



Technical Report 1

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Lighting/Electrical

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University of California, Riverside Student Recreation Center

Riverside, CA

Advisor: Dr. Kevin Houser

Executive Summary

The University of California, Riverside Student Recreation Center (UCR Rec Center) is currently undergoing an expansion and renovation. The addition contains a gymnasium, a rock wall, locker rooms, weight lifting areas, exercise areas, offices and classrooms. The Portion of the existing building that is being renovated will be converted from primarily a workout space to offices and all of the exercise areas will be housed in the addition. Four spaces in the building are examined in this report. The four spaces are as follows:

Outdoor Space | Courtyard/Entrance

Circulation Space | Lobby/Atrium

Special Purpose Space | Rock Wall

Large Work Space | Gymnasium

Each of these spaces is assessed based on the current lighting system, spatial properties, finishes, and glazing types in the spaces. With each description of the existing conditions is a set of design criteria with different design criteria that apply to each space. Following the design criteria is a critique of the current lighting system based on the selected design criteria. Overall the lighting system is very effective and well designed, but there are some changes that have the potential to improve energy efficiency or visual comfort in the spaces. Overall, this building does a very good job of using efficacious light sources and integrating daylight into the spaces to save on lighting costs.

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Building Overview

Location: Riverside, CA

Building Occupant Name: University of California, Riverside

Occupancy or Function Types: A-3 Recreation Center

Size: 15,984 SF Renovation, 79,936 SF Addition

Stories Above Grade: Two

Dates of Construction: August 2012 to January 2014

Building Cost: \$36.9 Million including construction costs

Project Delivery Method: Design-Bid-Build

Outdoor Space: Courtyard/Entrance

The existing building is connected to the addition by an open exercise area on the second level, creating a breezeway between the two buildings on the first level. This breezeway is connected on one side to a small courtyard area and a set of steps leading up to the building on the other.

Existing Conditions

Courtyard:

Area: 10,623 sq ft

Length: 218 ft

Width: 42 ft

Entrance:

Area: 11,905 sq ft

Length: 130 ft

Width: 102 ft

The courtyard that is located between the two buildings on the east side of the breezeway provides access to the main entrance to the existing building, as well as a place where students can congregate.

On the west side of the breezeway is a set of stairs that provides access to the main entrance to the addition and a secondary entrance to the existing building. The two sets of stairs are divided by a brick planter. These spaces will be mainly used for circulation and for interaction between students before and after using the exercise facilities.



Image from the Architect's Newspaper: <http://archpaper.com/news/articles.asp?id=6035>

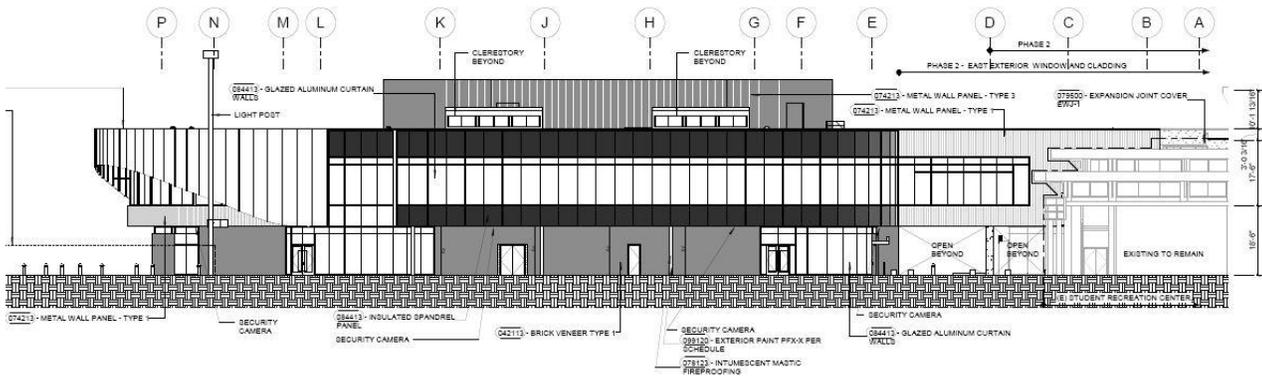


Figure 1: East Elevation

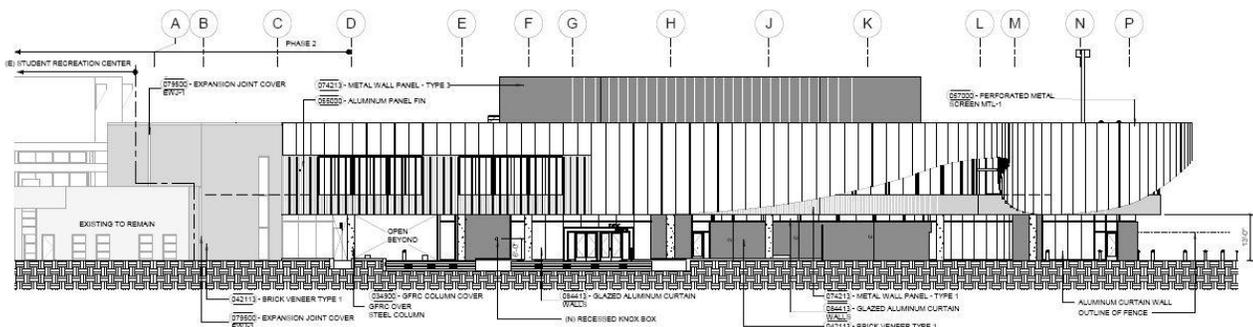


Figure 2: West Elevation

Lighting and Controls

The lighting in the courtyard currently consists of twelve foot tall pedestrian columns running down the center of the courtyard. These luminaires provide the general illumination necessary to ensure that patrons feel safe while they are in the space at night. LED downlights in the breezeway provide a bright illuminance, informing patrons of the location of the building's main entrance. On the east side of the breezeway, more columns are used to illuminate the area in front of the stairs while LED step lights provide illumination for the steps and ramp. A linear LED provides grazing on the brick planter separating the stairs from the ramp.

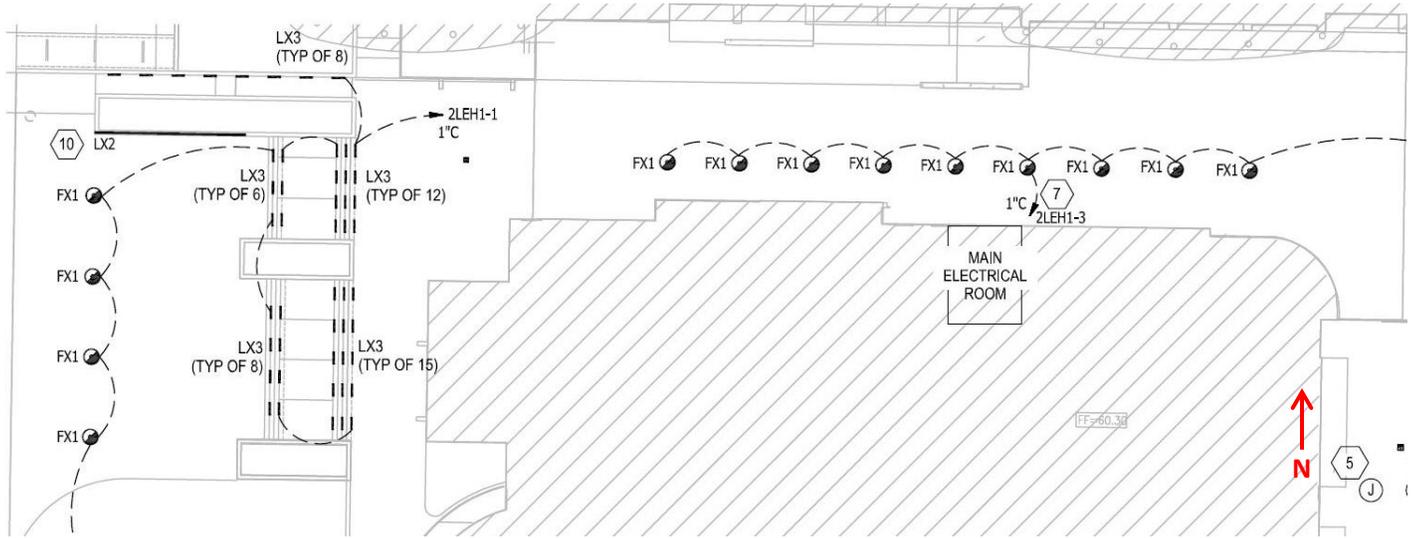


Figure 3: Courtyard and Entrance Lighting Plan

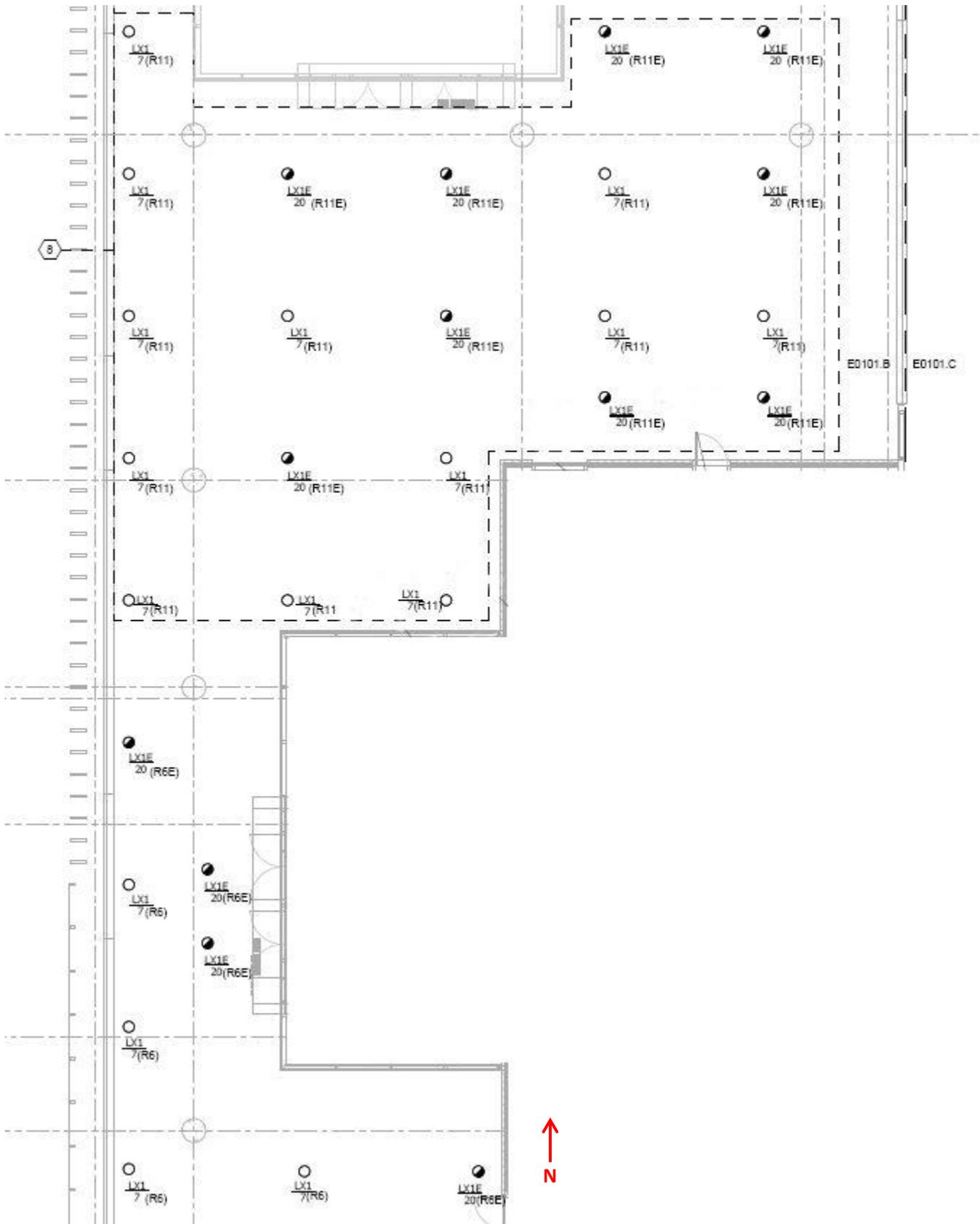


Figure 4: Breezeway Lighting Plan

TYPE	DESCRIPTION	MOUNTING	LAMP	BALLAST	VOLTAGE	INPUT WATTS	MANUFACTURER
FX1	12' PEDESTRIAN LIGHT COLUMN	ON GRADE	(4) F32HPT8	ELECTRONIC COLD WEATHER	277	110W	SE'LUX MTRC COLUMN SERIES
LX1	6" LED DOWNLIGHT	RECESSED	3500K, 1500 LUMEN PACKAGE	INTEGRAL DRIVER	277	39W	OMEGA LIGHTING OM8LED SERIES
LX2	CONTINUOUS LINEAR LED	RECESSED	3500K, 129 LUMENS/FT LED PACKAGE	REMOTE TRANSFORMER	24 VAC	4.5W/FT	WINONA WINLINE 200 SERIES
LX3	LED STEP LIGHT	RECESSED	3000K, 450 LUMEN LED PACKAGE	INTEGRAL DIMMABLE DRIVER	277	7.5W	BEGA 2382 LED SERIES

*Note: Luminaires on plan with E at end of type indicate emergency luminaires.

