



# GLARE AND MATERIALS

A STUDY OF THE MATERIAL FINISHES ON COLLEGE OF EDUCATION BUILDING

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ARCH 571: Building Performance Evaluation



# HYPOTHESIS

The various reflective material finishes along the interior and exterior of the education building induce glare, thus causing discomfort for occupants.



# METHODOLOGY

Over the past few months, moving from winter to spring, we have observed and measured the Education Building's exposure to natural lighting in relation to occupant comfort. We began by recording how, when, and where occupants used the space, and along with data related to weather conditions. The four bottom levels of this building feature seating along the south and west glazed facades, while the fifth level has seating just along the south. While simultaneously observing and recording how people responded to the lighting conditions we also recorded the luminosity levels of the sunlight at each level seating zones. We also used photographic and diagrammatic evidence to back up the stated hypothesis.



# TERMINOLOGY

**Reflectivity** - an optical property of material which describes how much light is reflected from the material in relation to an amount of light incident on the material. The reflection occurs always on the surface of the material, and for light-diffusing (translucent) materials also in the volume of the material.

**Interior** - situated within or inside; relating to the inside; inner.

**Exterior** - forming, situated on, or relating to the outside of something.

**Glare** - a visual sensation caused by excessive and uncontrolled brightness in the presence of bright light such as direct or reflected sunlight or artificial light such as car headlamps at night.

**Albedo** - the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon.

**Emittance** - the energy radiated by the surface of a body per second per unit area.

**Solar Reflectance Index** - a measure of the roof's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, the standard black has a temperature rise of 90 deg. F (50 deg. C) in full sun, and the standard white has a temperature rise of 14.6 deg. F (8.1 deg. C).



# MATERIAL FINISHES



## Exterior Finishes:

- Aluminum composite panel cladding
- Brick wall
- Double insulated glass

## Interior Finishes:

- Polished concrete floor
- Painted wall finish
- Painted aluminum panels for columns
- Variety of colored fabrics used in furniture



# MATERIAL FINISHES



## Exterior Finishes:

- **Aluminum composite panel cladding**
- Brick wall
- Double insulated glass

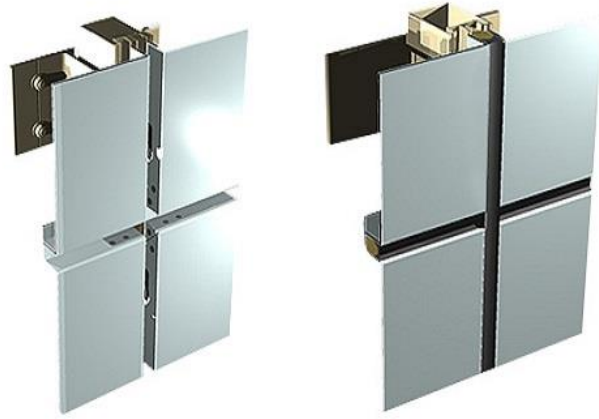
## Interior Finishes:

- **Polished concrete floor**
- Painted wall finish
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# MATERIAL FINISHES

## Aluminum composite panel cladding



### Advantages:

- It is renowned for its durability. It can withstand all the vagaries of weather such as extreme heat, cold, and rain.
- It is a flexible material. It can be molded in variety of ways.
- It can reflect light in a very efficient manner.
- It is fireproof and corrosion proof.
- It is very light in weight.

### Disadvantages:

- It requires special process to be welded.
- The aluminum oxide coating that forms upon aluminum is abrasive to tooling.
- It is more expensive than steel.



Actual material photo from COE building



# MATERIAL FINISHES

## Polished concrete floor



### Disadvantages:

- Once set, defects are difficult to rectify.
- Cannot be satisfactorily repaired by patchwork.
- Poor insulation against sound and heat.

### Advantages:

- Durable. A properly constructed floor will outlast most of the other components of the building.
- It is designed to carry the imposed loading; will not deflect under applied load.
- It possess high thermal mass and can be used to improve the internal environment and reduce energy demand.
- It is nonabsorbent and resistant to dampness. Can be used for water retaining floors as well as water storage.
- Non-combustible material.



