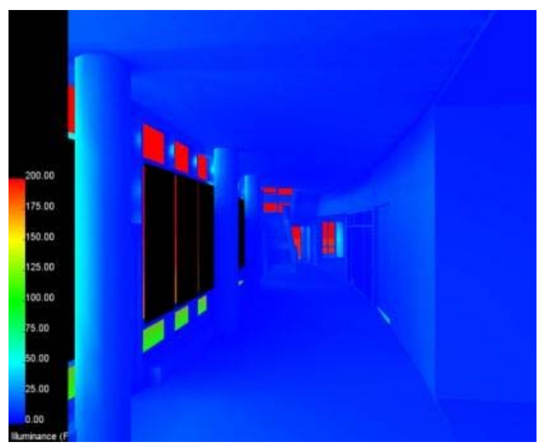
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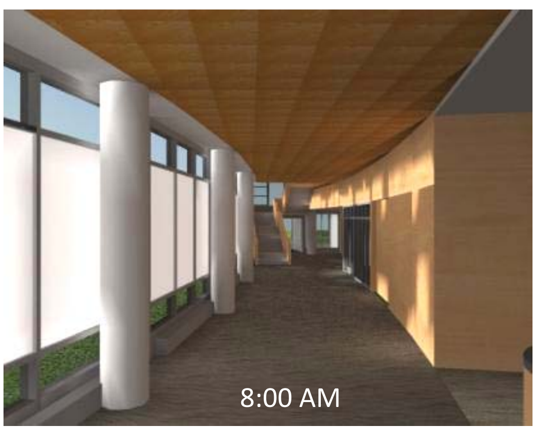
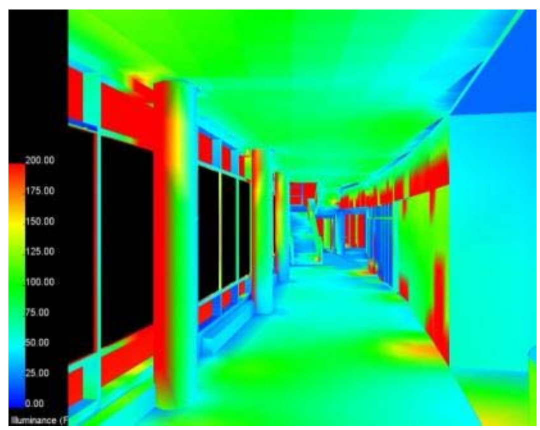
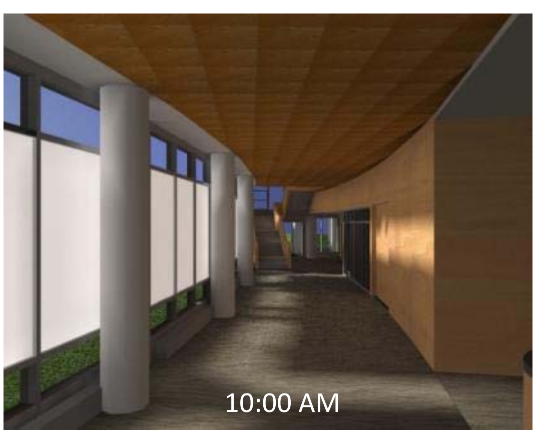
KALWALL SYSTEM ANALYSIS

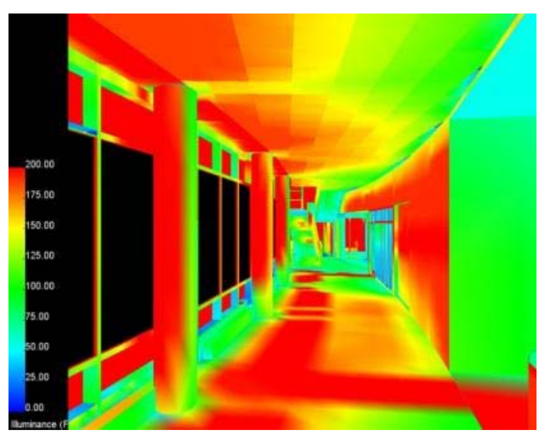
The image above is a Kalwall translucent window installation.