Finishes & Glazing

The most abundant material in this space is by far the concrete that makes up the ground. The only other building materials that affect this space are those of the planters near the stairs and the materials of the building façade. The façade of the existing building on one side of the courtyard is made of brick veneer while the addition is comprised of brick veneer on the first level with metal paneling and curtain wall glazing on the second level. The breezeway is comprised of metal paneling and glazing. On the opposite side of the breezeway, the lower level of both the existing building and addition are comprised of brick veneer and glazing while the upper level is made of aluminum fins and glazing. Finish and glazing schedules can be found below.

TYPE	DESCRIPTION	MANUFACTURER	COLOR	REFLECTANCE
BRICK VENEER	BLEND RUFFLED TEXTURE NORMAN FACE BRICK	PACIFIC CLAY	RED BRICK	0.30
CONCRETE	-	-	GRAY	0.30
METAL WALL PANEL	ZINC COATED STEEL SHEET	CENTRIA ARCHITECTURAL SYSTEMS	SILVER	0.60

TYPE	T _{vis}	U _{winter}	U _{summer}	SHGC	SC
PPG SOLARBAN XL70	0.658	0.28	0.26	0.28	0.32

Design Criteria

The design criteria for this space come from recommendations from the Illuminating Engineering Society Tenth Edition Lighting Handbook and Title 24. Specific design criteria are listed below in order of importance. This space will be used to create three different schematic design concepts.

Lighting Power Density

Title 24 requires that all outdoor spaces comply with lighting power density requirements. These requirements are the most important to meet because they are code requirements and the building cannot be occupied without complying. The UCR Rec Center is located in Zone 3 lighting. Applicable lighting power densities specified are summarized in the table below.

Description	Allowance
Area Allowance	0.092 W/SF
Linear Allowance	0.92 W/LF
Initial Allowance	770 W
Building Entrance	100 W
Hardscape Ornamental Lighting	0.04 W/SF
Facade	0.35 W/SF

Controls

Title 24 also requires certain lighting control equipment for exterior luminaires. Again, meeting these requirements is essential as the building cannot be occupied without compliance. A list of criteria can be found below.

- Permanently installed outdoor luminaires using lamps rated over 100 watts must have a lamp efficacy of at least 60 lumens per watt or be controlled by a motion sensor unless they are LEDs.
- All permanent outdoor lighting must be on an astronomical time switch to automatically turn off lights when daylight is available.
- For lighting of building facades an automatic time switch must be installed that is capable of turning off the lighting when not needed and reducing the lighting load, in watts, by at least 50 percent but not more than 80 percent.

Luminaire Cutoff

Title 24 requires that all luminaires that use lamps rated greater than 175 watts used in hardscape areas have cutoff light distributions. This means that the candela per 1000 lamp lumens does not exceed 25 at or above a vertical angle of 90 degrees from nadir or 100 at or above a vertical angle of 80 degrees above nadir. This cutoff does not apply to fixtures lighting the building façade.

Illuminance

The IES Tenth Edition Lighting Handbook provides illuminance recommendations for all types of exterior spaces of a building. While these recommendations are not required by code, they should be used as a guideline because safety is important in this space. If a patron does not feel safe in the space, he or she will not use the space. Following the IES recommendations will allow patrons to feel safe in the space. IES recommendations are summarized in the table below.

Space	E_h (lux)	E_v (lux)
Entrance	15	7.5
Courtyard	3	1
Stairs	4	2

Uniformity

The IES Tenth Edition Lighting Handbook also provides illuminance uniformity recommendations for outdoor spaces. It is important to follow these criteria to provide a safe environment for patrons. IES recommendations are summarized in the table below.

Space	$E_{max}:E_{avg}$	$E_{h,avg}:E_{h,min}$	$E_{v,avg}:E_{v,min}$
Entrance	4:1	2:1	4:1
Courtyard	4:1	5:1	10:1
Stairs	4:1	5:1	10:1

Sustainability

This project is striving to attain a LEED Gold rating, but at minimum attain a LEED Silver rating. For this reason it is important to use minimal up lighting, use efficient light sources and to minimize light trespass.

Circulation

This space not only serves as a place where patrons can gather but also as a circulation space for people entering and exiting the building. The lighting design should take this into account and should facilitate circulation, guiding patrons to important locations.

Psychological Impression

Psychological reinforcement can be used in this space to create an atmosphere for the patrons that are entering and exiting the building. This is not a necessary component of the design but can make the space feel more visually appealing.

Evaluation of Existing Lighting

The existing lighting system uses a variety of luminaire types to achieve the desired average illuminance. Most of the sources used are LEDs but the pedestrian columns are fluorescent. Luminaires that use metal halide lamps or LEDs are often preferred over luminaires that use fluorescent lamps due to the environment's negative effects on their performance. These effects, however, mostly occur during cold weather which should not be a problem in southern California. A color temperature is not specified for the fluorescent lamps in the pedestrian columns the lamps that should be used are 3500K lamps to match the majority of the rest of the luminaires. This would make the step lights the only luminaires that operate at a color temperature other than 3500K, as they operate at 3000K. Another step light could be selected with a correlated color temperature to match the other luminaires. The lighting design does, however, provide a safe atmosphere for patrons and helps to guide them towards the entrance to the buildings by using higher light levels near the entrance.

Circulation Space: Lobby/Atrium

Under the breezeway is the entrance to the main lobby of the addition. Right inside the doors there is a desk for staff and turnstiles to track occupancy. Beyond the turnstiles is a large open space with access to the locker rooms, an exercise area and a staircase to the second floor.

Existing Conditions

Area: 7117 sq ft

Length: 110 ft

Width: 91

Ceiling Height: 14ft 6in, 36 ft for double height

This space is very open in order to facilitate movement. The exercise area is incorporated into the atrium in order to make use of the plentiful daylight that comes from the open weight rooms to the south and open climbing wall area to the north. This space will be used mostly for circulation and exercising but there will also be office work being completed at the desk.