Actual material photo from COE building

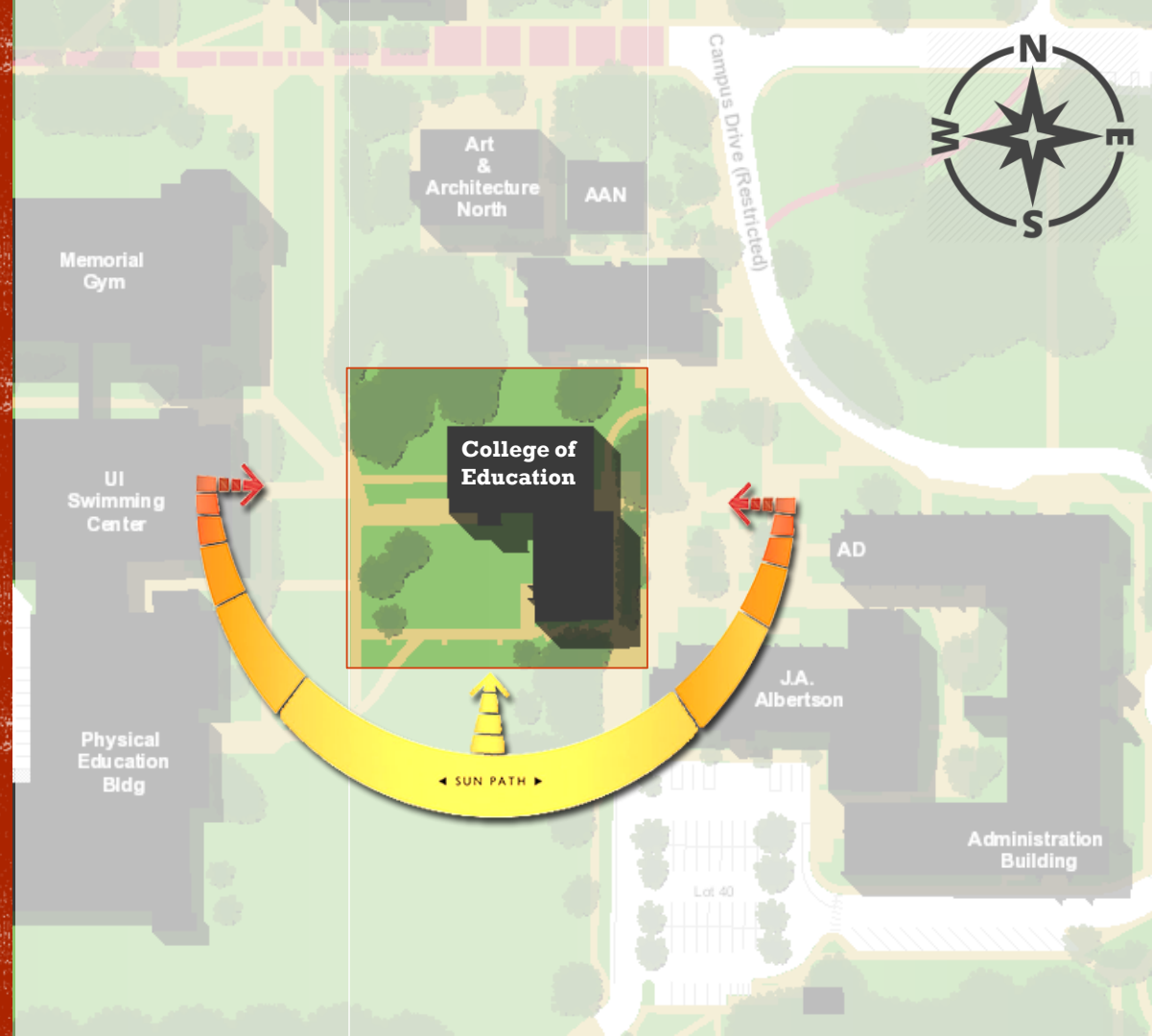




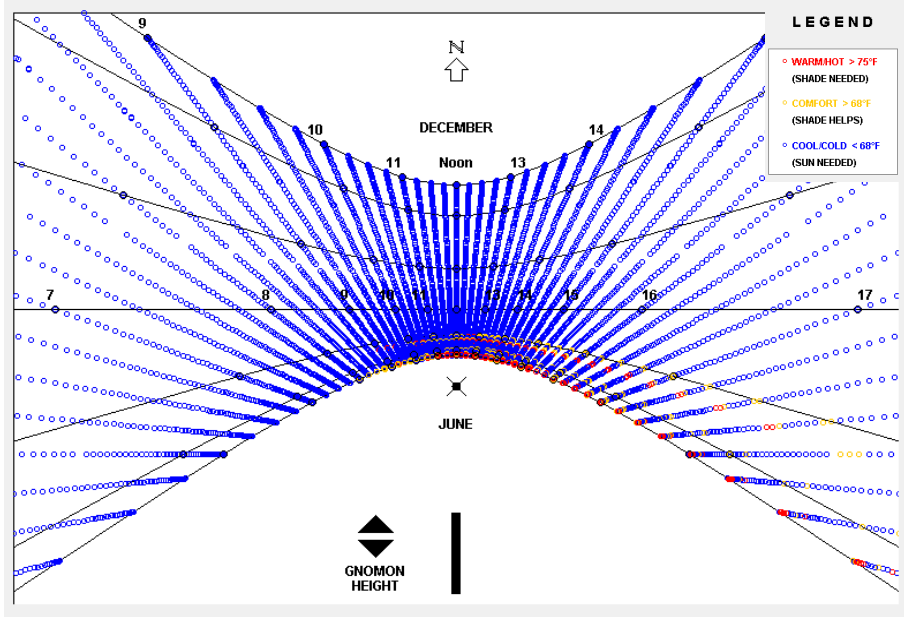
**ANALYSIS**



# THE SITE: COLLEGE OF EDUCATION

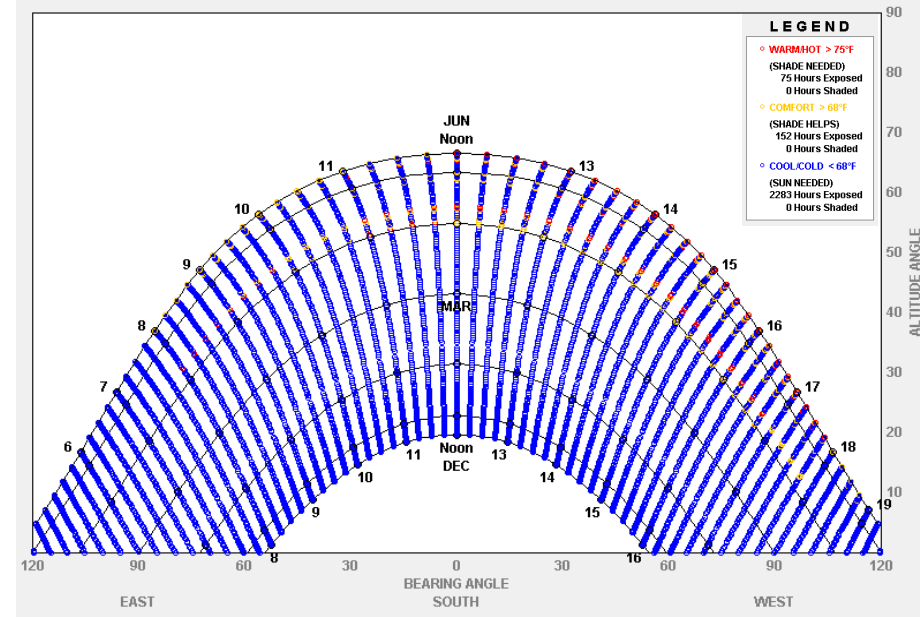


## Sun Path Diagram (Winter – Spring)



- Comfort levels during daytime start in April, and will stay cool at nighttime. Approximately 68 deg. F and up.
- Warm/hot levels will rise up to 75 deg. F and higher in mid June as the summer season starts.

