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Native American Cultural Center | Arizona

Technical Report I

Executive Summary

The Native American Cultural Center in Arizona is a 48,000 sf facility created for tribe members and visitors to learn about the culture and heritage of the Arizona tribe. The lighting design of the center is one that complements the architecture and fully develops the concepts given forth by the tribe.

The following report examines the lighting design of four spaces within the Native American Cultural Center:

Classroom 112 | Large Work Space

Museum | Special Purpose Space

Entry Lobby | Transition Space

Promenade | Outdoor Space

The lighting design of each space is analyzed based on existing conditions and juxtaposed with design criteria proceeding from recommendations by the Illuminating Engineering Society and requirements of the International Energy Conservation Code.

Overall, the existing lighting design for the building is uniform and simplistic in nature. It complies with code and recommendations in each space with the exception of the classroom: light levels greatly exceed the recommendations, with 800 lux versus the recommended 400 lux; and the power density does not comply with code at 1.6 W/sf, rather than 1.3 W/sf.

Though the design is appropriate for this cultural center, there exists endless lighting design schema that could further develop the overarching concepts for the center.

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0.0 Overview

The Native American Cultural Center is a place for both members and public to learn about the culture and heritage of the Arizona tribe. From classrooms to art studios, the facility includes spaces for learning a range of topics relating to the tribe. Additionally there is a museum, café, and gift shop for the enjoyment of anyone interested in gaining an understanding of the tribe.

The existing lighting design is carefully calculated to provide appropriate lighting levels in a pleasant fashion that is neither glaring nor uncomfortable. Each space has thoughtfully placed luminaires in a very regular and uniform fashion that allows them to recede into the backdrop of the room.

The following graphic indicates the four spaces that will be studied through the course of the capstone project and illustrates their locations relative to one another.

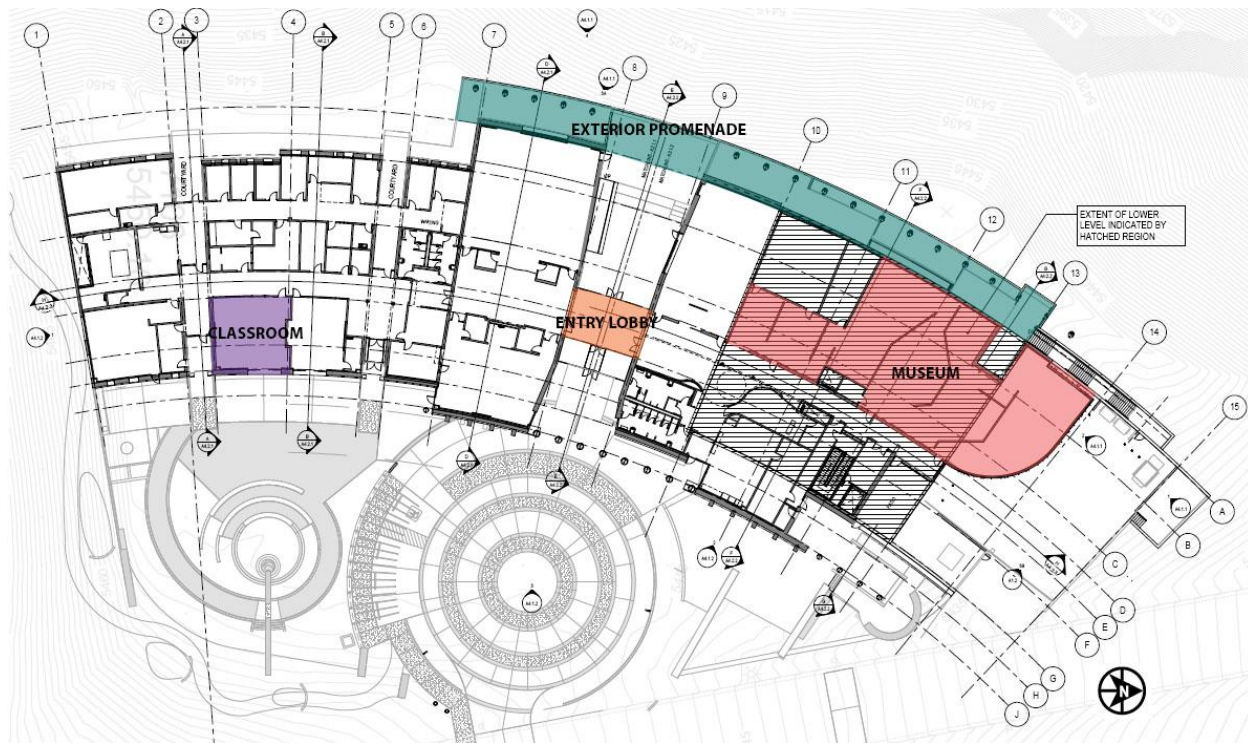


Figure 0.1 | Native American Cultural Center 1st Floor Plan with Room Designations

1.0 Large Work Space | Classroom 112

1.1 Classroom Existing Conditions

Classroom 112 is located on the south end of the building in the education area. It is a place to teach and learn the history, culture, and language of the Arizona tribe. The room is 930 sf, furnished with desks and a white board.