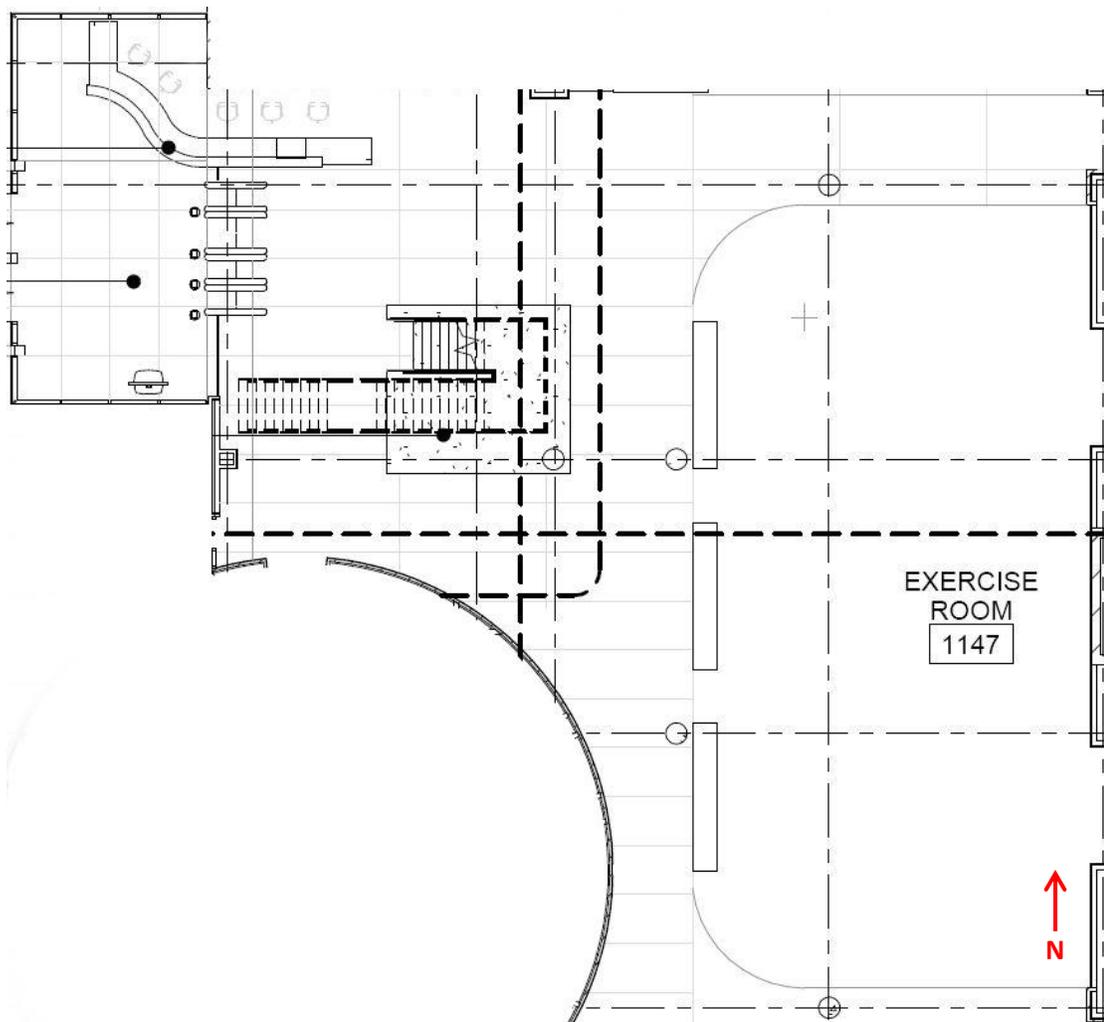


Figure 5: Lobby/Atrium Plan

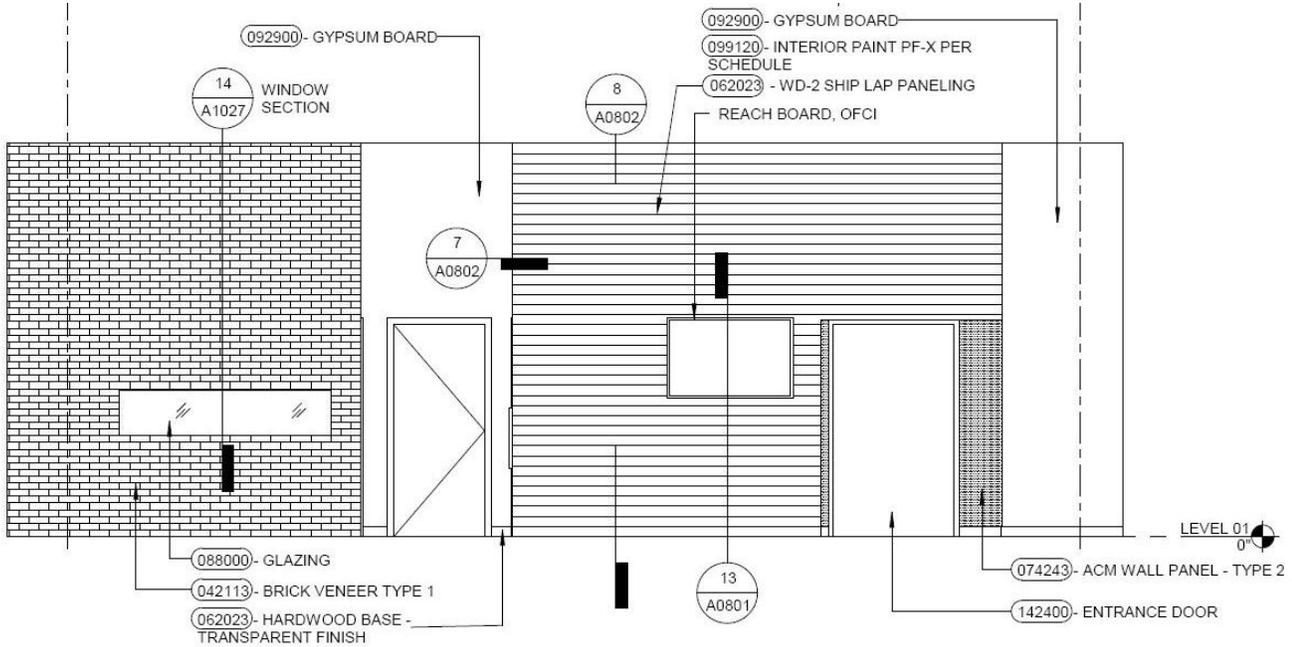


Figure 6: Control Counter North Elevation

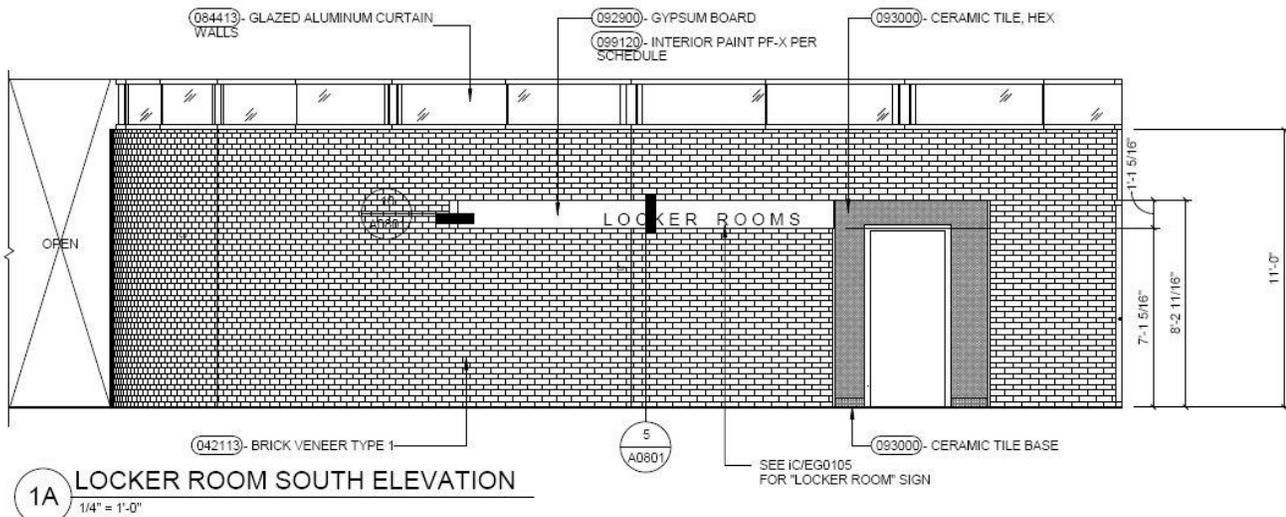


Figure 7: Locker Room South Elevation

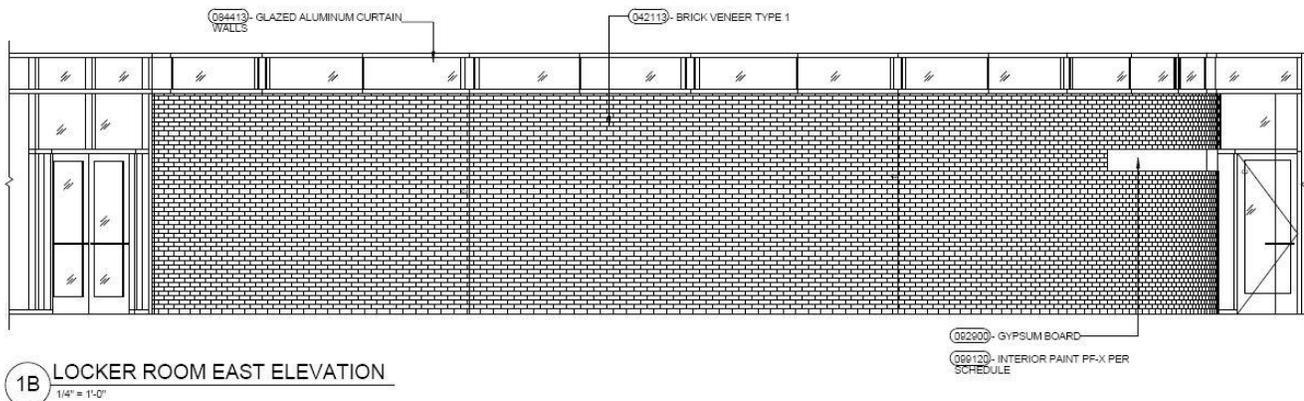


Figure 8: Locker Room East Elevation

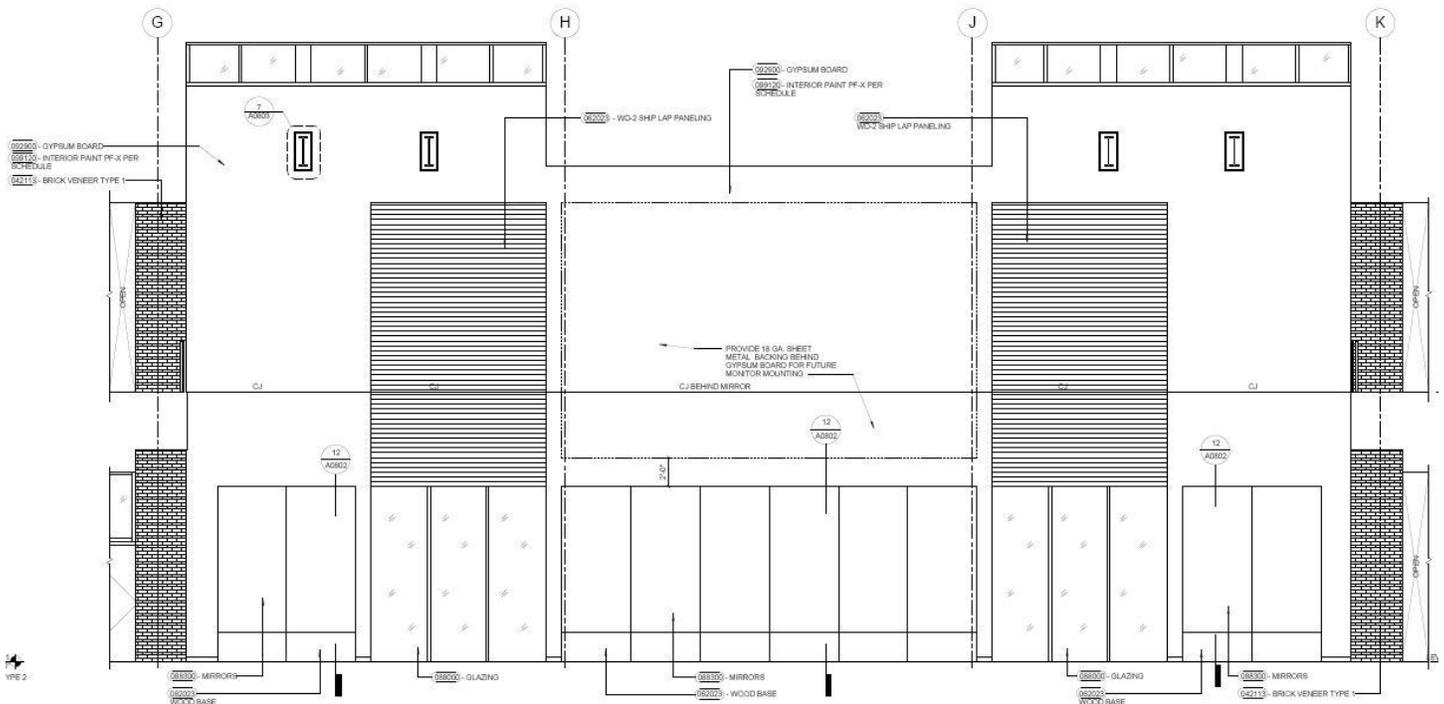


Figure 9: Exercise Space East Elevation

Lighting and Controls

Because the lobby and atrium space is open to both levels of the recreation center, its lighting is affected by luminaires on both levels. It is also affected greatly by daylight from the glazing near the entrance and above the exercise area. It is also affected by the daylight that enters the building through side lighting in the weight room that wraps around the perimeter of the building. As a patron first enters the building, he or she encounters the lobby and control desk. Overhead are fluorescent lensed slot fixtures used for ambient lighting in the lobby, behind the desk, and in the hallway behind the desk. There are also LED downlights in the lobby to provide additional illumination. Behind the counter a linear fluorescent cove draws attention to the wall behind the security desk and LED task lights provide additional illumination at the desk when needed. As the patron moves further into the space, linear fluorescent troffers provide general illumination around the exercise area and the locker room core to the south of the staircase. A LED wall grazing brings the patrons attention to the entrance to the locker rooms. The main source of electric light for the exercise area is provided from the second floor ceiling from recessed linear LEDs and LED cove fixtures. Another span of recessed linear LEDs provides a wall wash between the two spans of horizontal glazing at the back of the exercise area.