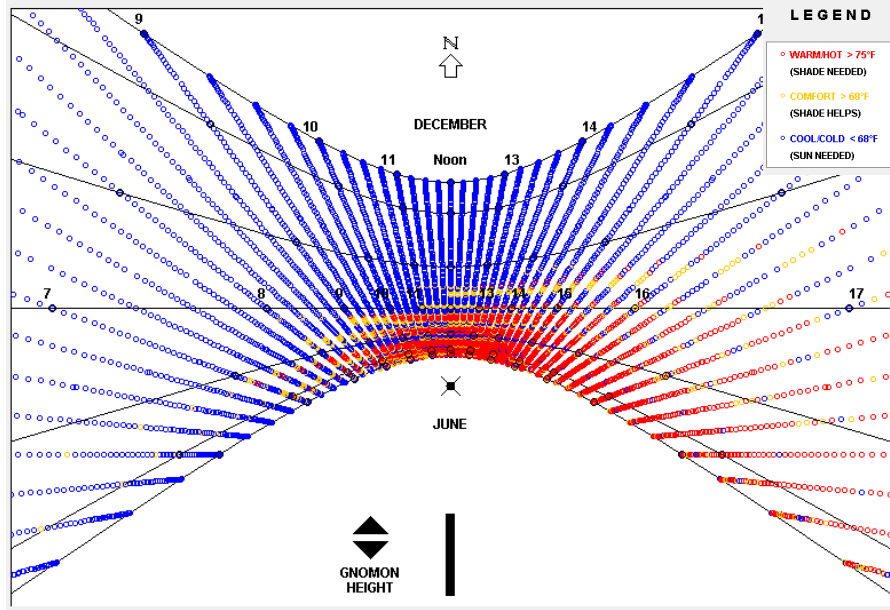
## Sun Shading Diagram (Winter – Spring)



- April to June is exposed to the sun with warm/hot level of 75 deg. F and higher, approximately 75 hours. Shade is needed to reduce the amount of exposure from the sun.
- 152 hours of comfort. Shade can help reduce the amount of exposure from the sun.
- 2283 hours of cool/cold. Sun is needed in order to balance thermal comfort.