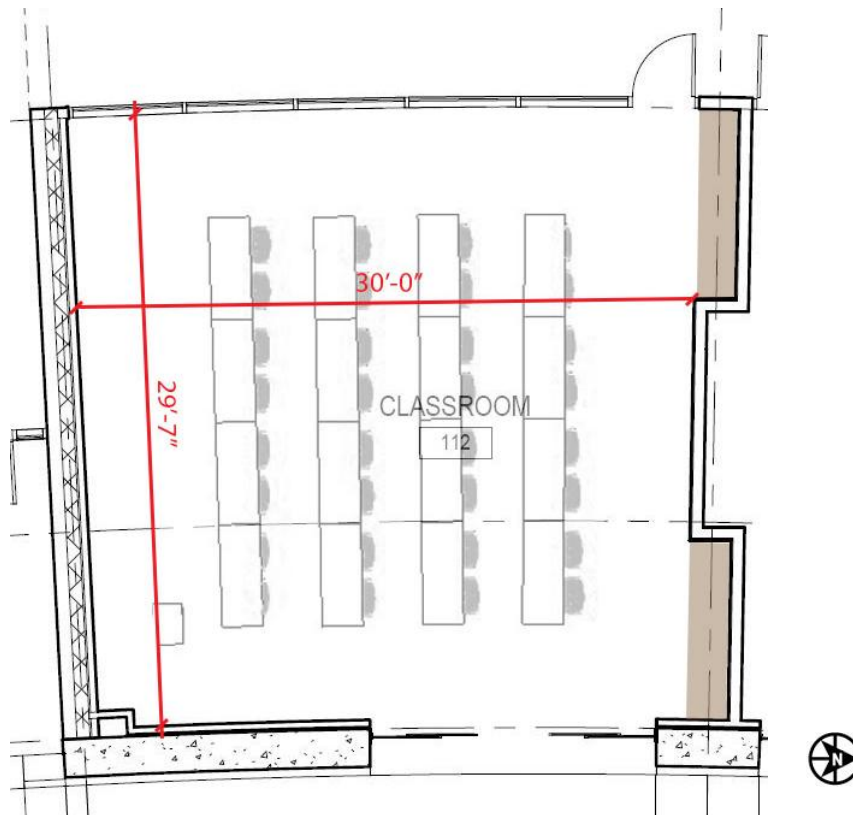


Figure 1.1 | Classroom Plan: Dimensions and Furniture Layout

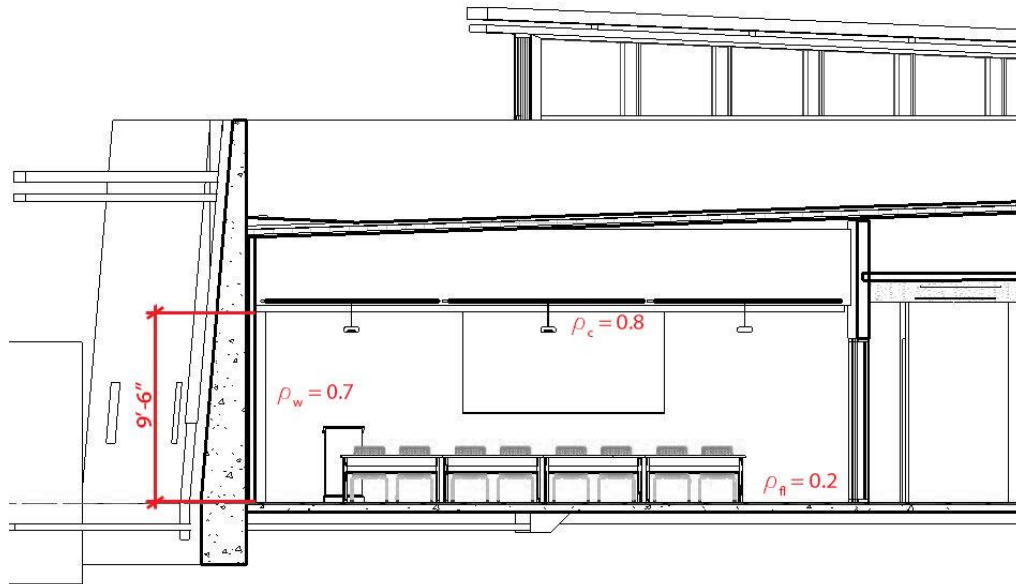
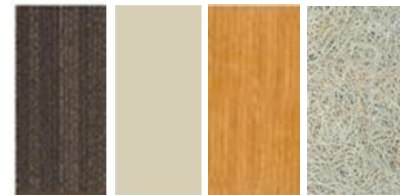


Figure 1.2 | Classroom Section: Height and Reflectance Values

The classroom space materials consist of a dark brown carpeting, tan-painted walls, and tectum ceiling panels. Additionally, there is a 1" clear glass wall, with a 70% transmittance, on the corridor side of the classroom. The case work is plastic laminate with a light wood finish.



The existing lighting consists of linear T8 fluorescent luminaires for general lighting and LED downlights for tasking lighting on the white board and storage cubbies. Specific Luminaire types described in Table 1.1.

The lighting is controlled in the classroom by a passive infrared/ultrasonic occupancy sensor mounted to the ceiling in the center of the room. The luminaires are also connected to two switches, one by the entry door and another behind the podium. The lighting layout and switching diagram can be seen in Figure 1.3.



Figure 1.3 | Classroom Reflected Ceiling Plan

Classroom 112

| Type | Description | Manufacturer | Model | Load | Lamp | Voltage | Comments |
|-------------------------------------|--|--------------|--|--------|---------------------|---------|----------|
| ■ | 6" LED RECESSED DOWNLIGHT | FOCAL POINT | FL6D-13LED-L35-277-RO-TR6-RO-DN-CD-NP | 23 VA | 3000K CCT LED | 277 V | |
| ■ | 8' PENDANT MOUNTED DIRECT/INDIRECT FIXTURE WITH 2-LEVEL LIGHTING CONTROLS (CENTER LAMP OR OUTER LAMPS). PROVIDE FINELITE WITH COMPLETE ILCS SYSTEM IN CLASSROOM AREAS. | | SERIES 16-WCB-X-3TB-DC-91W-CCO-277-FA-EE | 128 VA | (6)32W TB 3000K CCT | 277 V | |

Table 1.1 | Classroom Fixture Schedule

1.2 Classroom Lighting Design Criteria and Considerations

Classroom 112 will be used for smaller setting education. There is a whiteboard, podium, projector, and desk seating in this room; subsequently, the room will be used for reading, writing, and audio-visual communicating. The lighting in this space should be based specifically for the tasks as to avoid drawing attention away from them.

The following chart lists the criteria based on applicable tasks for education as presented in the IES Lighting Handbook, 10th ed.

| Task | E_h (lux) | E_v (lux) | Avg:Min | Daylight? | Coverage |
|---------------------|----------------------------|----------------------------|----------------|------------------|-----------------|
| Reading and Writing | 400 | 150 | 2:1 | Y | Room |
| White board | - | 300 | 3:1 | Y | Task |
| AV | 50 | 30 | 2:1 | N | Room |

Illuminating Engineering Society Lighting Handbook, 10th ed.

Table 1.2 | Illuminance Criteria

With differing illuminance values, it may be appropriate to provide dimming and/or switching controls capable of achieving both settings.

The Native American Cultural Center was designed using the International Energy Conservation Code (as opposed to ANSI/ASHRAE/IESNA Standard 90.1), which determines design criteria, specifically controls and lighting power densities. The classroom must employ occupancy sensors that automatically turn off lights within 30 min of room vacancy. The room must include manual- or automatic- on switching to no more than 50% power¹. The IECC lists the LPD for classrooms as 1.3 W/sf.

To prioritize the criteria based on the discussion above, the most important is achieving the illuminance level for tasks in the classroom. Following illuminance criteria is flexibility and aesthetic appeal.

1.3 Classroom Lighting Evaluation

The lighting design created by SmithGroupJJR is a simple, regular layout, ideal for uniform lighting as well as aesthetic appeal. This particular solution provides an immense amount of light: over 800 lux; this is greater than the IES Handbook recommendations as documented above. It could be, however, that SmithGroupJJR was designing for individuals over the age of 65, with the intention of dimming the system. In this case, I would still go with an average age group from 25-65 because this facility is for not only older tribe members but also tribe youth and the public.