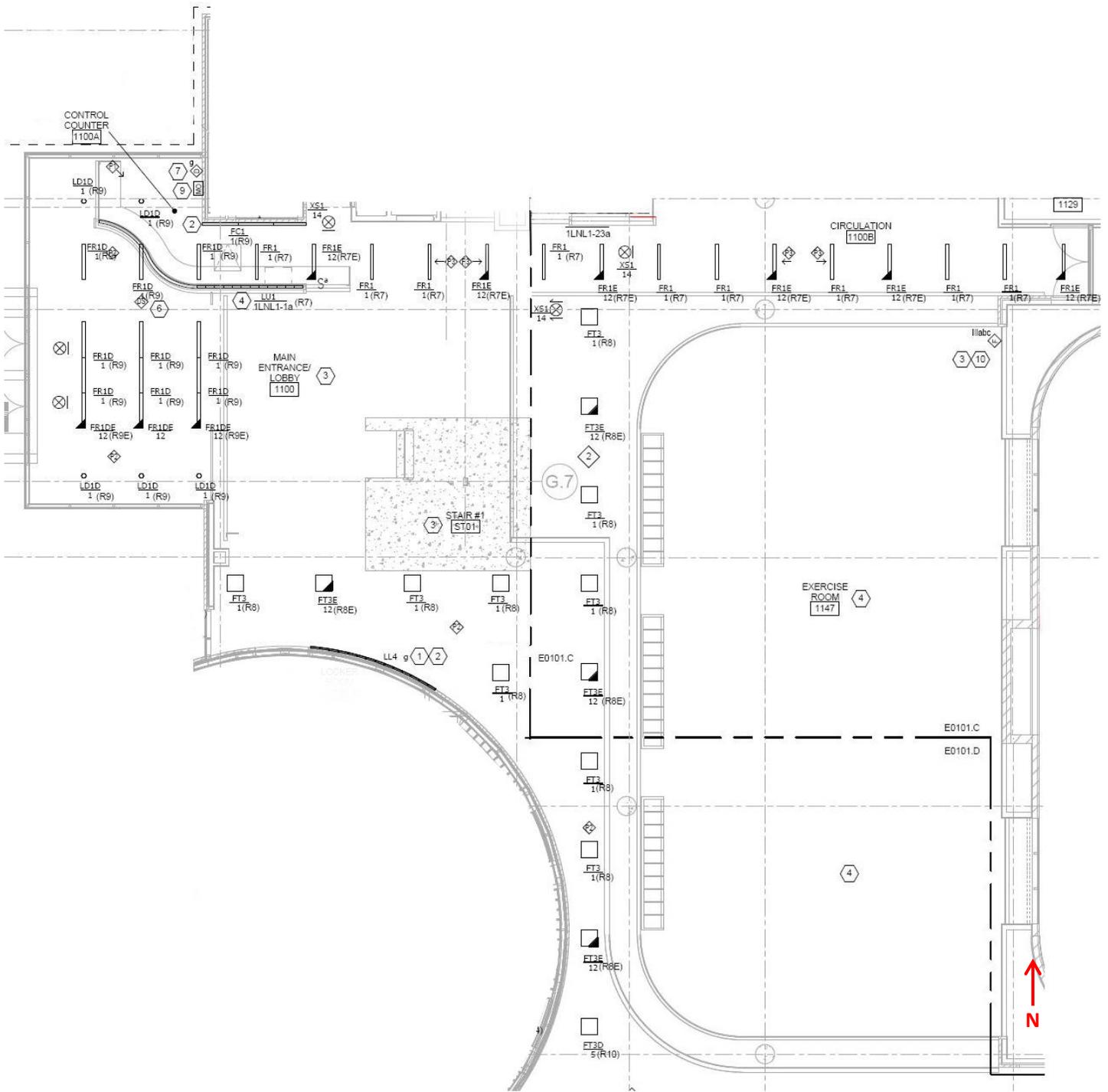


Figure 10: Lobby/Atrium Lighting Plan

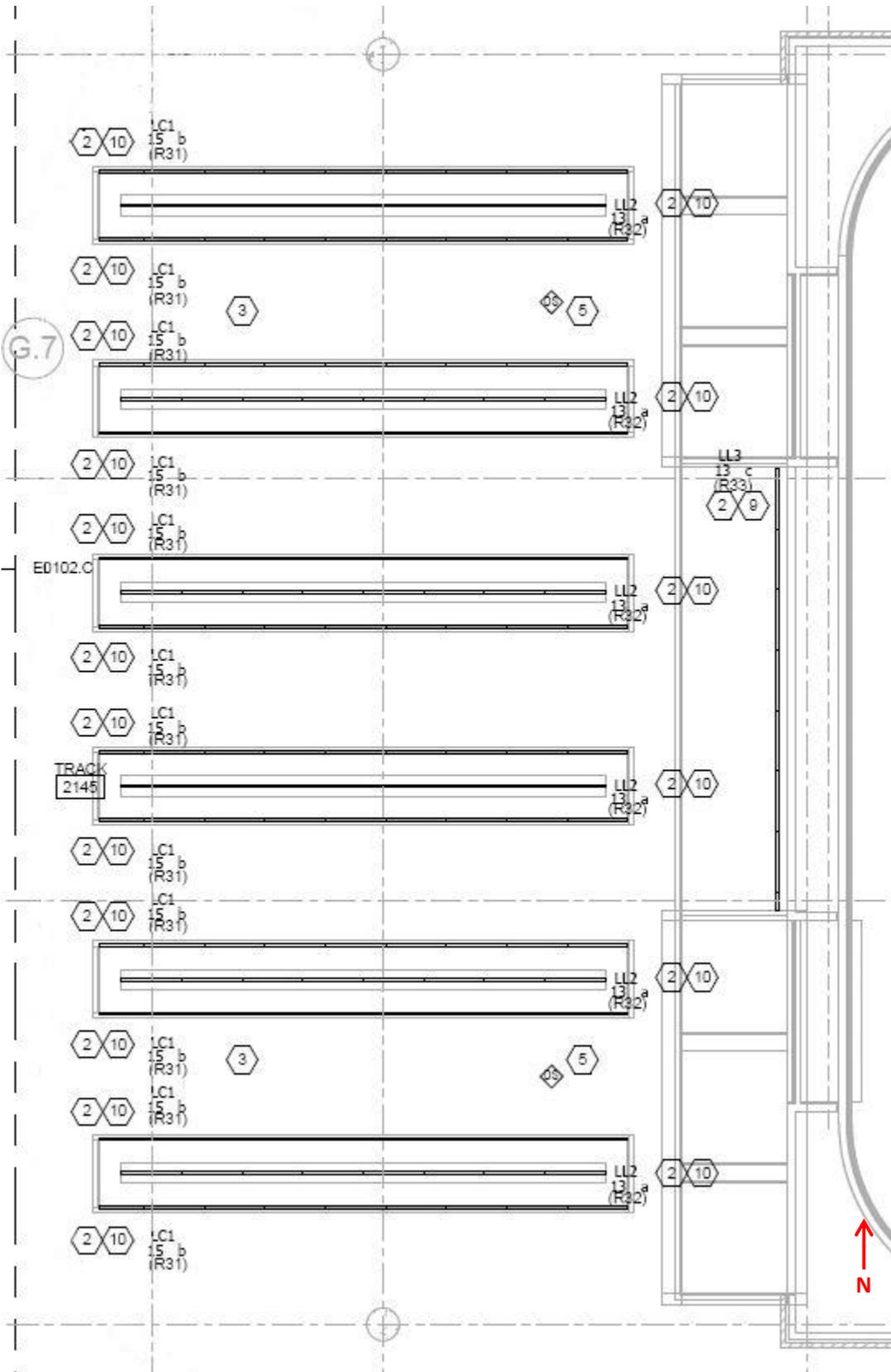


Figure 11: Exercise Area Lighting Plan

TYPE	DESCRIPTION	MOUNTING	LAMP	BALLAST	VOLTAGE	INPUT WATTS	MANUFACTURER
FC1	CONTINUOUS COVE	SURFACE	STAGGERED F32HPT8/ F25HPT8	PROGRAMMED START ELECTRONIC	277	30W	NEORAY 76 PF SERIES
FR1	LENSED SLOT	RECESSED	(1) F32HPT8	PROGRAMMED START ELECTRONIC	277	30W	PINNACLE LIGHTING EDGE 4 SERIES
FT3	2X2 DIRECT/ INDIRECT TROFFER	RECESSED	(2) F24T5HO	PROGRAMMED START ELECTRONIC	277	52W	NEORAY LUMINOUS HE SERIES
LC1	CONTINUOUS LED COVE	SURFACE	4000K, 773 LUMENS/FT PACKAGE	INTEGRAL DIMMABLE DRIVER	277	12W/FT	LUMENPULSE LUMENCOVE HIGH OUTPUT SERIES
LD1	6" LED DOWNLIGHT	RECESSED	3500K, 2000 LUMEN LED PACKAGE	INTEGRAL DIMMABLE DRIVER	277	39	OMEGA LIGHTING OM6LED SERIES
LL2	CONTINUOUS LINEAR LED	RECESSED	4000K, 2455 LUMEN LED PACKAGE	INTEGRAL DIMMABLE DRIVER	277	15.25W/FT	LUMENPULSE LUMENFACADE HIGH OUTPUT SERIES
LL3	CONTINUOUS LINEAR LED	RECESSED	4000K, 2455 LUMEN LED PACKAGE	INTEGRAL DIMMABLE DRIVER	277	15.25W/FT	LUMENPULSE LUMENFACADE HIGH OUTPUT SERIES
LL4	CONTINUOUS LINEAR LED	SURFACE	3500K LED PACKAGE	REMOTE TRANSFORMER	24 VAC	4.5W/FT	WINONA WINLINE 200 SERIES
LU1	LED TASK LIGHT	SURFACE	4000K, 250 LUMEN LED PACKAGE	INTEGRAL DRIVER	120	7W/FT	ALKCO ARIS SERIES

*Note: Luminaires on plan with E at end of type indicate emergency luminaires. Luminaires on plan with D at end of type indicate dimmable luminaires.

Finishes & Glazing

The lobby and atrium area has a wide variety of finishes because of the multiple functions of the space. The entrance to the lobby is made of the same type of glazing that is used everywhere else on the building. Right inside the lobby, the wall behind the control desk has finishes of brick veneer, eggshell paint on gypsum wall board, and maple ship lap paneling. This progression helps to connect the exterior and interior of the building. The floor is made of polished, sealed concrete. The majority of the rest of the space is eggshell color painted walls except for the outer locker room walls, which are made of brick, and the exercise area wall. The exercise wall is framed on both sides by brick veneer. On the lower part of the wall there are mirrors so patrons can watch themselves as they work out and interior glazing allowing patrons to see into the gymnasium. Above the mirrors is the same maple ship lap paneling that is on the wall behind the control counter and the rest of the wall is gypsum wall board painted the same eggshell color as the rest of the space. The floor in the exercise space is a sport flooring material. The ceiling throughout the space is a flat white paint.

TYPE	DESCRIPTION	MANUFACTURER	COLOR	REFLECTANCE
BRICK VENEER	BLEND RUFFLED TEXTURE NORMAN FACE BRICK	PACIFIC CLAY	RED BRICK	0.30
POLISHED CONCRETE	GROUND, POLISHED, SEALED CONCRETE	-	NATURAL GRAY	0.30
PAINT	FLAT FINISH	DUNN EDWARDS	WHITE	0.90
PAINT	FLAT FINISH	DUNN EDWARDS	EGGSHELL	0.70
WOOD PANELING	MAPLE SHIP LAP PANELING	-	MAPLE	0.30
SPORT FLOOR	NEPTUNE COLORED SPORT FLOORING	ECORE ECOSURFACES	BLUE	0.40

TYPE	T _{vis}	U _{winter}	U _{summer}	SHGC	SC
PPG SOLARBAN XL70	0.658	0.28	0.26	0.28	0.32
FLAT GLASS	0.80	-	-	-	-

Design Criteria

The design criteria for this space come from recommendations from the Illuminating Engineering Society Tenth Edition Lighting Handbook and Title 24. Specific design criteria are listed below in order of importance. This space will be used for psychological reinforcement.

Lighting Power Density

Title 24 requires that all spaces comply with lighting power density requirements. These requirements are the most important to meet because they are code requirements and the building cannot be occupied without complying. Applicable lighting power densities specified are summarized in the table below.

Description	Allowance
Lobbies, Main Entry Lobby	1.5 W/SF
Exercise Center, Gymnasium	1.0 W/LF
Other	0.6 W/SF

Controls

Title 24 specifies that indoor spaces must have certain lighting controls. This ensures that energy is being saved when the lighting is not needed. A list of control requirements can be seen below.

- The general lighting of any enclosed space 100 square feet or larger that has a connected load of 0.8 watts per square foot or larger must have multi-level controls with at least one step between 30 and 70 percent of design load.
- Luminaires in the primary sidelit and skylit daylight areas must have at least one control that controls at least 50 percent general lighting power in that area separately from the rest of the lighting and controls primary sidelit luminaires separately from skylit area luminaires.
- The skylit daylight area general lighting shall be controlled separately by an automatic daylighting control device.
- All spaces must have a device to automatically shut off luminaires.

Illuminance

The illuminance criteria for this space are very important because people will be lifting weights and doing other exercises. If the proper illuminance is not provided someone could injure him or herself. Illuminance criteria are summarized in the table below.

Space	E_h (lux)	E_v (lux)
Lobby Day	50	15
Lobby Night	25	10
Transition	45	15
Exercise Area	150	50

Uniformity

The IES Tenth Edition handbook also provides recommendations for illuminance uniformity. Following these illuminance uniformity criteria will make the space seem much more visually appealing and will make it easier to work out and move through the space. Uniformity criteria can be seen in the table below.

Space	$E_{max}:E_{avg}$	$E_{h,avg}:E_{h,min}$	$E_{v,avg}:E_{v,min}$
Lobby Day	-	3:1	3:1
Lobby Night	-	3:1	3:1
Transition	-	2:1	2:1
Exercise Area	-	3:1	3:1

Sustainability

This project is striving to attain a LEED Gold rating, but at minimum attain a LEED Silver rating. For this reason it is important to use efficient light sources and to integrate daylight into the space.

Circulation

Because this space has many different functions, it is important to highlight the important areas of the space. This will make it easier for patrons to find their way around the space.

Psychological Impression

Psychological reinforcement can be used in this space to create an atmosphere for the patrons that are entering and exiting the building. This is a very open building so it is important that the first space occupants enter has a very public feel.

Evaluation of Existing Lighting

The current lighting system accomplishes one of the main goals of this building, which is to be sustainable. The lobby and atrium space is filled with highly efficacious sources such as LEDs and linear fluorescents. The majority of luminaires in the space are LEDs which provides the space with a low power density. The space will often be consuming even less power than the connected power due to the high daylight concentration. The space has glazing at the entry to the lobby and skylights above the exercise area. The open floor plan of the building also allows daylight from the perimeter weightlifting areas to enter the space. These views to the exterior, combined with the uniform lighting, create a very public and open environment. The lighting design uses some accenting near the locker room to draw the occupant's attention and help to aid circulation towards the locker rooms. This space also uses luminaires with different correlated color temperatures, which could possibly be distracting during the night when there isn't any daylight in the space.

Special Purpose Space: Rock Wall

Located to the north of the atrium and exercise area on the first floor is the rock wall area. This area is also open to the corridor and atrium adjacent to it.