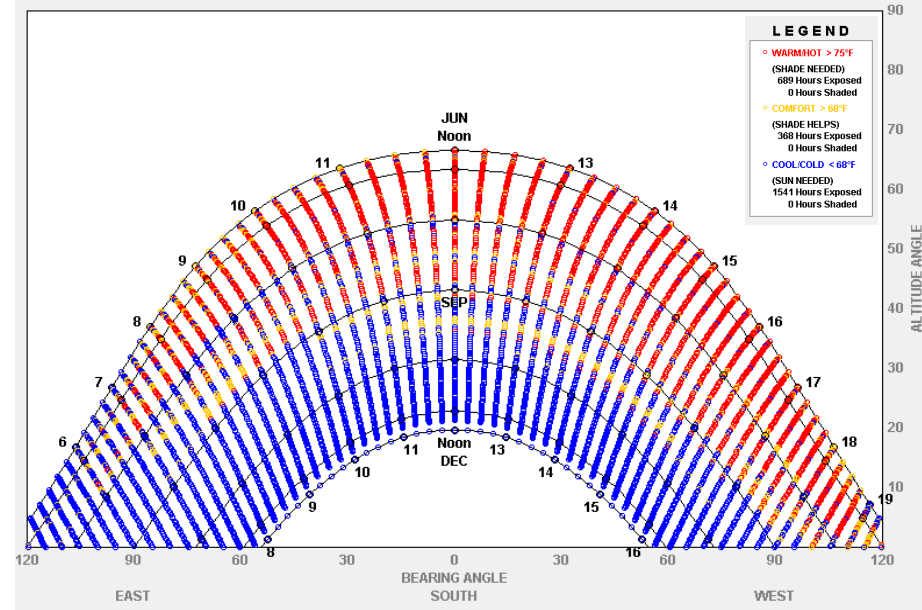


## Sun Path Diagram (Summer – Fall)



- Comfort levels during daytime occurs at certain time and days. Approximately 68 deg. F and up.
- Warm/hot levels will rise up to 75 deg. F and higher from June to September.

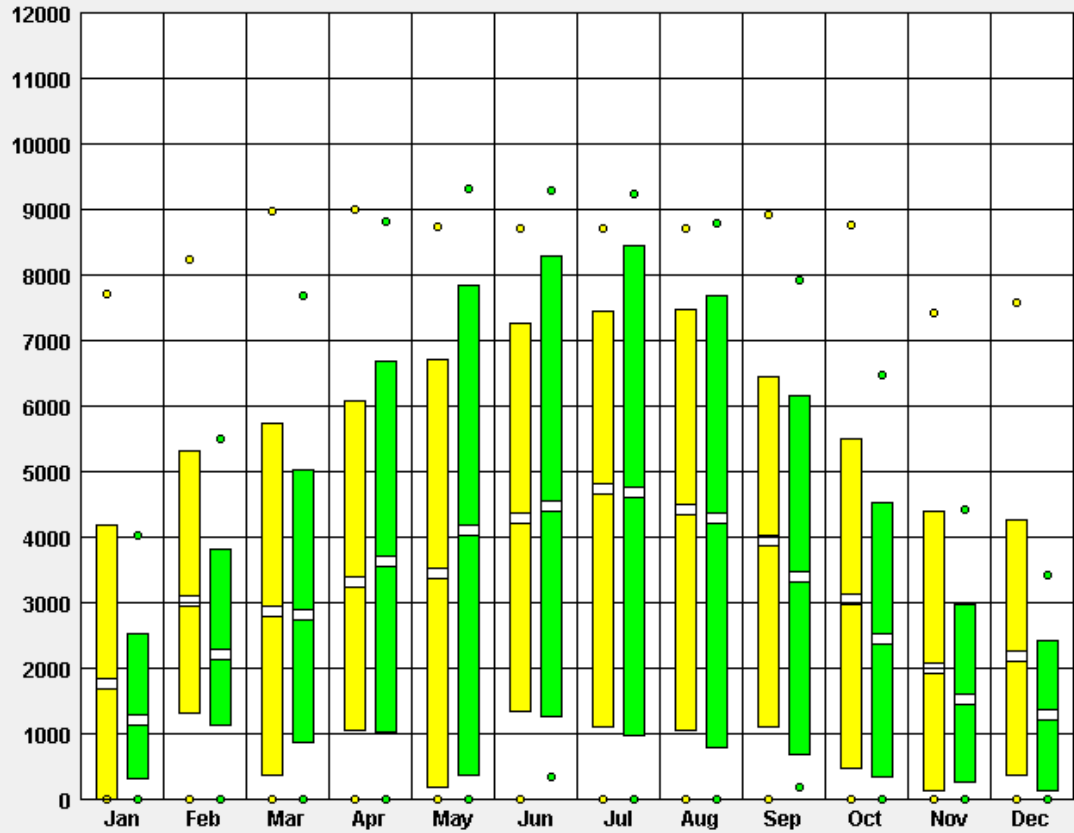
## Sun Shading Diagram (Summer – Fall)