¹ International Energy Conservation Code 2012 (IECC) Chapter 4 Section 5

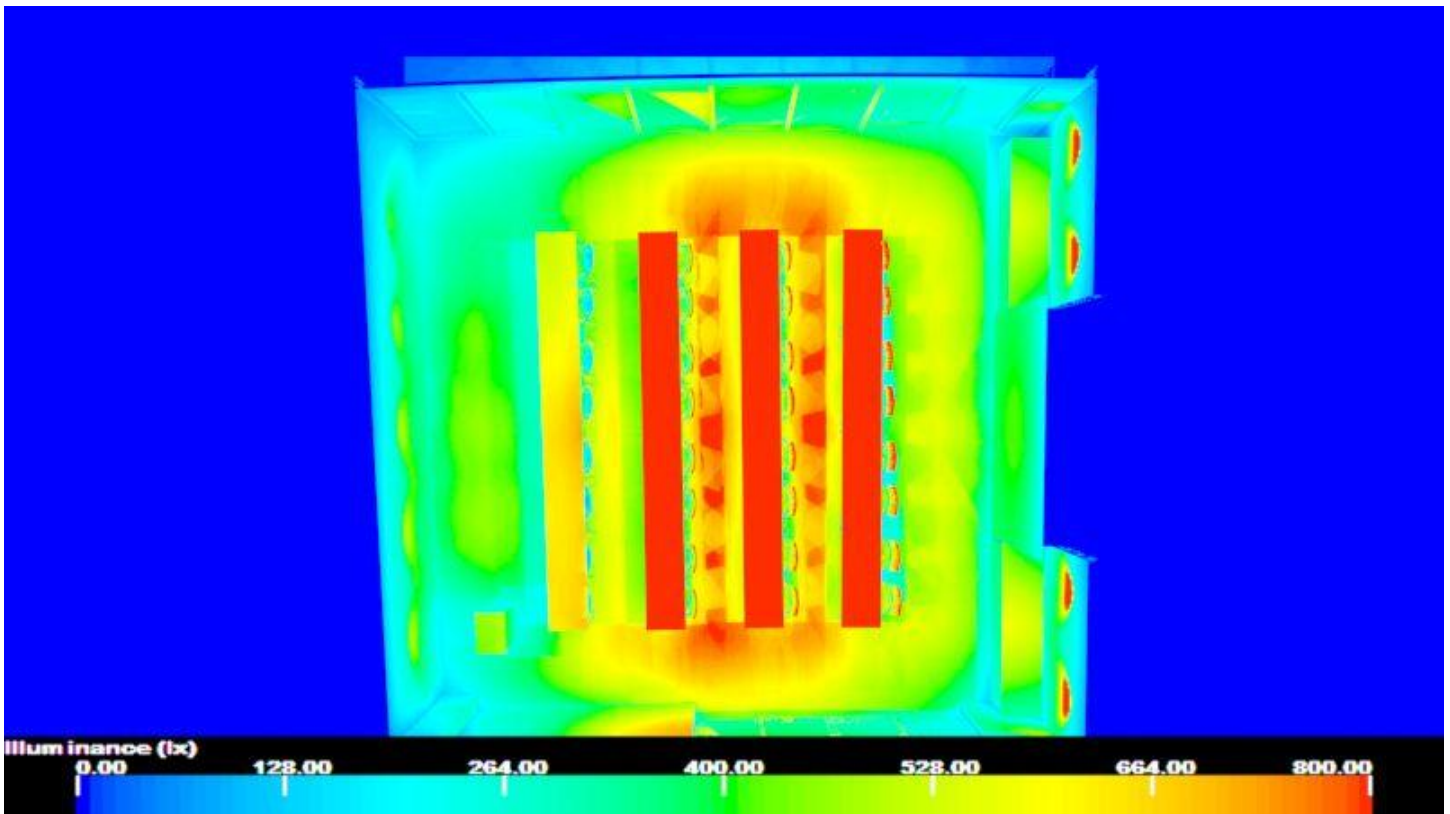


Figure 1.4 | 3D Studio Max Calculation for Classroom 112

Note: The lighting calculation for the classroom was conducted using 3D Studio Max 2013 with the following light loss factors: Finelite linear fluorescents, 0.85 and Focal Point LED downlight, 70.

Each fluorescent luminaire has 106 input watts, and each downlight has 24 input watts; this totals to 1488W. The room is 936 sf, resulting in 1.6 W/sf. According to IECC, this lighting power density exceeds the allowable of 1.3 W/sf.

The classroom controls comply with IECC requirements for occupancy sensors, but do not incorporate any sort of dimming or switching that would permit flexibility within the space.

2.0 Special Purpose Space | Museum Exhibits

The Arizona Tribe believes that it is very important to pass on information of its culture and heritage to the younger generations for both tribe and non-tribe individuals. They want more than just to spread knowledge, however; they want to create an emotional connection with visitors. One of the ways they want to do this in their new cultural center is through a museum that progresses through the seasons, instilling the importance of nature while also telling the story of the Tribe's traditions and hardships.

2.1 Museum Existing Conditions

The museum is a 6000 sf space separated into five sections by 6" two-sided-assembly partition walls. Four of the sections represent the seasons, Summer to Spring, and they each have corresponding

stories and lessons. There are displays including items like a faux stone partition for petroglyphs and display cases for items such as baskets and bows. The museum will also have portable and temporary displays for community members to have their own exhibits from time to time. Additionally, the each section has its own projector to display images and videos.

Materials in the museum consist of a lighter brown carpet, white paint walls, plastic laminate casework with a light wood finish, and tectum ceiling tiles.

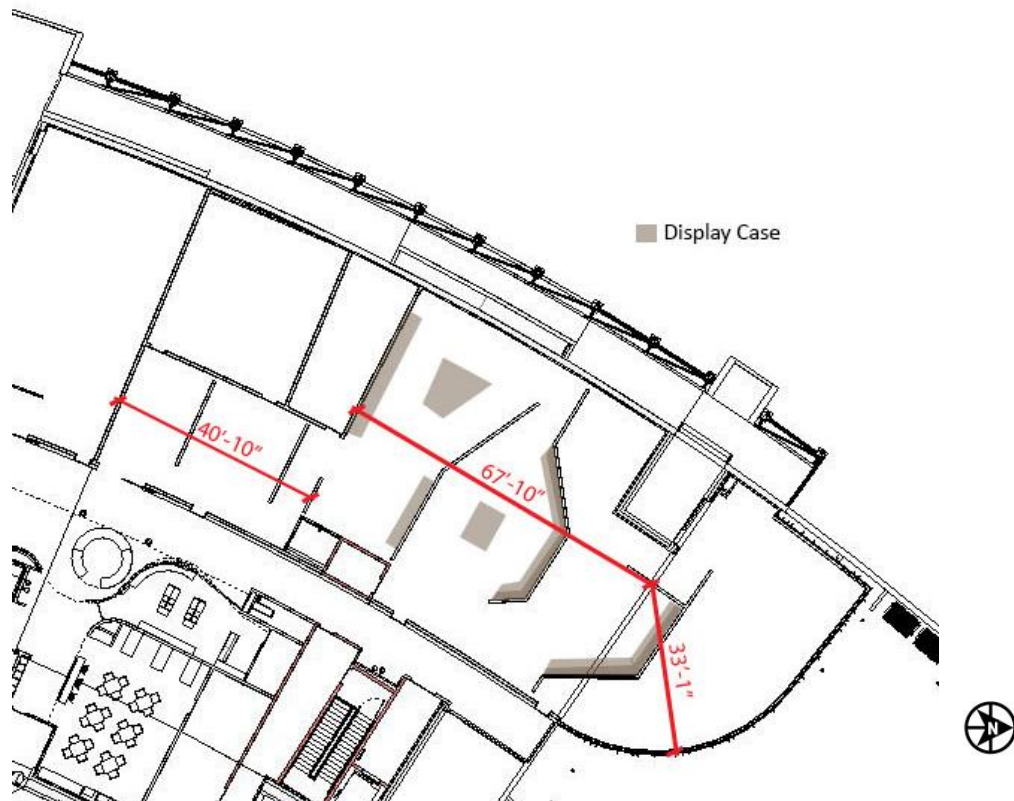
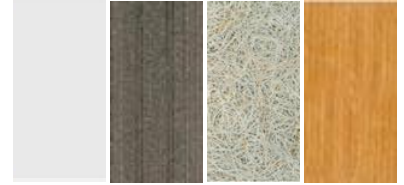