Existing Conditions

Area: 1449 sq ft

Length: 53 ft

Width: 27 ft

Ceiling Height: 14ft 6in, 36 ft for double height

This space contains two rock walls. One is a shorter formation that can be climbed on any side and sits in the middle of the space. This formation only reaches about the first floor ceiling. The second wall wraps around the north and east walls and is a more traditional climbing wall, reaching all the way to the ceiling of the second level. This space will primarily be used for climbing but there will be some paperwork being completed at the climbing wall counter.

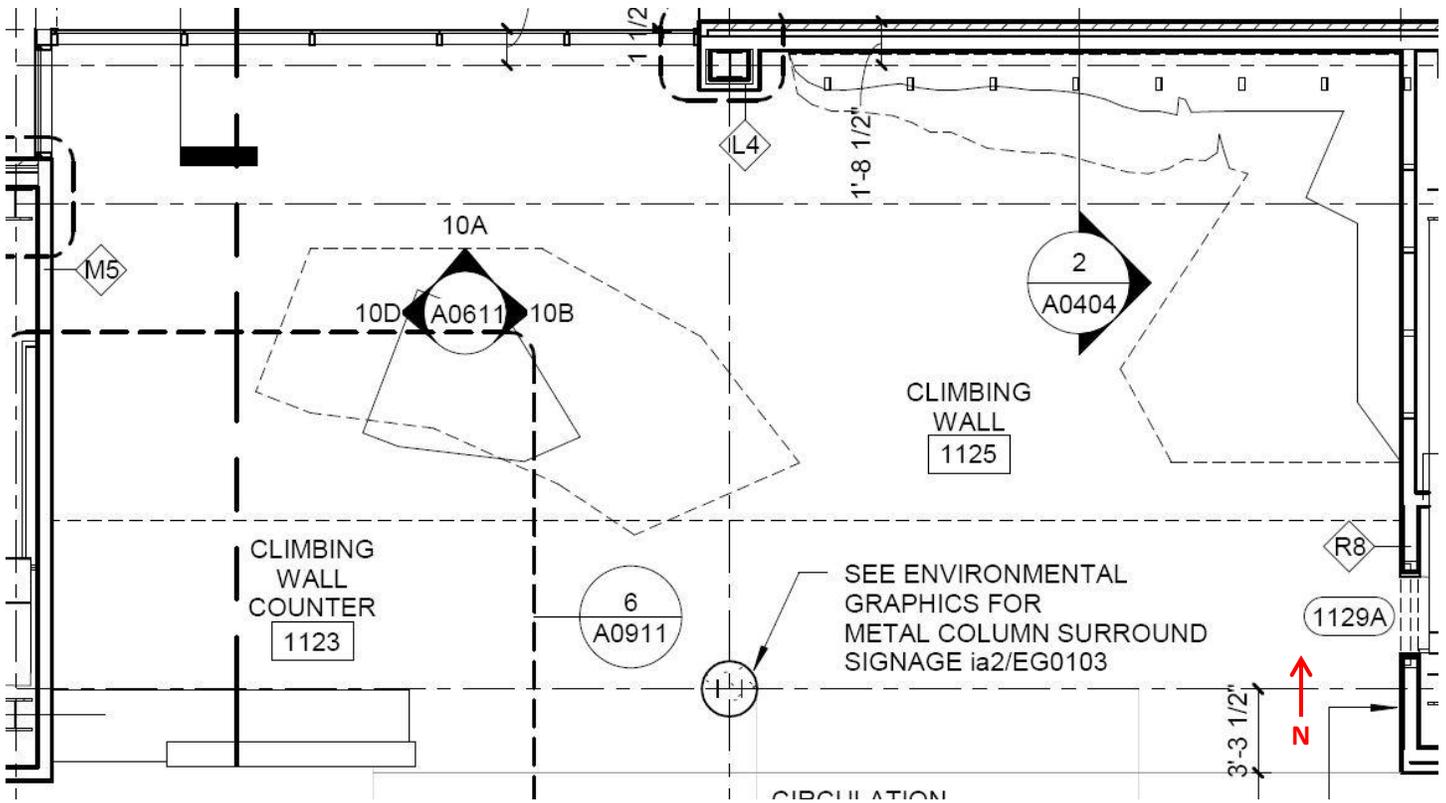


Figure 12: Rock Wall Area Floor Plan

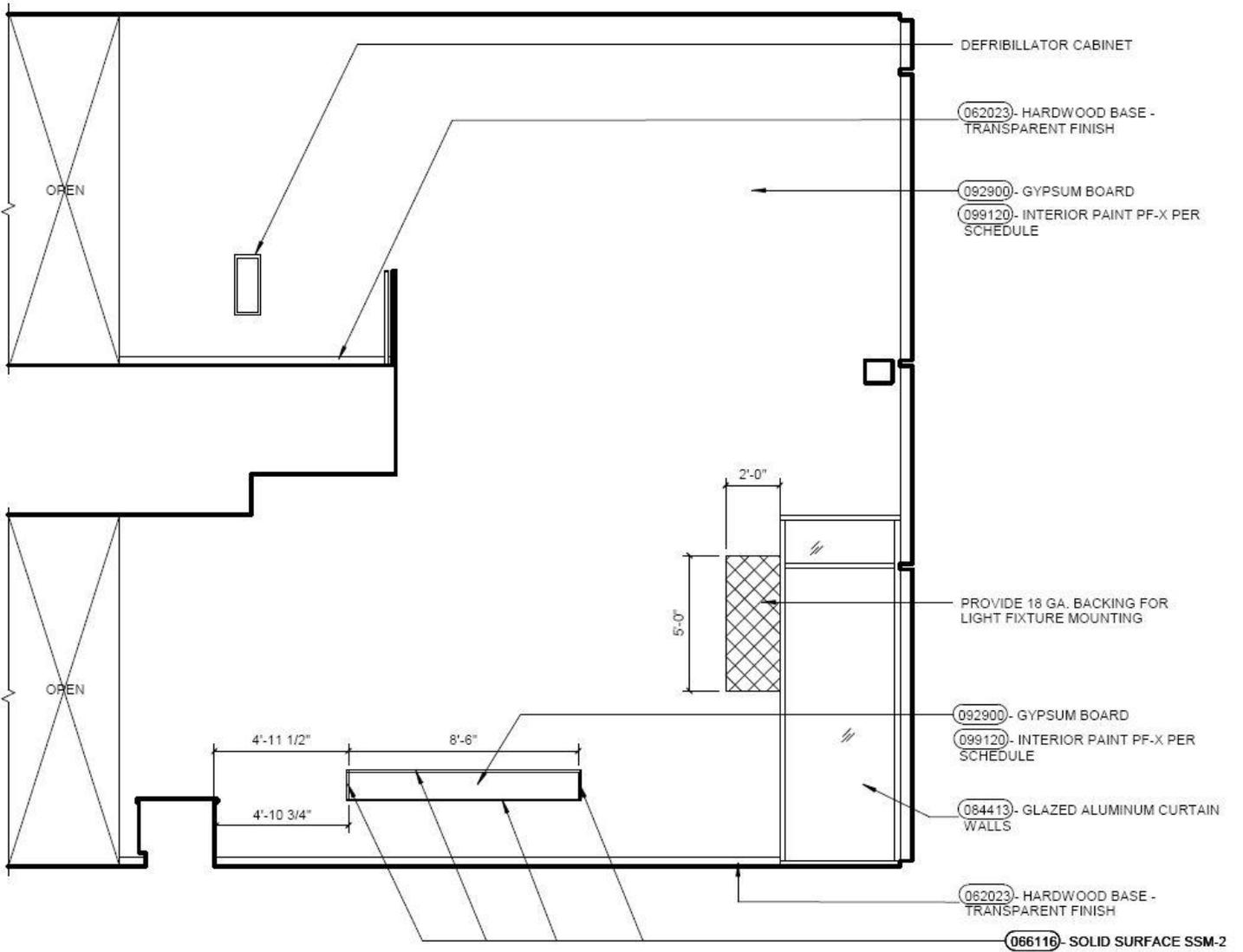


Figure 13: Rock Wall Area West Elevation

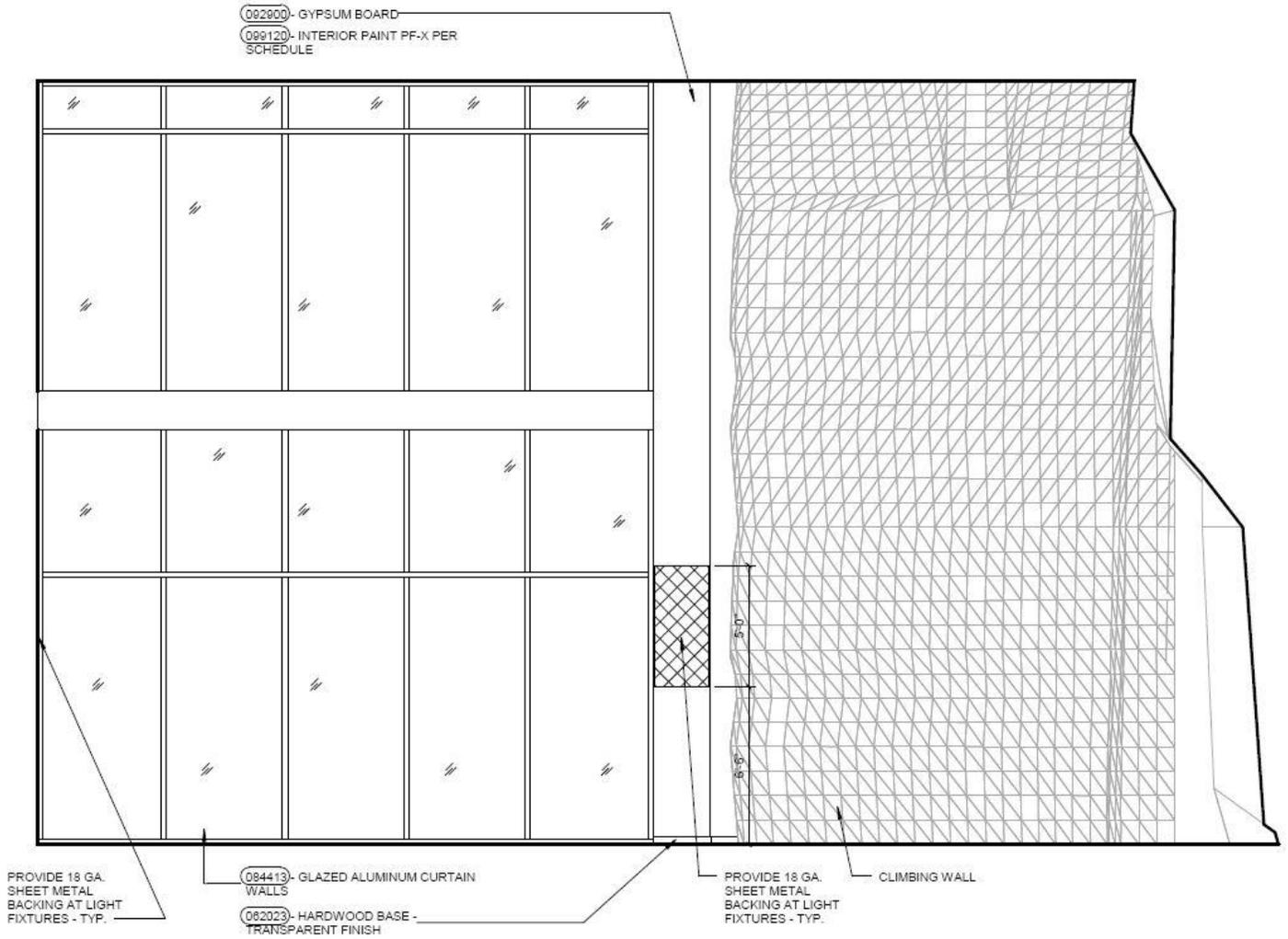


Figure 14: Rock Wall Area North Elevation

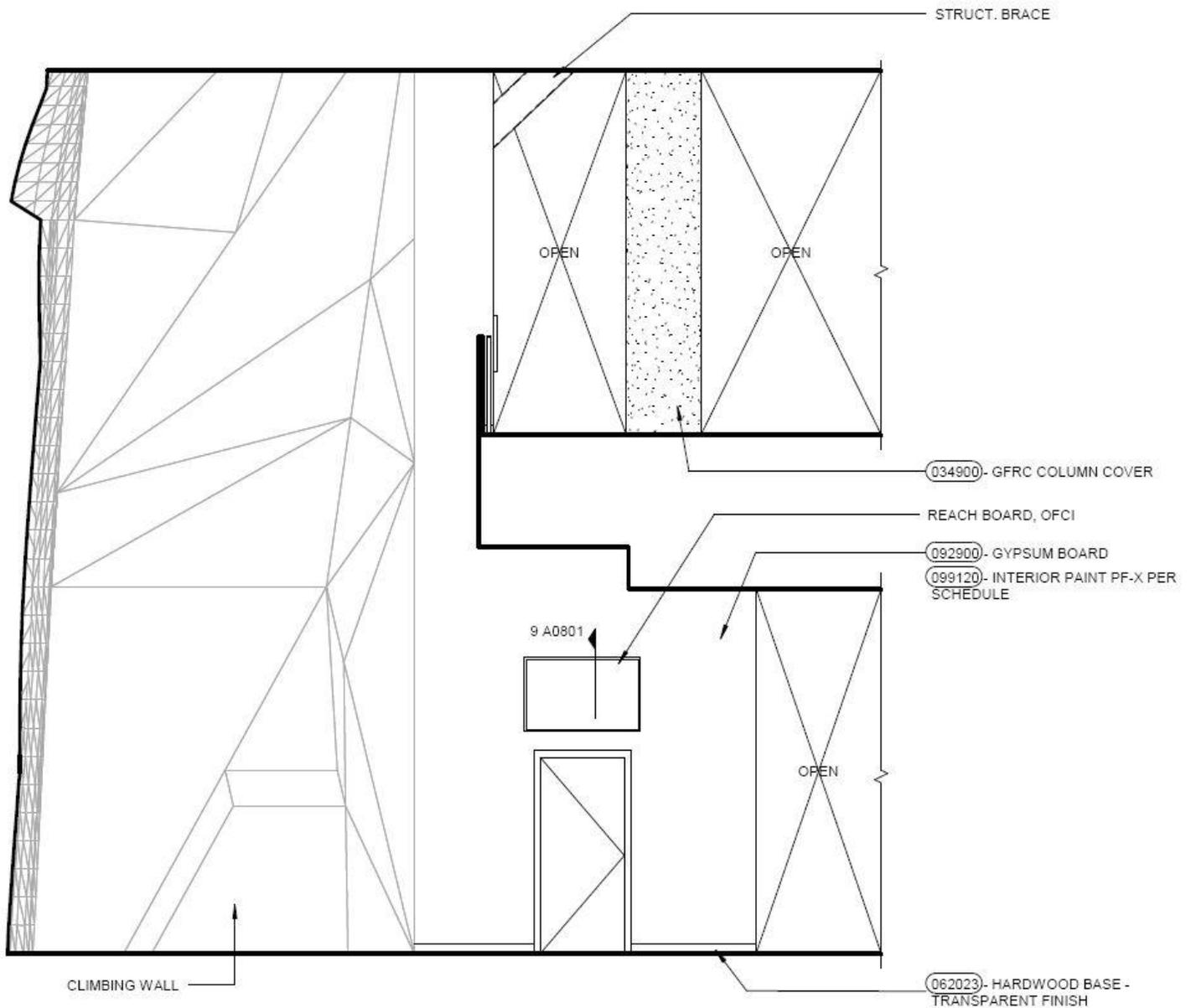


Figure 15: Rock Wall East Elevation

Lighting and Controls

LED downlights are used in this space for general illumination in the transition space between the corridor and the climbing area, where the climbing wall counter is located. This lighting is supplemented at the counter by LED task lights controlled by a local switch. The rock walls are currently lit by metal halide high bay luminaires for general illumination and LED theatrical luminaires to illuminate the climbing walls. The metal halide luminaires use a 3000K metal halide lamp with a color rendering index above 90 and are suspended from the ceiling, with the bottom of the luminaires at twenty eight feet above the finished floor. These luminaires are grouped into two zones, the east side and west side of the room, and are controlled by two switches on the west wall. The