- June to September is exposed to the sun with warm/hot level of 75 deg. F and higher, approximately 689 hours. Shade is needed to reduce the amount of exposure from the sun.
- 368 hours of comfort. Shade can help reduce the amount of exposure from the sun.
- 1541 hours of cool/cold. Sun is needed in order to balance thermal comfort.



# Illumination range

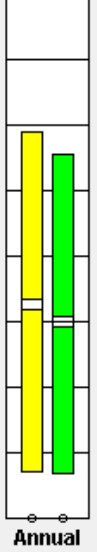


**LEGEND**

HOURLY ILLUMINATION  
DAYLIT HOURS ONLY

RECORDED HIGH - ○  
 AVERAGE HIGH - □  
 MEAN - □  
 AVERAGE LOW - □  
 RECORDED LOW - ○

RECORDED:  
 DIRECT NORMAL (yellow)  
 GLOBAL HORIZONTAL (green)  
 (footcandles)



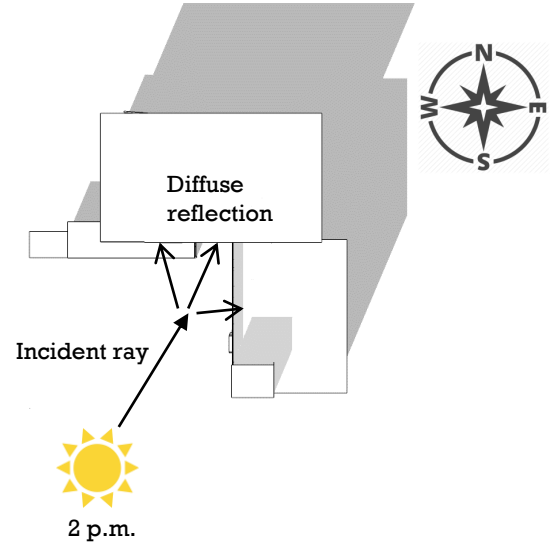
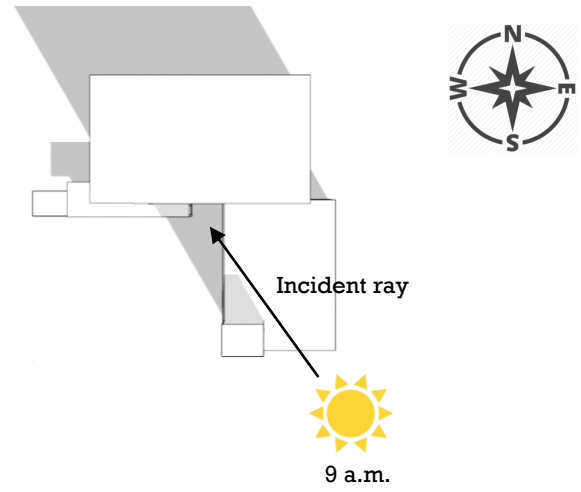
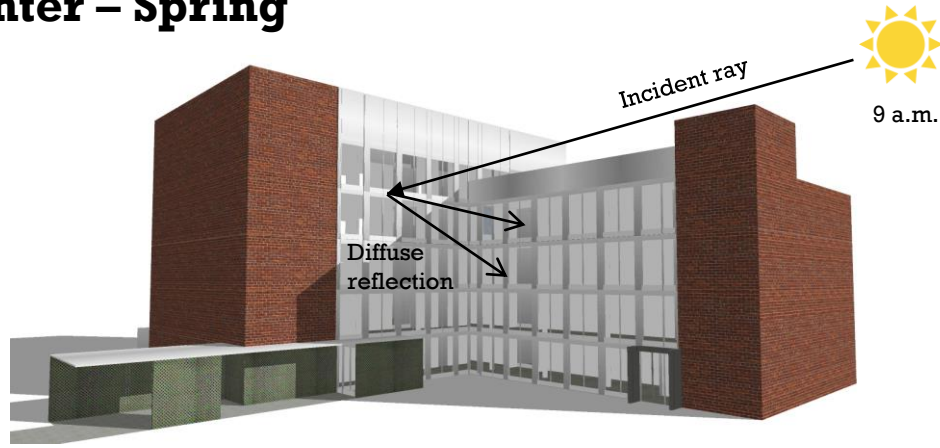
- Average high illuminance ranges from 4000 to 7000. Average lowest illuminance ranges from 0 to 1000.
- The recorded high illuminance is at the months of March, April and September.