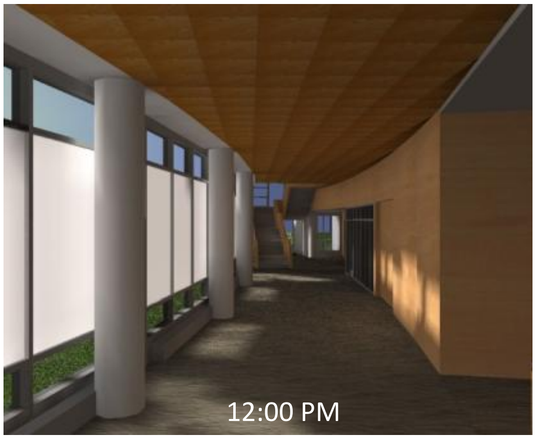
A final study was done evaluating the effectiveness of a Kalwall system replacing the large picture windows in the space. While this system would obstruct the view to the outside, it would allow daylight to enter the space without an uncomfortable glare, while greatly reducing the solar heat gain to the space. A clear view to the outside is not necessary due to the parking lot behind the building. The Kalwall is assumed to have a 30% transmittance.







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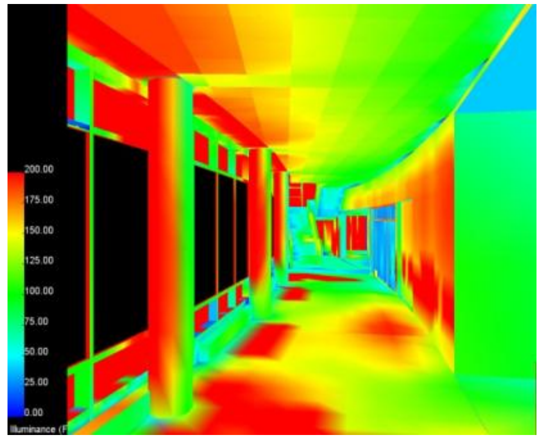
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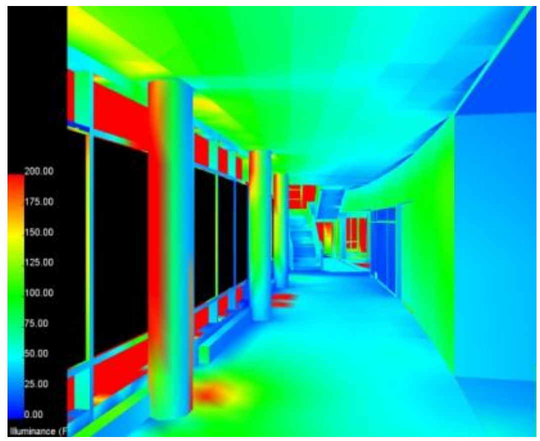
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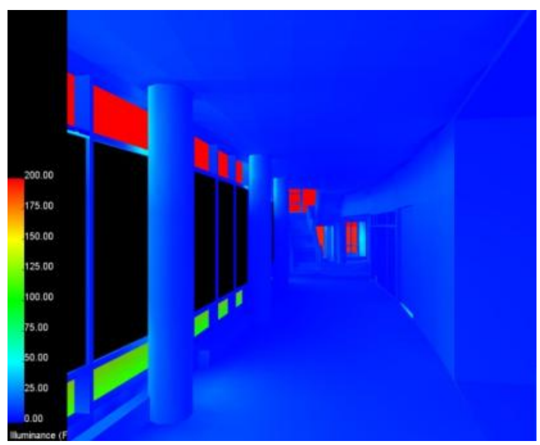
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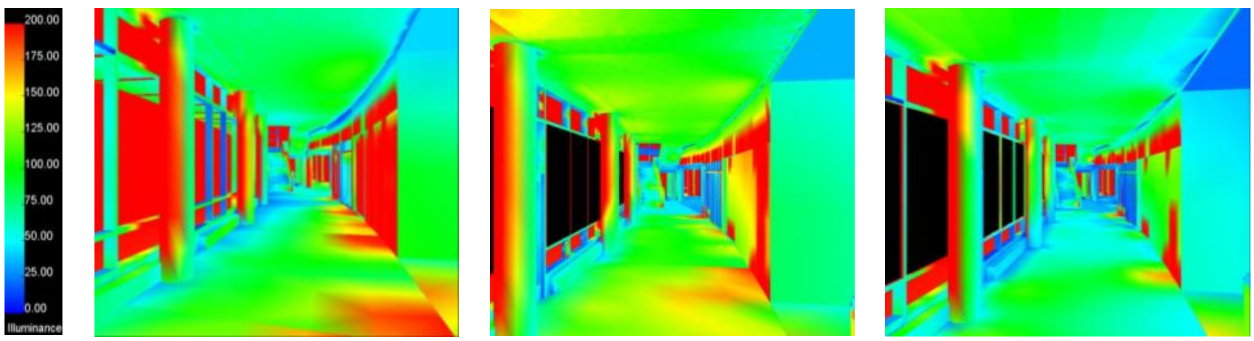
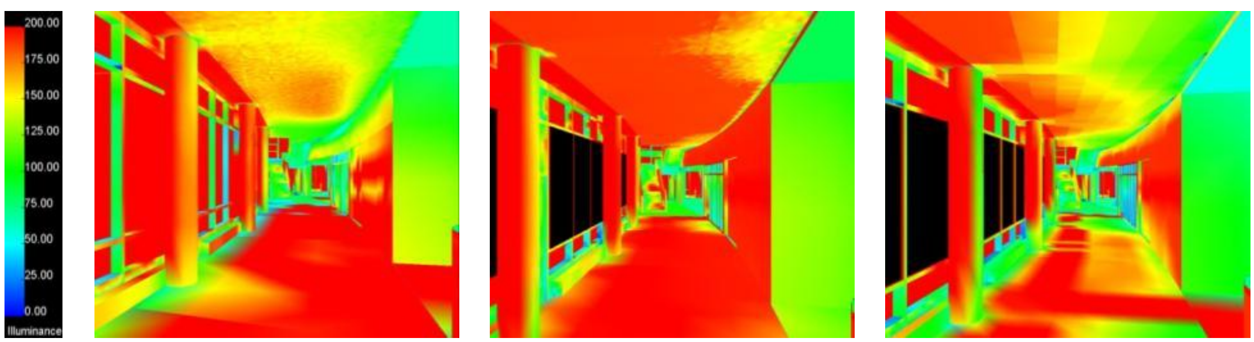
DAYLIGHT EVALUATION