theatrical luminaires are mounted to the walls at various heights. Two different beam spreads, twenty and forty degree, of 4000K LEDs are used to illuminate the climbing walls sufficiently. These fixtures are grouped into five zones and are controlled by a Lumentouch control station, manufactured by Lumenpulse, located on the west wall adjacent to the switches controlling the metal halide luminaires.

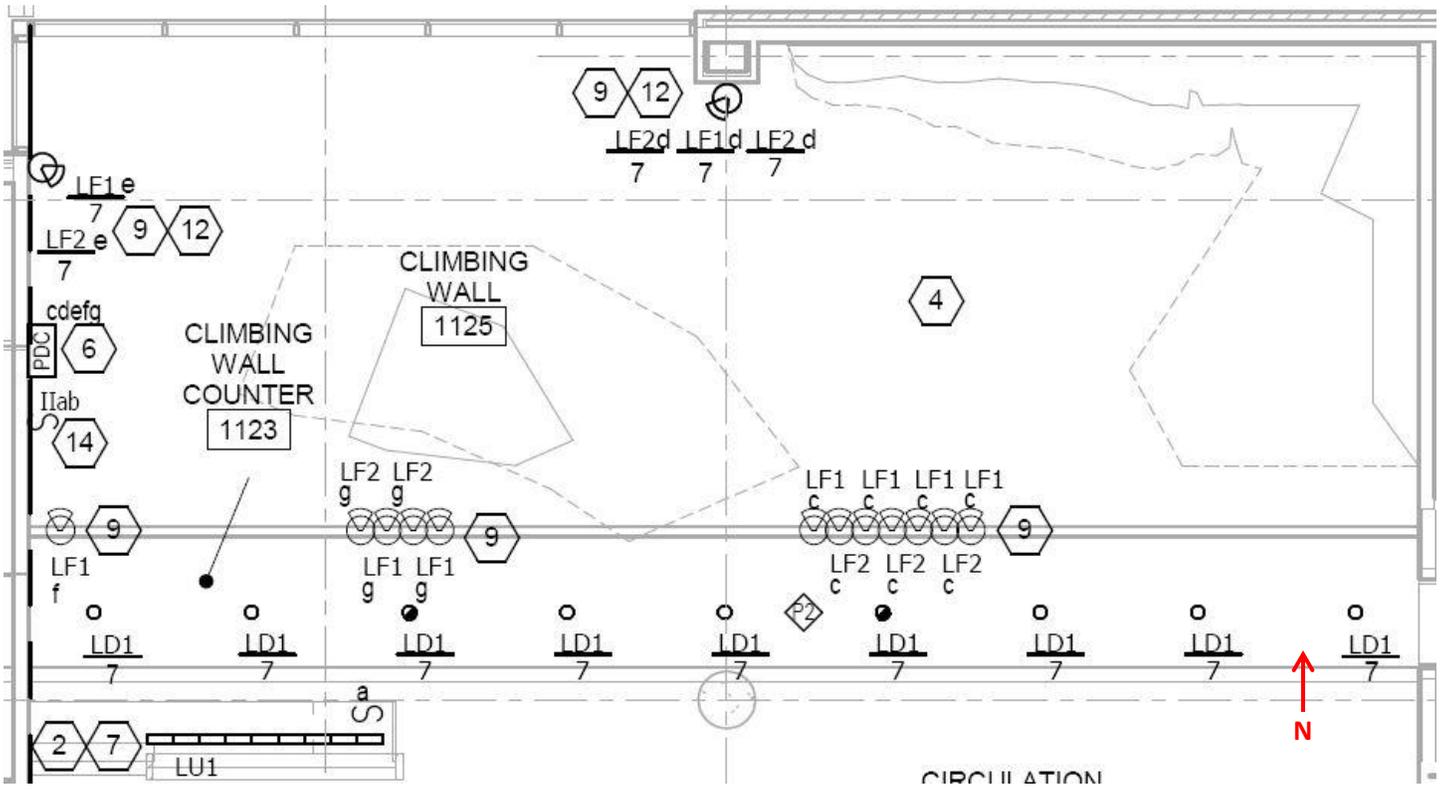


Figure 16: Rock Wall Area Level 1 Lighting Plan

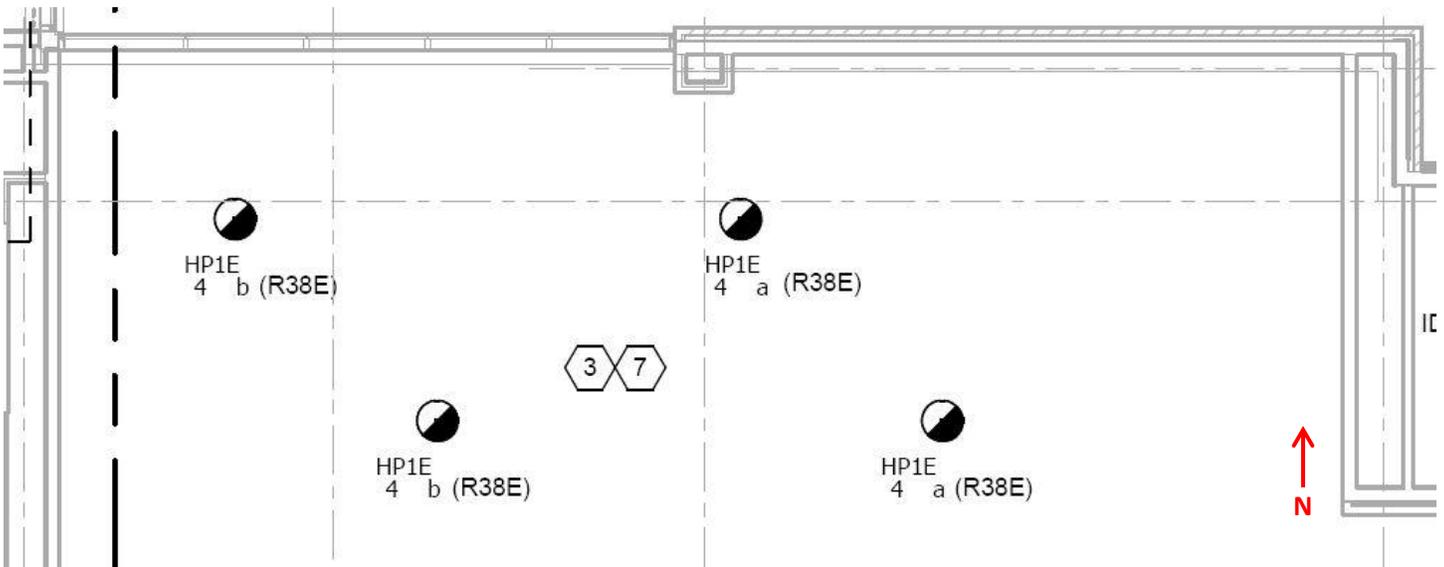


Figure 17: Rock Wall Area Level 2 Lighting Plan

TYPE	DESCRIPTION	MOUNTING	LAMP	BALLAST	VOLTAGE	INPUT WATTS	MANUFACTURER
HP1	METAL HALIDE INDUSTRIAL PENDANT	SUSPENDED	(1) 315W MH	HIGH EFFICIENCY ELECTRONIC	277	341	HOLOPHANE ENDURATRON SERIES
LD1	6" LED DOWNLIGHT	RECESSED	3500K, 2000 LUMEN LED PACKAGE	INTEGRAL DIMMABLE DRIVER	277	39	OMEGA LIGHTING OM6LED SERIES
LF1	LED FLOOD	SURFACE	4000K, 1400 LUMEN PACKAGE, 20° BEAM	INTEGRAL DIMMABLE DRIVER	277	27	LUMENPULSE LUMENBEAM MEDIUM SERIES
LF2	LED FLOOD	SURFACE	4000K, 1400 LUMEN PACKAGE, 40° BEAM	INTEGRAL DIMMABLE DRIVER	277	27	LUMENPULSE LUMENBEAM MEDIUM SERIES
LU1	LED TASK LIGHT	SURFACE	4000K, 250 LUMEN LED PACKAGE	INTEGRAL DRIVER	120	7W/FT	ALKCO ARIS SERIES

*Note: Luminaires on plan with E at end of type indicate emergency luminaires.

Finishes & Glazing

The majority of the area of the walls in the rock wall area is finished with eggshell paint on gypsum wall board. The surfaces that aren't are the glazing in the northwest corner and the rock wall itself. The glazing is aluminum curtain wall with the same glass as the rest of the building. The color of the rock wall is to be selected by the architect after mock-ups.