**THE BUILDING:  
COLLEGE OF EDUCATION**



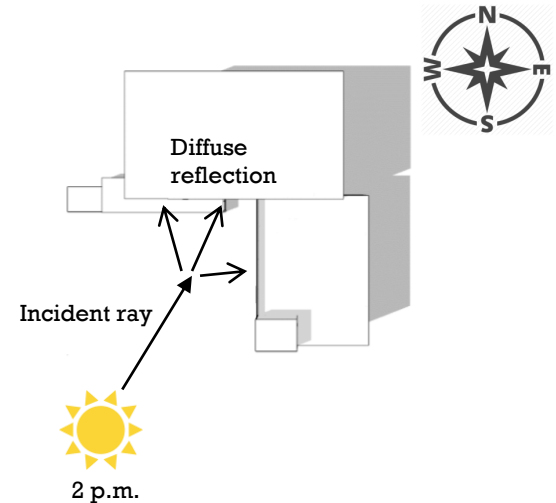
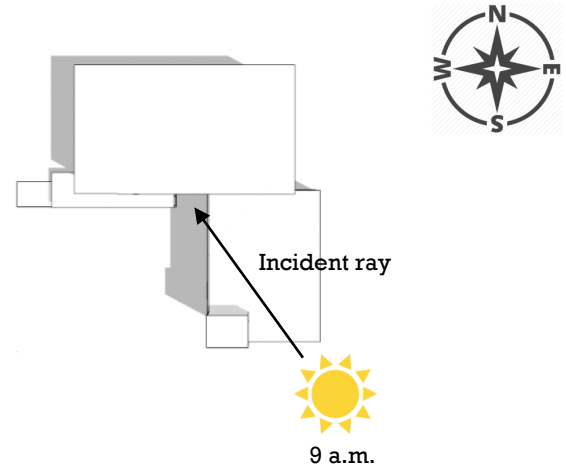
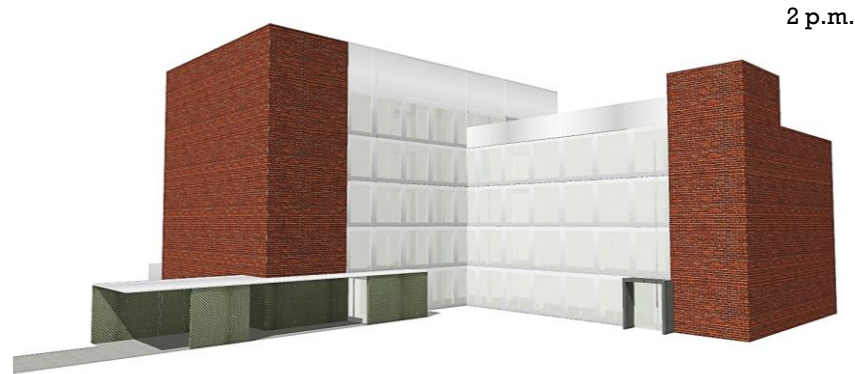
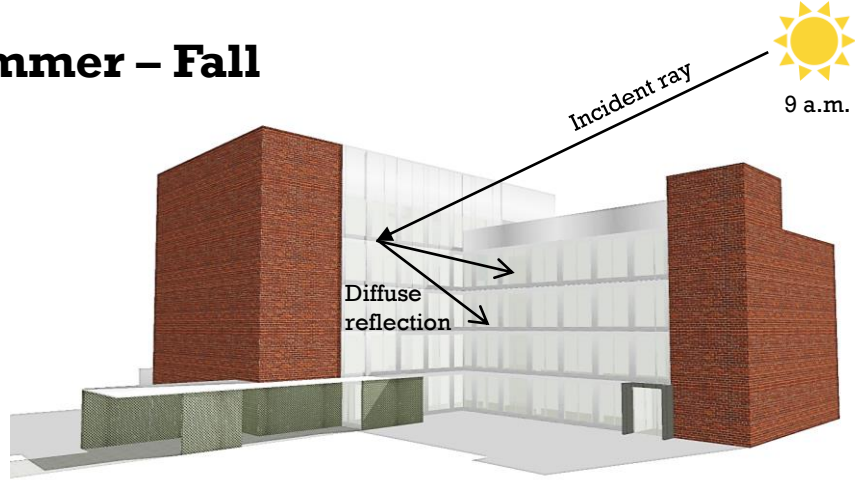
# Winter – Spring