After observing the daylight rendering from each of the daylight integration solutions, it seems that the Kalwall is the best solution. From the renderings, it is apparent that the most direct sunlight enters into the space in the morning. If the three solutions are compared at this time, one can see the most controlled solution is the Kalwall translucent panel installation. In addition to excellent daylight control, Kalwall also has superb insulation properties, and will prevent excessive solar heat gain in the space. More information on the Kalwall system may be found in Appendix D.

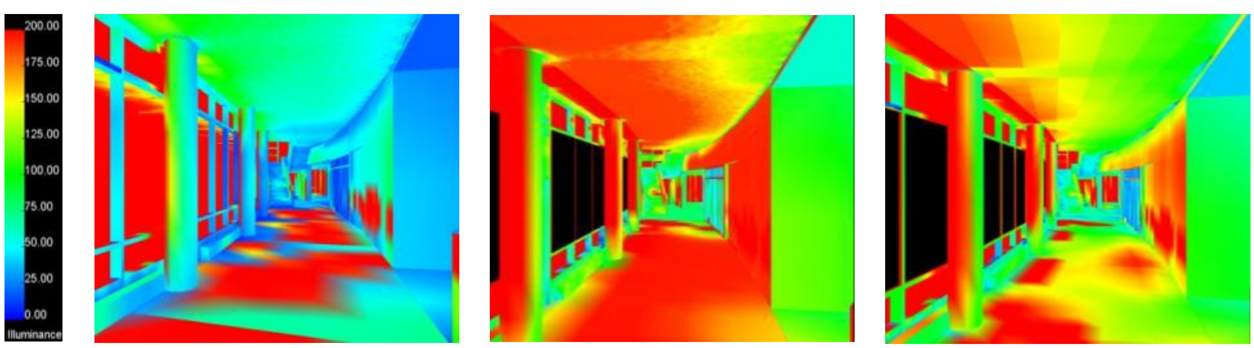
SUN SHADE | SHEER SHADE | KALWALL



Clear Sky at 8:00 AM



Clear Sky at 10:00 AM



Clear Sky at 12:00 PM