TYPE	DESCRIPTION	MANUFACTURER	COLOR	REFLECTANCE
METAL CEILING	METAL CEILING	HUNTER DOUGLAS	METALLIC SILVER	0.60
PAINT	FLAT FINISH	DUNN EDWARDS	EGGSHELL	0.70
SPORT FLOOR	SPECTRAPOUR	SPECTRATURF	BLUE-GRAY	0.25
CLIMBING WALL	CLIMBING WALL	ENTRE PRISES USA	SELECTED BY ARCHITECT	0.50

TYPE	T _{vis}	U _{winter}	U _{summer}	SHGC	SC
PPG SOLARBAN XL70	0.658	0.28	0.26	0.28	0.32

Design Criteria

The design criteria for this space come from recommendations from the Illuminating Engineering Society Tenth Edition Lighting Handbook and Title 24. Specific design criteria are listed below in order of importance.

Lighting Power Density

Title 24 requires that all spaces comply with lighting power density requirements. These requirements are the most important to meet because they are code requirements and the building cannot be occupied without complying. The applicable lighting power density is specified in the table below.

Description	Allowance
Exercise Center, Gymnasium	1.0 W/SF

Controls

Title 24 specifies that indoor spaces must have certain lighting controls. This ensures that energy is being saved when the lighting is not needed. A list of control requirements can be seen below.

- The general lighting of any enclosed space 100 square feet or larger that has a connected load of 0.8 watts per square foot or larger must have multi-level controls with at least one step between 30 and 70 percent of design load.
- Luminaires in the primary sidelit area must have at least one control that controls at least 50 percent general lighting power in that area separately from the rest of the lighting.
- All spaces must have a device to automatically shut off luminaires.

Illuminance

The IES Tenth Edition Lighting Handbook provides illuminance recommendations for all types of spaces of a building. While these recommendations are not required by code, they should be used as a guideline because safety is important in this space. Climbers need to be able to see handholds and footholds easily so they do not slip and injure themselves on the climbing wall. IES recommendations are summarized in the table below.

Space	E_h (lux)	E_v (lux)
General Activities	150	50

Uniformity

The IES Tenth Edition Lighting Handbook also provides illuminance uniformity recommendations for outdoor spaces. It is important to follow these criteria to provide a safe environment for patrons. IES recommendations are summarized in the table below.

Space	$E_{max}:E_{avg}$	$E_{h,avg}:E_{h,min}$	$E_{v,avg}:E_{v,min}$
General Activities	-	3:1	3:1

Glare

It is very important to minimize glare in this space because it can be dangerous to blind a climber while he or she is climbing. Even though the climber will be in a harness it is possible that he or she could be blinded and then misses a handhold or foothold. This could pull a muscle or cause another type of injury.

Sustainability

This project is striving to attain a LEED Gold rating, but at minimum attain a LEED Silver rating. For this reason it is important to use efficient light sources.

Evaluation of Existing Lighting

The existing lighting does a very good job of meeting the design criteria for the space. The metal halide fixtures provide an average illuminance of 13.74 footcandles which is about 137 lux. This value is slightly below the target illuminance value but it is within ten percent of the target illuminance and this is a general rule of thumb used in most lighting design. The average vertical illuminance value of 29.90 footcandles on the climbing surface, however, exceeds the recommended illuminance value of 50 lux or about 5 footcandles. This value could be reduced but an excess is not the worst case scenario, as it provides extra illuminance and provides a safer environment. This space also uses light sources of two different correlated color temperatures. The metal halide luminaires use 3500K lamps while the theatrical fixtures produce light a 4000K. If these correlated color temperatures matched it would make the space more pleasant. One of the negative aspects to using metal halide fixtures in a space with daylighting is that the fixtures cannot be dimmed. If these fixtures were replaced and a daylight sensor were installed, the space could benefit from even greater energy savings. Below are renderings and pseudo color renderings of the space from AGI32.

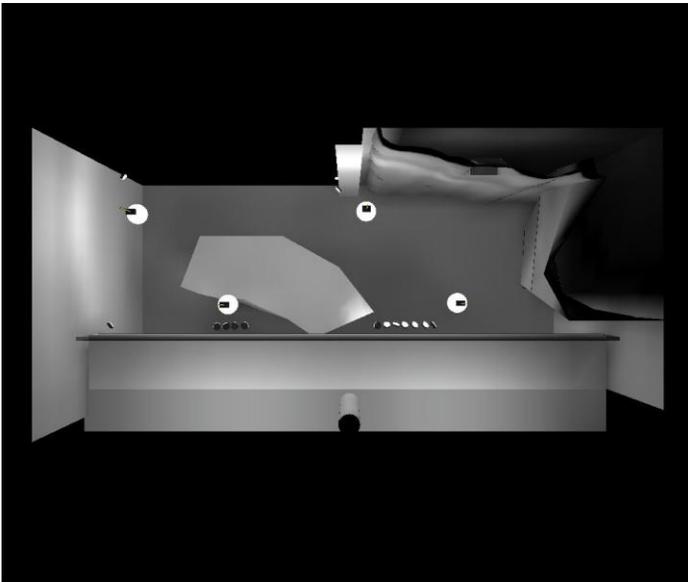


Figure 18: Top view rendering of rock wall space.

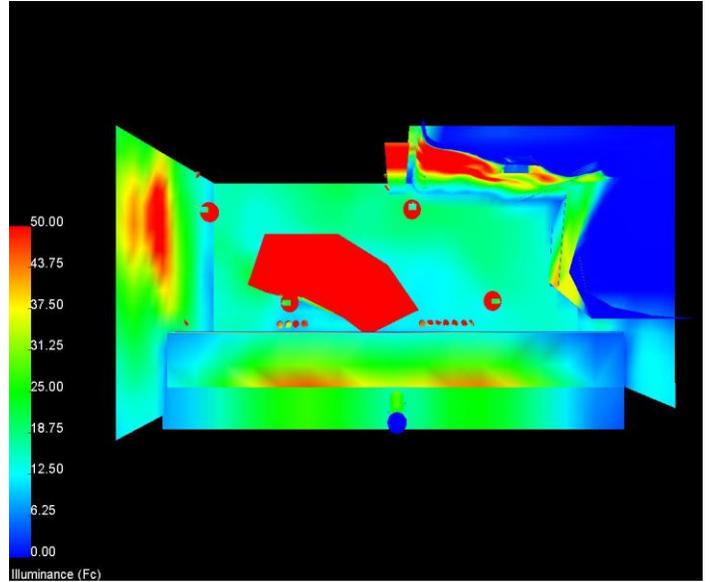


Figure 19: Top view pseudo color rendering of rock wall space.

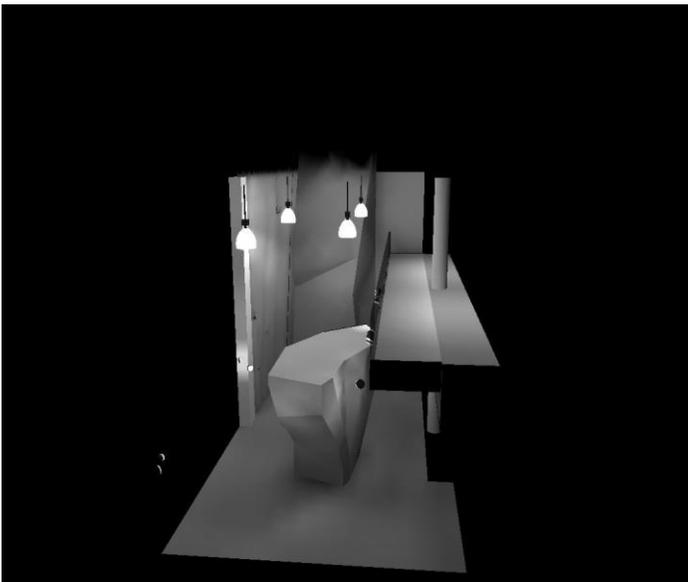


Figure 20: Rendering of rock wall space.

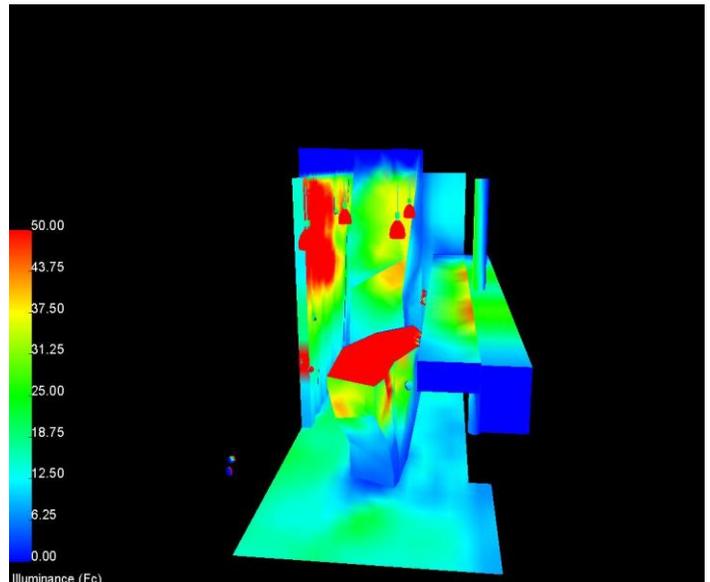


Figure 21: Pseudo color rendering of rock wall space.

Large Work Space: Gymnasium

The gymnasium is located in the northwest corner of the building. It is a double height space and is surrounded by corridors on the first level and an indoor running track on the second level.

Existing Conditions

- Area: 8230 sq ft
- Length: 104 ft
- Width: 80 ft
- Ceiling Height: 36 ft



The gymnasium will provide students with a space to play basketball and many other sports. The walls on the north side of the space on the first level are made of glass, keeping the open them throughout the building and allowing other occupants to view activities inside.