Figure 2.1 | Museum Plan: Dimensions and Furniture Plan

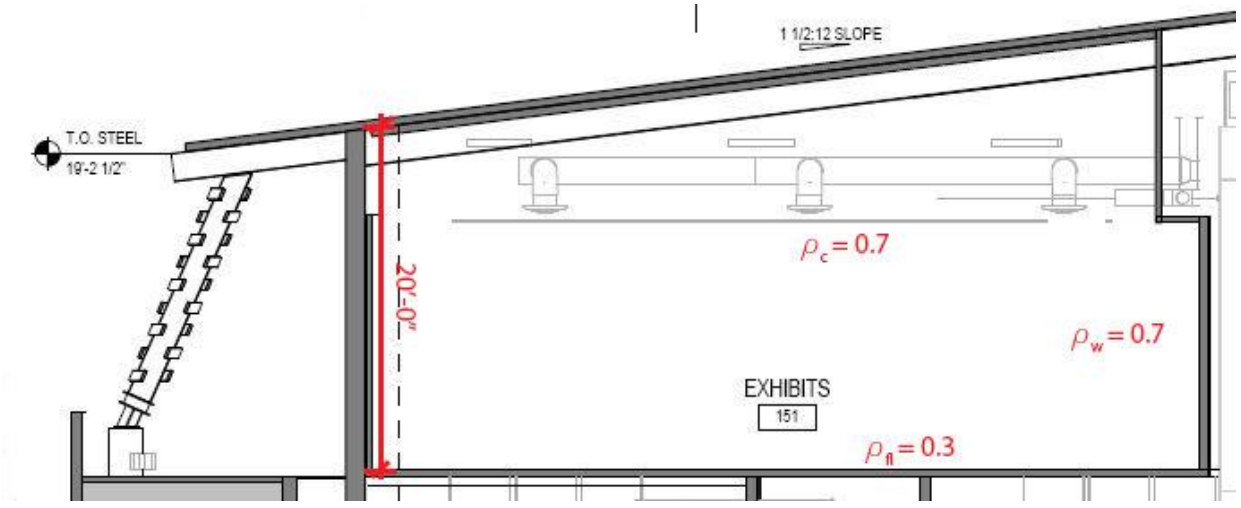


Figure 2.2 | Museum Section: Height and Reflectance Values

The current lighting in the museum consists of two layers. The upper layer utilizes linear fluorescent fixtures at 18'-0" AFF, and the lower level has LED downlights at 15'-0" AFF.

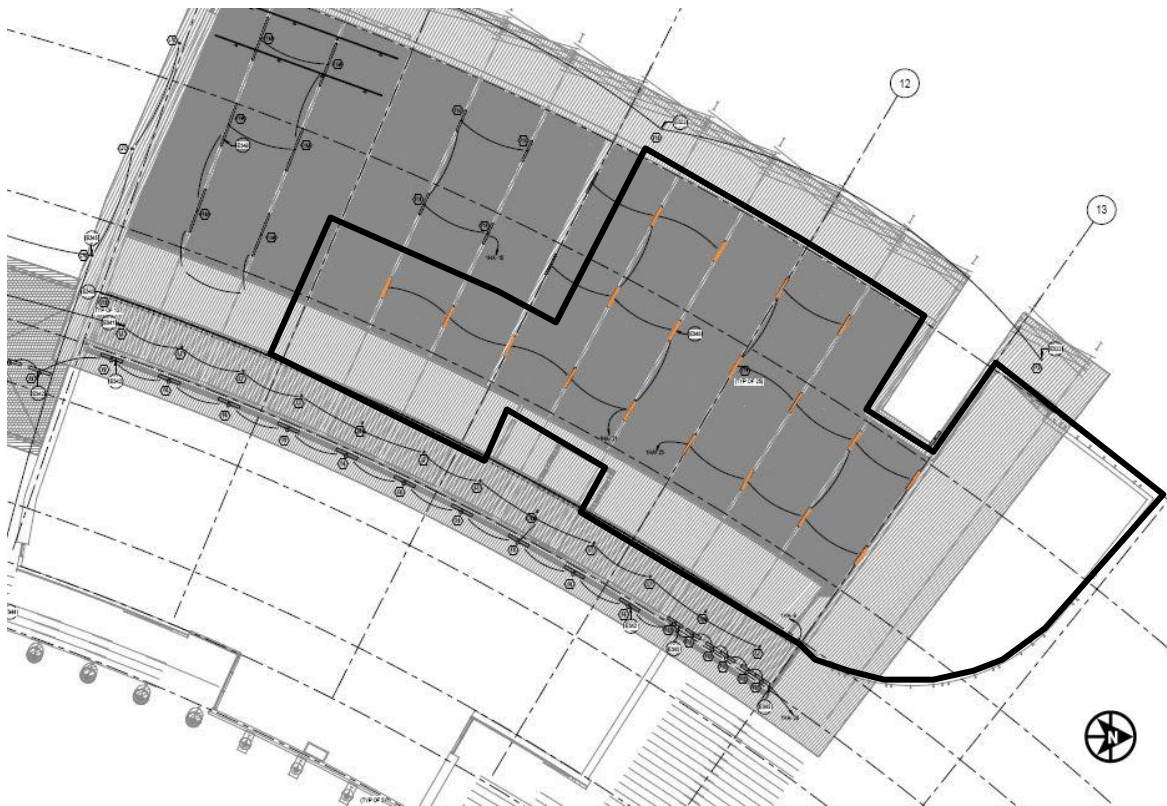


Figure 2.3 | Museum [Upper] Reflected Ceiling Plan



Figure 2.4 | Museum [Lower] Reflected Ceiling Plan

Museum



| Type | Description | Manufacturer | Model | Load | Lamp | Voltage | Comments |
|---|---|--------------|--|--------|---|---------|---------------------------|
|  | 48" LENGTH X 5" HEIGHT X 5" WIDTH LINEAR FLUORESCENT SURFACE MOUNT FIXTURE WITH DIRECT ONLY DISTRIBUTION, CUSTOM SPECULAR LOUVERS, CUSTOM BLACK FINISH, INTEGRAL ELECTRONIC BALLAST AND SINGLE CIRCUIT. | AXIS | BEAM4: BBS-PL-4-TSHO-2-C-227-ERS-1-SC | 117 VA | (2) 54W T5 3000K CCT | 277 V | |
|  | RECESSED 3.5" APERTURE LED DOWNLIGHT WITH REPLACEABLE 3000K CCT, SOLITE LENS, 1" REGRESSED CLEAR MATTE ALZAK BEVEL, WHITE PAINTED FLANGE AND INTEGRAL DRIVER 1700 LUMEN 80+ CRI LED MODULE WITH 80 DEGREE OPTICS AND 1% DIMMING DRIVER. | USA1 | BevelLED 2.0: 3110-B1-LSTD4-9035-C2-30KS-80-NC | 33 VA | 1700 LUMEN; 90+ CRI; 3000K CCT LED MODULE | 227 V | PROVIDE 1% DIMMING DRIVER |

Table 1.1 | Museum Fixture Schedule

2.2 Museum Lighting Design Criteria and Considerations

Because the exhibits in the museum have the potential to change on occasion, the criteria regarding the illuminance values may alter through the course of use. For this reason, I think it is important to create a system that is flexible in both layout and controls. In conjunction, it should be assumed that there will always be at least one light-sensitive object in each area; examples of light-sensitive objects include prints, skins, fabrics, and traditional dress. To preserve light-sensitive pieces, it is necessary to consider the amount of ultra-violet radiation in the space caused by artificial light and daylight. Four of the five sections of the museum are without exterior windows, leaving the main concern as the chosen light source for the space.