**THE BUILDING: COLLEGE OF EDUCATION**



# Summer – Fall



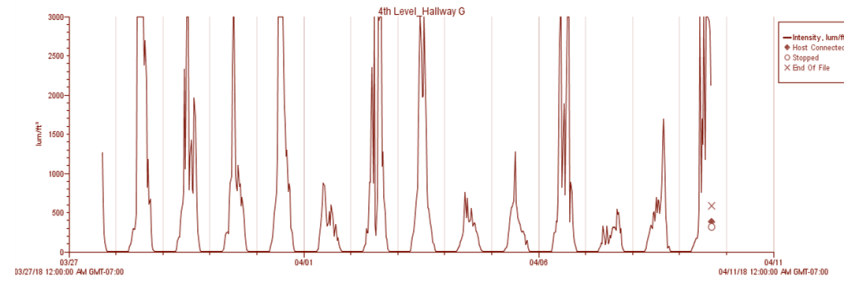
# THE BUILDING: COLLEGE OF EDUCATION





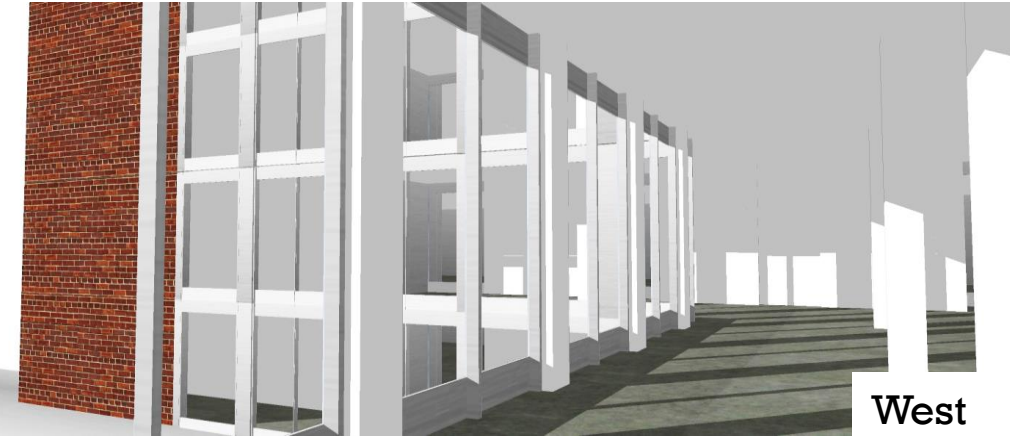


South

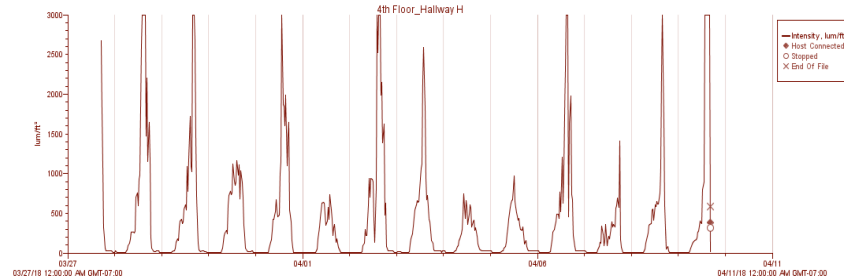


**HOBO Test: Light Intensity**

Date of test = March 27 to April 09, 2018 (13 days)  
 Maximum = 2,998.9 lum/ft<sup>2</sup>  
 Minimum = 1.1 lum/ft<sup>2</sup>  
 Average = 433.2 lum/ft<sup>2</sup>



West



**HOBO Test: Light Intensity**

Date of test = March 27 to April 09, 2018 (13 days)  
 Maximum = 2,998.9 lum/ft<sup>2</sup>  
 Minimum = 0.4 lum/ft<sup>2</sup>  
 Average = 380.6 lum/ft<sup>2</sup>

**THE BUILDING: COLLEGE OF EDUCATION**



**THE MATERIALS:  
COLLEGE OF EDUCATION**



# Concrete

- Absorbs and stores heat energy.
- Increases reflectivity value when polished.
- High exposure to sunlight and lateral movement can cause damage to the surface.

## Solar Performance of Concrete floor:

Albedo = 25%

Emittance = 90%

SRI = 25%



Rough finish

Polished finish



# Aluminum

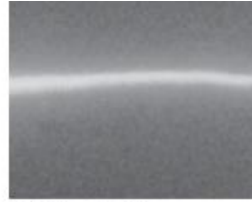
- High reflectivity rate of up to 97% if not oxidized. If oxidized it can be as low as 70%.
- A good insulator as it prevents the radiation of heat by reflection.
- Conducts heat.

## Solar Performance of Aluminum:

Albedo = 61%

Emittance = 25%

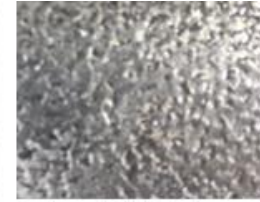
SRI = 50%



Stainless Steel



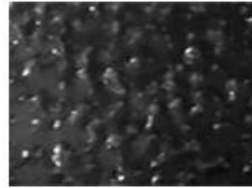
Embossed White Aluminum



Embossed Mill Aluminum



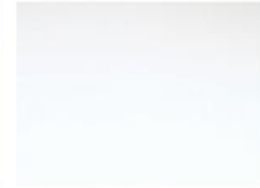
Smooth White Galvanized



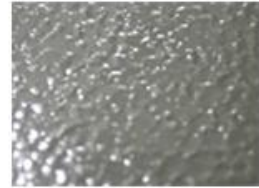
Embossed Black Galvanized



Embossed White Galvanized



Smooth White Aluminum



Embossed Gray Galvanized



# THE OCCUPANTS: COLLEGE OF EDUCATION



Table 1: Occupied Seats along the South and West Facades

Level and Façade and Seat Count	Date, Time, Weather Conditions								Avg. % of Seats Occupied
	Tue4/17 8am 40°F Mostly Cloudy	Wed4/18 12pm 55°F Sunny	Mon4/23 5pm 48°F Sun Setting	Tue4/24 10am 54°F Sunny	Tue4/24 2am 70°F Sunny	Thur5/3 12pm 72°F Sunny	Fri 5/4 9am 68°F Sunny	Mon5/7 4pm 65°F Cloudy	
LVL1 South (3 Seats)	0/3	0/3	0/3	0/3	0/3	1/3	0/3	0/3	1/24= 04%
LVL1 West (16 Seats)	1/16	3/16	0/16	1/16	3/16	1/16	5/16	0/16	14/128= 12%
LVL2 South (11 Seats)	2/11	0/11	2/11	4/11	6/11	0/11	1/11	3/11	18/88=21%
LVL2 West (27 Seats)	0/27	5/27	13/27	2/27	8/27	10/27	0/27	15/27	53/216=25%
LVL3 South (12 Seats)	3/12	2/12	2/12	0/12	4/12	0/12	0/12	6/12	17/96=18%
LVL3 West (225 Seats)	5/25	5/25	7/25	1/25	12/25	0/25	4/25	12/25	46/200=23%
LVL4 South (11 Seats)	1/11	4/11	0/11	0/11	6/11	4/11	0/11	2/11	17/88=19%
LVL4 West (28 Seats)	0/28	9/28	4/28	0/28	12/28	2/28	5/28	8/28	40/224=18%
LVL5 South (5 Seats)	0/5	0/5	0/5	0/5	0/5	2/5	0/5	0/5	2/40=05%

- As can be inferred from the low percentages of seats occupied, the seating spaces are not being used as intended in the building program. The pattern of unseated spaces correlates to weather conditions; fewer people use the seating during bright days and more seats are occupied when it is cloudy.



Ground floor



Actual photo



Infrared camera



**WHAT WE LEARNED**





- Building form and orientation are relevant to the selection of finishing materials (e.g. exterior walls and windows). High reflective materials may be inappropriate in areas of direct sunlight.
- Sun shading devices can help reduce heat and glare from the sun.
- The shape of the building, combined with aluminum composite panel finish selection, causes reflected sunlight to scatter. The result is visual discomfort from glare.
- Seat occupancy data (as little as 4% or 5% in the worst glare areas) shows that user discomfort will render parts of building almost unusable.

## **CONCLUSION**

Our careful analysis and observation of luminosity, glare, sun angles, and seat usage support our hypothesis that the glare caused by the highly reflective surfaces causes discomfort for the building occupants. A potential solution to this problem would be to implement more matte material finishes, thus significantly reducing the light's ability to glare off the surfaces. Overall, this exploration of glare and materiality was a worthwhile exercise in the post occupancy evaluation of the Education Building.

# **WHAT WE LEARNED**