Determining illuminance values for the museum depends on the desired psychological impressions, focal points, and the sensitivity to light. According to the IES Handbook, for the objects, the maximum vertical illuminance target for high-sensitivity pieces is 50 lux; low-sensitivity is 200 lux; and no-sensitivity

is up to 1000 lux². When determining the illuminance targets for circulation through the museum, the creation of focal points in the space becomes the deciding factor. Focal points are considered to be dramatic, moderate, or subdued, and they correspond with the area-to-object illuminance ratios of 0.1, 0.2 and 0.5, respectively³. The horizontal uniformity target for the museum is 4:1 (Avg:Min).

The application of projector screens also implicates the need for dimming and/or switching controls for each respective space with in the museum.

The IECC-required lighting power density for a museum (general) is 1.0 W/sf; this does not include decorative or accent lighting, which calculates to an extra 4100 W. Furthermore, display and accent lights must be controlled separately of the general lighting for the room⁴.

The museum is the chosen space to conduct the psychological impression study. I think that this would be a good place to create a somber and/or festive space as they progress through the rooms and tell the story of the suffered hardships and celebrate their great traditions. Visual attention, created through increased and/or decreased contrast is a way to promote visual cues for way finding and to establish focal points (levels of hierarchy, as previously discussed)⁵. Along the lines of somber, by highlighting the peripheral surfaces creating dominant and correspondingly subordinate features, the conditions promote a “more relaxed, introspective attitude in the occupants,” which is very important when the idea of the museum is for individuals to reflect on what they are learning as they pass through the space⁶. By doing the reverse and adding a higher general lighting level, an individual will be prompted to communicate more with others around them, creating a higher energy level for the space: festive, as interpreted from Flynn's Article 6 on the psychology of light.

To prioritize the criteria based on the discussion above, designing for the psychological aspect of the museum will do the most to enforce the ideals and goals that the tribe had when initializing the concepts and reasons for creating this facility in the first place. In conjunction, this correlates directly to the illuminance values and flexibility of the lighting in the space.

2.3 Museum Lighting Evaluation

SmithGroupJJR designed a fairly uniform lighting scheme that corresponds with the idea of flexibility. It is basic for museum lighting, in that it does not employ any special lighting for the displays. The horizontal light levels are appropriate assuming that there are no light-sensitive objects on display. This lighting design does not give way to much vertical illuminance on the walls, however, making it less suitable for vertically mounted displays, adding no hierarchy of focal points in the museum, and promoting no way-finding. Whether to have any hierarchy of focal points is a design consideration, but not always necessary. In order to achieve higher vertical illuminance values, if desired, the design would need to include adjustable luminaires that can aim light at the objects. Both concepts of the focal points and light-sensitivity must be balanced in accordance to the specific objects and the duration of exposure to higher light levels.

² Illuminating Engineering Society Lighting Handbook, 10th ed., p 21.12

³ Illuminating Engineering Society Lighting Handbook, 10th ed., p 21.4

⁴ International Energy Conservation Code, Chapter 4, Section 5.5.2

⁵ Flynn Psychology of Light Study 1972, p 15

⁶ Flynn Psychology of Light Study 1972, Article 6

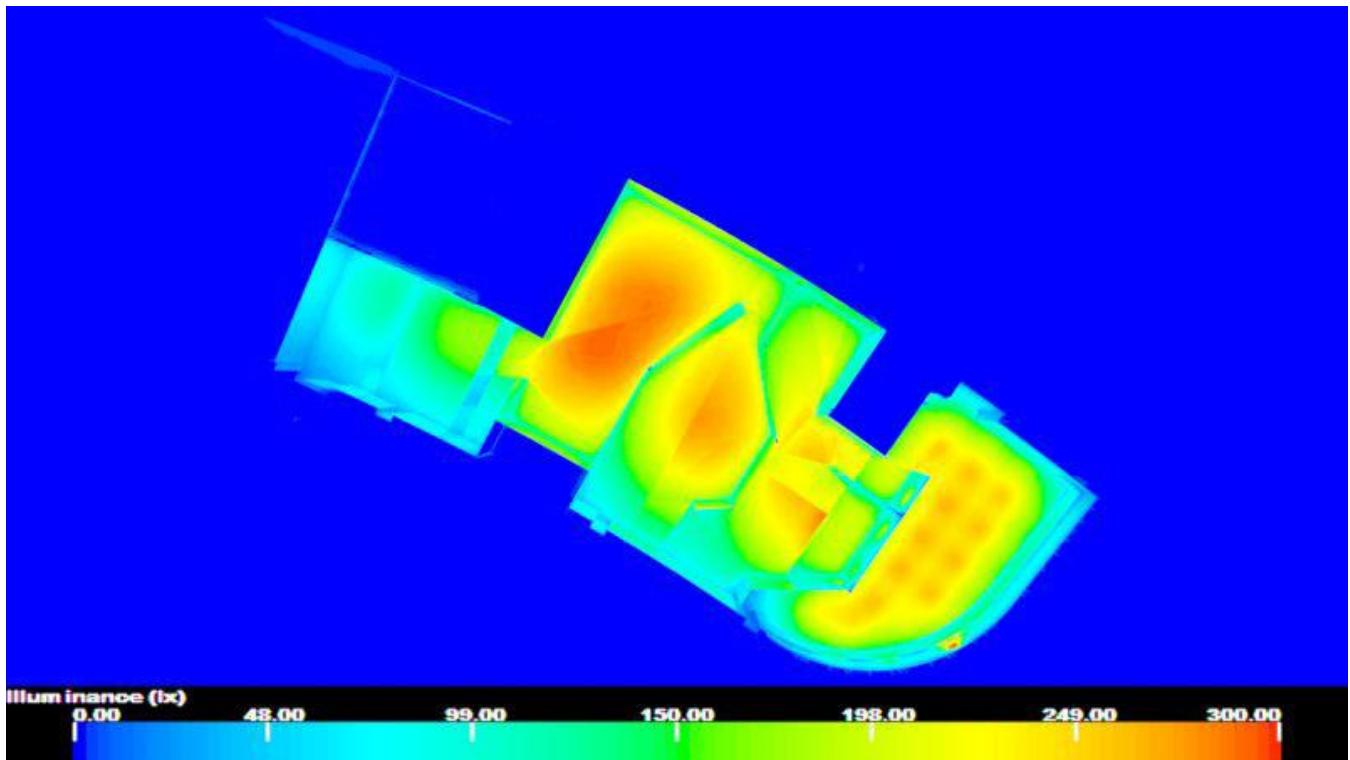


Figure 2.5 | 3D Studio Max Calculation for the Museum

Note: The lighting calculation for the museum was conducted using 3D Studio Max 2013 with the following light loss factors: Axis linear fluorescents, 0.87 and USAI LED downlight, 70.

The lighting power density as prescribed by the IECC for the museum is 1.0 W/sf, and the museum is 0.54 as designed, well under the required.

The switching for the museum is all done in the adjacent electrical room on the respective panel boards. Controlling the lighting from a remote location is necessary for a space such as a museum because of the heavy traffic of the public. I do, however, believe that there should be an intermediate scene controller for each section of the museum in order to provide flexible and dynamic lighting.

3.0 Transition Space | Entry Lobby

The Entry Lobby is a transition space that divides the Native American Cultural Center into the North, which contains the public areas, and the South, which houses the offices and learning spaces.

3.1 Entry Lobby Existing Conditions

The Lobby is 625 sf of transition area that can lead a visitor to three other main areas of the cultural center: the public side, the learning side, or the promenade directly ahead. It's a place for first impressions and way-finding.

In the Entry Lobby, the walls are painted white and the ceiling is metal panel. The flooring is a combination of both ground concrete and stained concrete, with the stained concrete running in a stripe through the space, from the entry doors to the doors leading directly to the promenade area. The glazing in the lobby is clear low-E Viracon Solarscreen with a visible transmittance of 48%.



There is also a clerestory over the lobby that allows sunlight to filter into the space throughout the day. It uses the same low-E Viracon Solarscreen glass type.

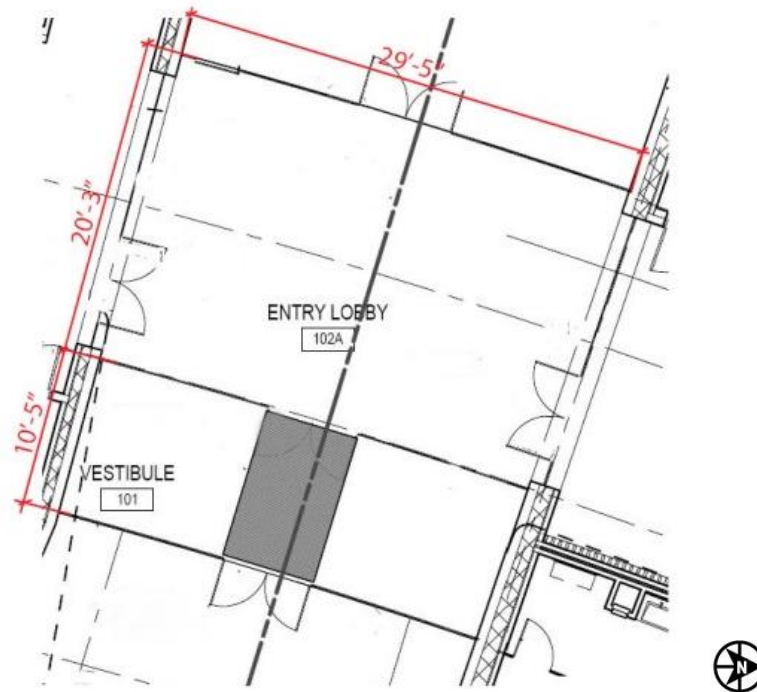


Figure 3.1 | Entry Lobby Floor Plan: Lobby Dimensions

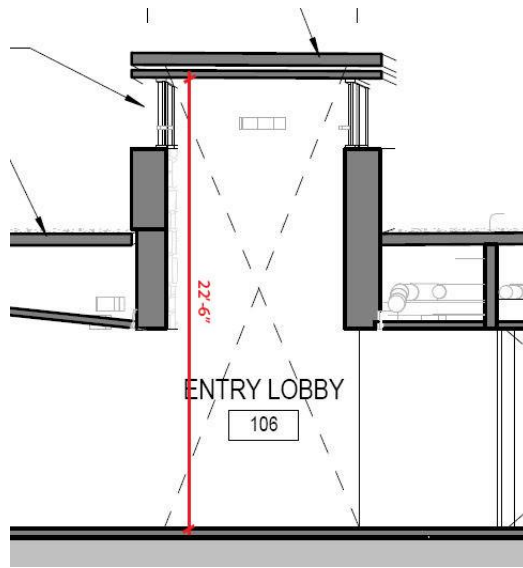


Figure 3.2 | Entry Lobby Section: Clerestory Height

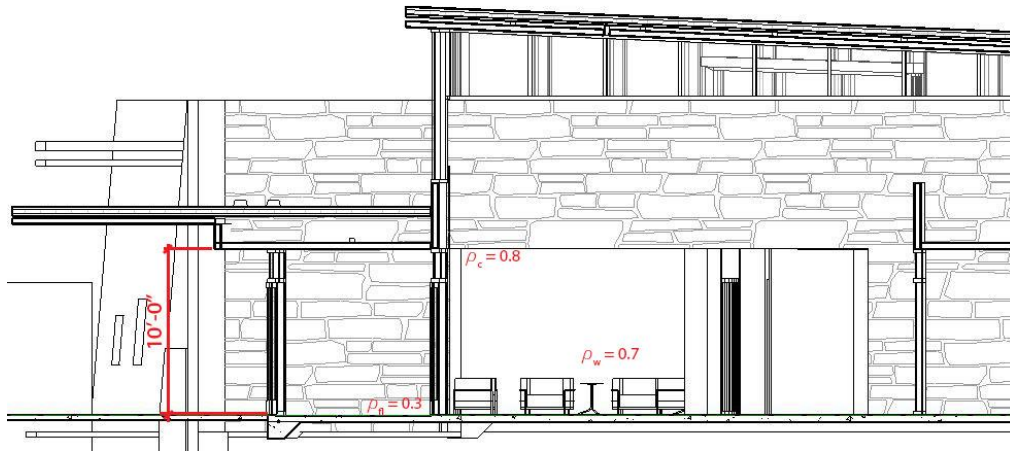


Figure 3.3 | Entry Lobby Section: Lobby Height and Reflectance Values

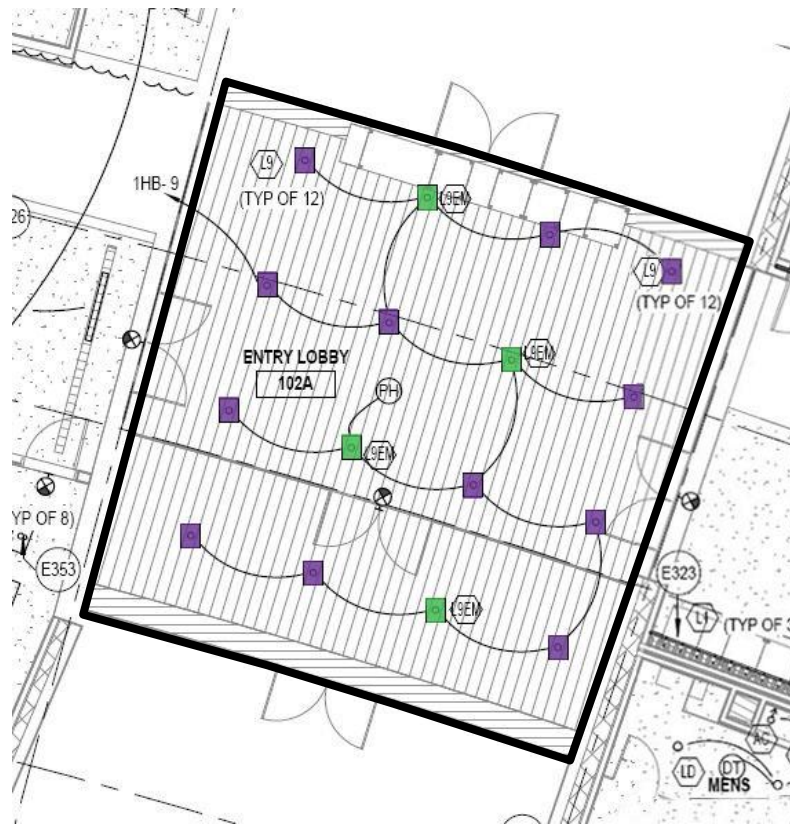


Figure 3.4 | Entry Lobby Lower Reflected Ceiling Plan

Entry Lobby



| Type | Description | Manufacturer | Model | Load | Lamp | Voltage | Comments |
|---|--|--------------|-------------|-------|--------------------------------|---------|----------------|
|  | RECESSED 2.5" APERTURE LED DOWNLIGHT WITH, REPLACEABLE 3000K CCT MINIMUM 950 LUMEN LED MODULE, DIMMABLE TO 15%, WITH 50° OPTICS, SOLITE LENS, 1" REGRESSED BLACK ALZAK REFLECTOR/TRIM, AND INTEGRAL DRIVER | USAI | NANOLED NXT | 20 VA | 950 LUMEN 3000K CCT LED MODULE | 277 V | DIMMING DRIVER |
|  | RECESSED 2.5" APERTURE LED DOWNLIGHT WITH, REPLACEABLE 3000K CCT MINIMUM 950 LUMEN LED MODULE, WITH 50° OPTICS, SOLITE LENS, 1" REGRESSED BLACK ALZAK REFLECTOR/TRIM, INTEGRAL DRIVER, AND EMERGENCY LIGHTING BATTERY PACK WITH REMOTE TEST SWITCH | USAI | NANOLED NXT | 20 VA | 951 LUMEN 3000K CCT LED MODULE | 227 V | |

Table 3.1 | Entry Lobby Fixture Schedule

3.2 Entry Lobby Lighting Design Criteria and Considerations

The Entry Lobby is a space of transition with a vestibule, interior and exterior doors, and adjacent corridors. Because it is in close proximity to the doorways, the IES Handbook, 10th ed., recommends designing the lighting to assist with adaptation from exterior to interior light levels⁷.

⁷ Illuminating Engineering Society Lighting Handbook, 10th ed., p 22.3

Entry Lobby

| Task | E_h (lux) | E_v (lux) | Avg:Min | Daylight? | Coverage |
|-------|-------------|-------------|---------|-----------|----------|
| Day | 100 | 30 | 4:1 | Y | Room |
| Night | 50 | 20 | 4:1 | -- | Room |

Illuminating Engineering Society Lighting Handbook, 10th ed.

Table 3.2 | Illuminance Criteria

The IECC required maximum lighting power density for a lobby is 1.10 W/sf. Also in accordance with IECC regulations, it is necessary to have the vestibule lights on a time clock or photosensor to prevent unnecessary energy expenditure.

To prioritize the criteria based on the discussion above, it will be beneficial to create a welcoming entry lobby, making the aesthetic appeal a significant factor in the space. Additionally, provide the correct illuminance values for transition spaces as it also serves as emergency egress.

3.3 Entry Lobby Lighting Evaluation

The existing design for the entry lobby is one that is uniform and flexible. Having dimming drivers on the LED fixtures will provide the ability during the day to adjust for adaptation of patrons' eyes; this result can also be achieved by having specific luminaires with the purpose of being used only when needed in the space. There are other possibilities to explore in the lobby to create interest and break up the uniformity.

The switching control for the lobby is through the respective panel board. This seems appropriate for the lobby, being that it is an area of heavy traffic.

The lighting power density of the design is 0.37 W/sf, well below the required-maximum of 1.1 W/sf.

4.0 Outdoor Space | Promenade

4.1 Promenade Existing Conditions

The Promenade is approximately 3000 square feet of sanctuary, a place for tribe members and guests to enjoy the outdoors and admire nature. Admiring and respecting nature is something that is an integral part of the tribe's culture. From below the trellis, individuals can view down over the hillside and take in the Arizona landscape. The trellis is more of an architectural feature than a shading device as it is on the west and north-west side of the building. It is suggestive of a basket weave which is an art form of the tribe, and thereby symbolizes who they are.

The exterior wall of the building is boardform concrete in an adobe brown. The floor is a stained concrete with metal grating near the exterior wall. The trellis is made of aluminum and steel.



The existing lighting controls enlist the use of time clocks to switch the exterior lighting on and off based on a set curfew.

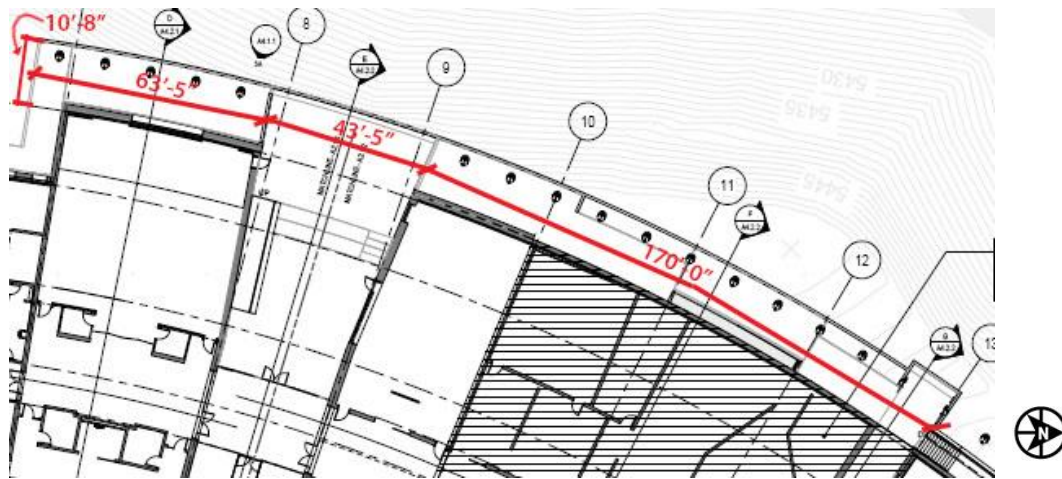


Figure 4.1 | Promenade Floor Plan: Dimensions

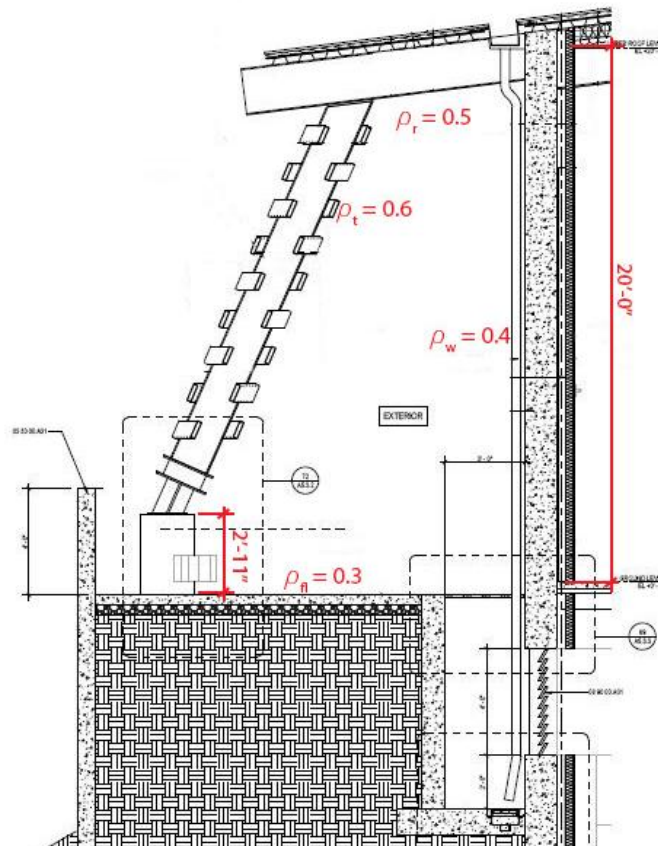


Figure 4.2 | Promenade Section: Promenade Height and Reflectance Values



Figure 4.3 | Promenade Lighting Plan

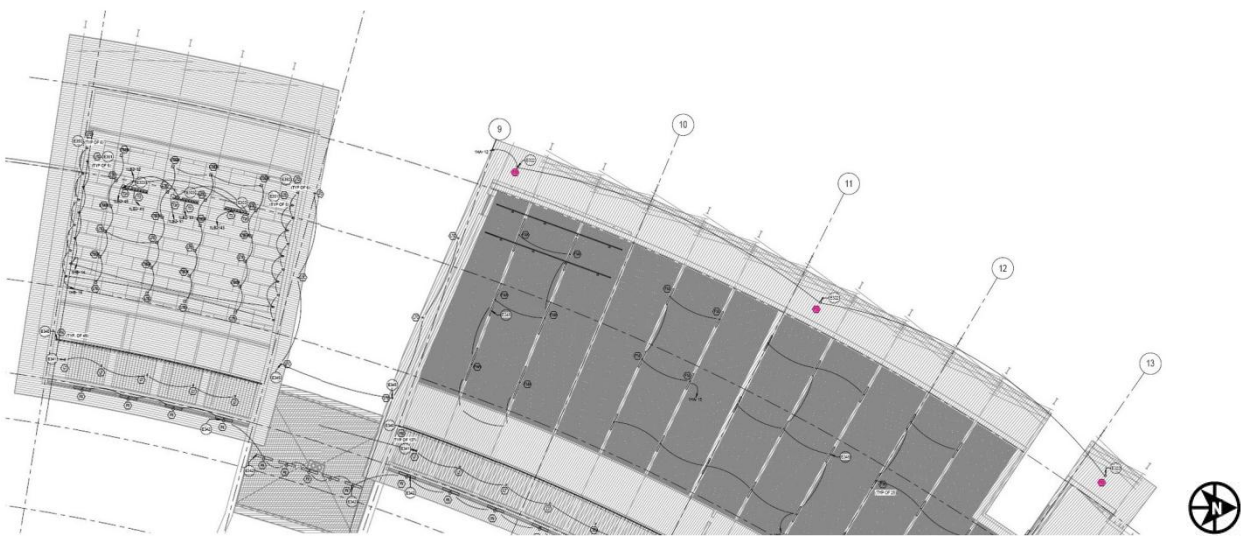


Figure 4.4 | Promenade Reflected Ceiling Plan

Promenade



| Type | Description | Manufacturer | Model | Load | Lamp | Voltage | Comments |
|---|--|-----------------------|------------------|-------|------------------------------|---------|------------------------------------|
|  | EXTERIOR SURFACE MOUNTED CFL CYLINDER FIXTURE WITH DIE CAST ALUMINUM HOUSING, TEMPERED GLASS LENS, SILICONE RUBBER GASKET, ANODIZED ALUMINUM REFLECTOR, IP 66 RATING AND COLD START EMERGENCY BALLAST. | WE-EF | 630-11331 DAC220 | 18 VA | 18W CFL 3000K CCT | 277 V | |
|  | 4.5" DIAMETER x 7" LENGTH ADJUSTABLE ACCENT LUMINAIRE WITH DIE-CAST ALUMINUM HOUSING, TEMPERED GLASS LENS, 10°X41° SPREAD LENS, INTEGRAL DRIVER, IP66 RATING, ARCHITECTURAL YOLK MOUNTING FOR 180° VERTICAL AND 360° HORIZONTAL LOCKABLE AIMING, AND 3000K CCT WHITE LED | Philips Color Kinetic | eW BURST COMPACT | 15 VA | 3000K CCT; 80+ CRI LED ARRAY | 227 V | PROVIDE 10°X41° LINEAR SPREAD LENS |

Table 4.1 | Promenade Fixture Schedule

4.2 Promenade Lighting Design Criteria and Considerations

Because of the location in Arizona, the cultural center is considered to be in a Lighting Zone III with a curfew and low activity. Consequently, there must be considerations for light pollution.

Promenade

| Task | E _h (lux) | E _v (lux) | Avg:Min | Daylight? | Coverage |
|---------------|----------------------|----------------------|---------|-----------|----------|
| LZ3 w/ curfew | 2 | 1 | 5:1 | -- | Room |

Table 4.2 | Illuminance Criteria

Most of the exterior lighting is governed by Arizona's *Title 49. Arizona Title 49-1102* which states that "all outdoor light fixtures shall be fully or partially shielded except incandescent fixtures of one hundred fifty watts or less and other sources of seventy watts or less⁸." In continuation, *Arizona Title 49-1103: Nonconforming light fixtures* states the following, "in addition to other exemptions provided in this article, outdoor light fixtures not meeting the provisions of this article shall be allowed provided such fixtures are extinguished between the hours of midnight and sunrise by an automatic shutoff device."

It is also a consideration that the promenade serves as a piece of aesthetic architecture that embodies the tribe's identity. With this in mind, lighting could further make this exterior space a statement.

To prioritize the criteria based on the discussion above, the Promenade must, foremost, comply with code requirements for exterior lighting in relation to light pollution. Following code, illuminance level and aesthetic appeal should be considered because of its prominent façade, visible for miles.

4.3 Promenade Lighting Evaluation

Without calculation it would seem that three 18W CFL downlights with a separation of over 78' would have a very low illuminance value and a large uniformity ratio. By adding in the LED luminaires that serve also as an accent to the architecture, the overall illuminance value increases. With a curfew, it is possible to use fixtures without full-cutoff and to have more light in this space without breaching

⁸ Arizona Title 49. Chapter 7, Article 1. <http://www.azleg.state.az.us/ArizonaRevisedStatutes.asp?Title=49>

code requirements. The existing lighting conforms to this aspect of the code by the use of time clocks.

The existing lighting design uses a warm color temperature of 3000K with all of the light sources on the project. Specifically on the exterior, a 3000K color temperature will accent the warm red and yellow tones of the building materials.

The existing lighting design for the promenade provides a pleasant space for the enjoyment of tribe members and visitors, and also highlights the architecture for viewers in the adjacent town to see up on the hillside.

5.0 Additional Requirements

Additional requirements as set forth by the International Energy Conservation Code that apply to the building as a whole are listed below.

- 1 manual control per room (floor to ceiling partitions)
- Control to allow occupant to reduce connected load uniformly by at least 50% - unless in area with occupancy control, lobby, spaces w/ $< 0.6\text{W/sf}$
- Daylight zones must be controlled independently of the general area lighting by either manual or automatic controls. Automatic controls must be continuous to less than 35% of rated power or stepped dimming with at least two channels, one between 50% and 75%, and the second less than 35%.
- Display and accent lights must be controlled separately of the general lighting for the room.
- Fluorescent lighting located within the same area must be tandem wired: recessed, within 10ft, and pendant or surface mounted, within 1ft.