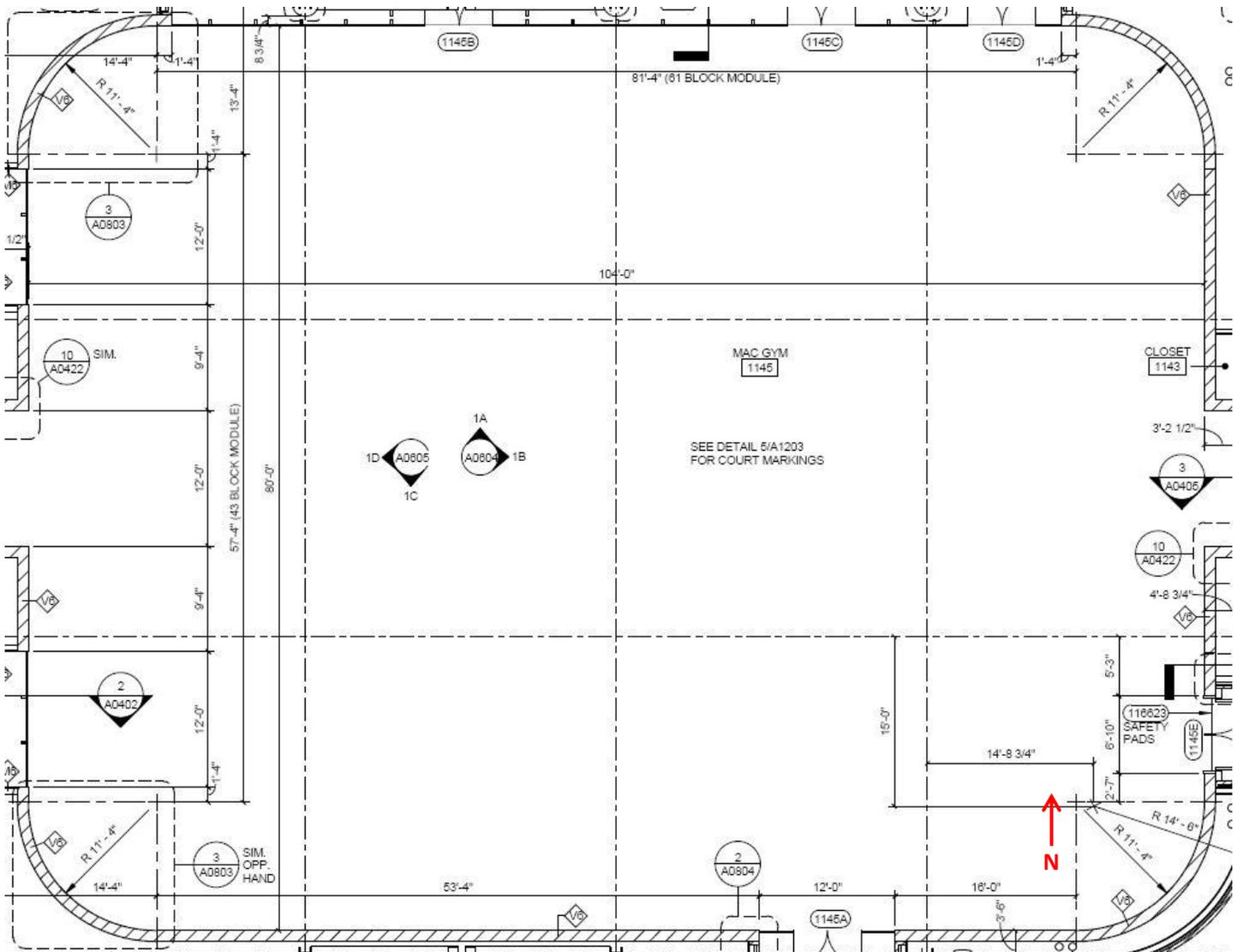


Figure 22: Gymnasium Floor Plan

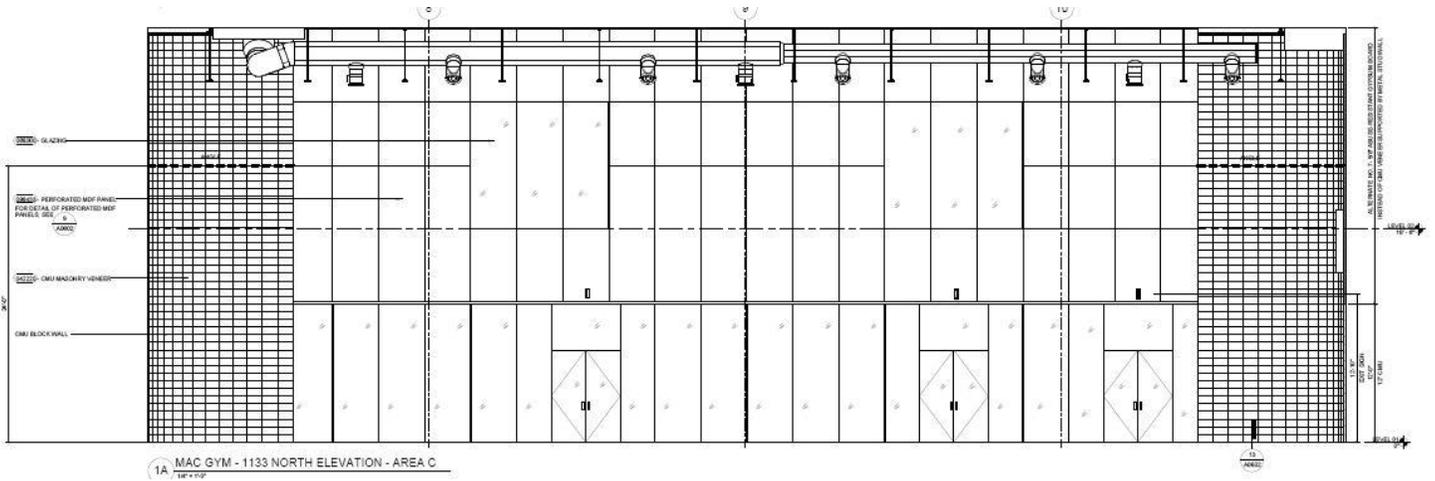


Figure 23: Gymnasium North Elevation

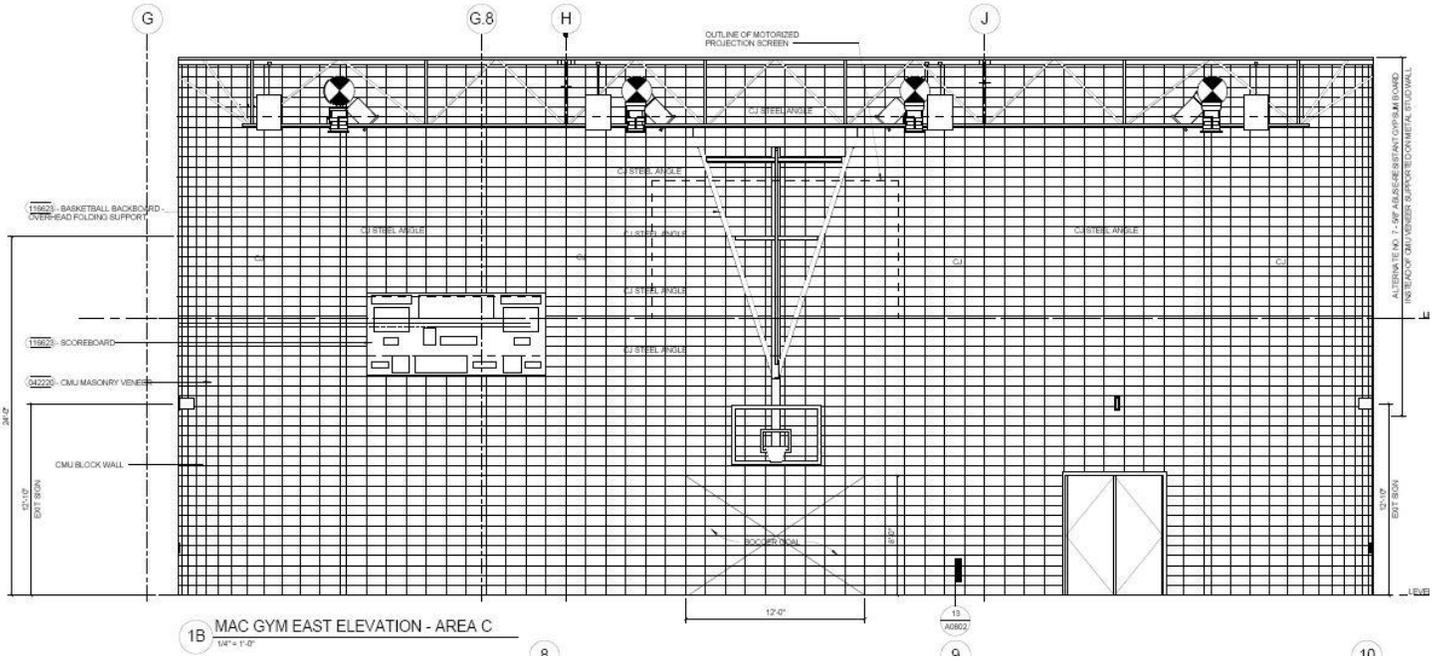


Figure 24: Gymnasium East Elevation

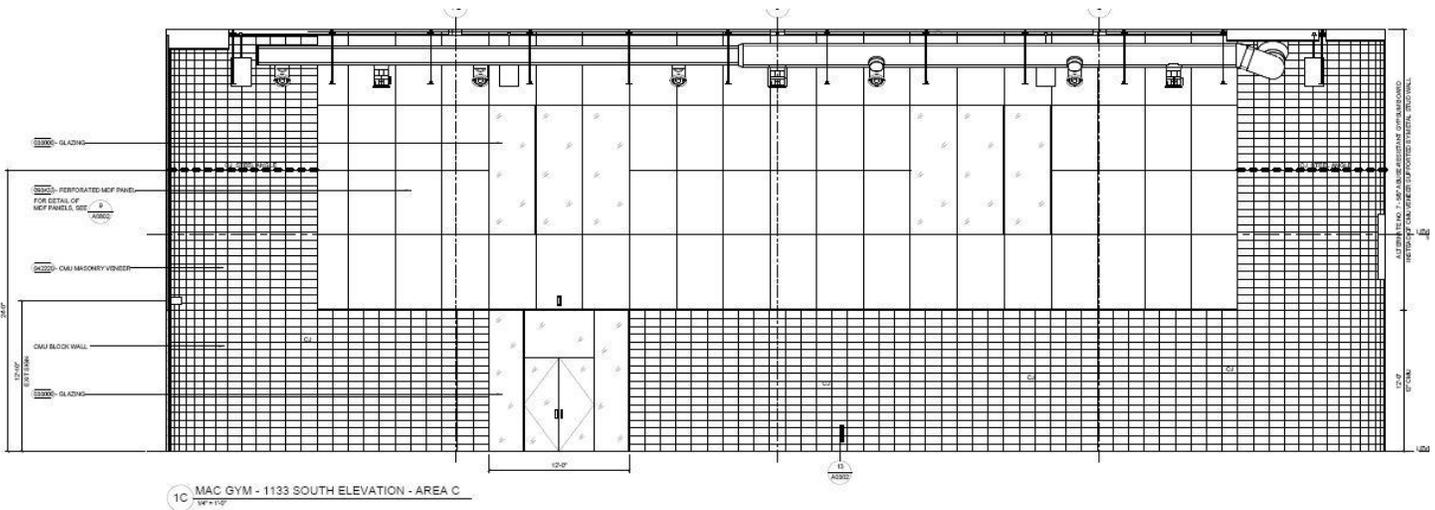


Figure 25: Gymnasium South Elevation

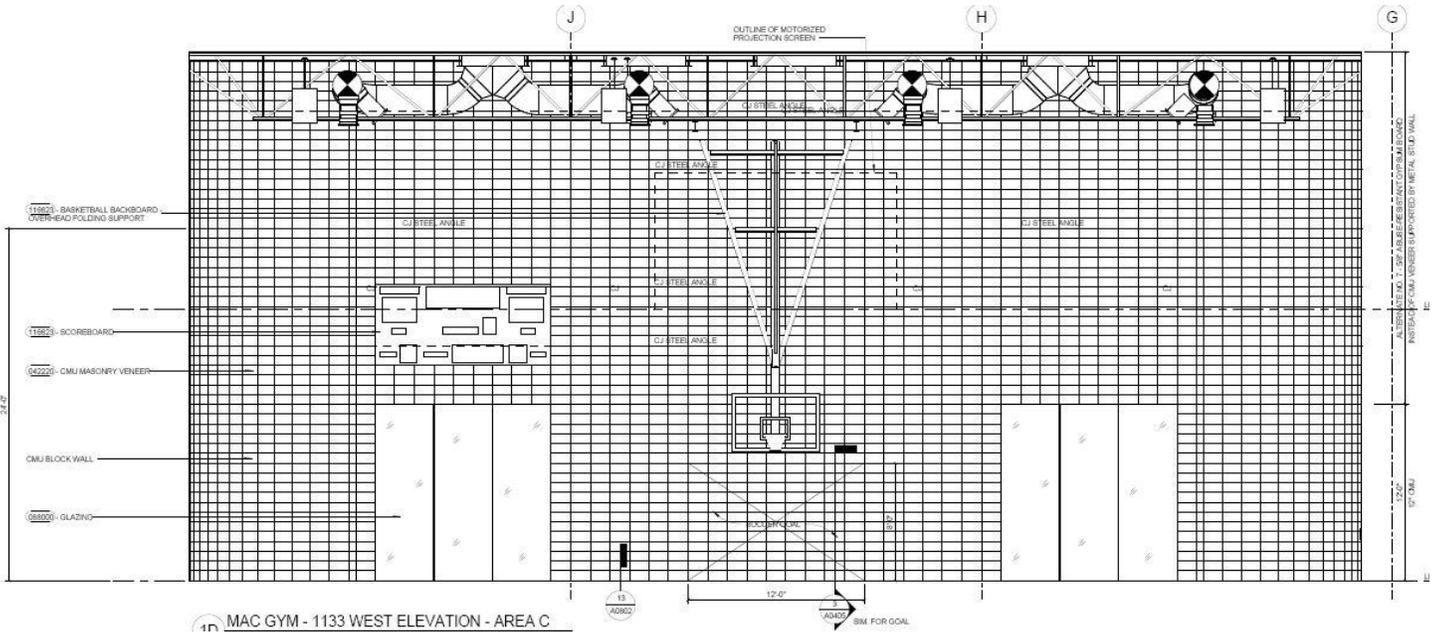


Figure 26: Gymnasium West Elevation

Lighting and Controls

The gymnasium is illuminated by the same metal halide luminaires that are used in the rock wall space for general illumination. These luminaires use 3000K metal halide lamps with a color rendering index of above 90 and are suspended twenty eight feet above the finished floor. The fixtures are grouped into two zones, controlled by two switches on the north wall. Keeping with the open floor plan, there is some glazing on the walls of the gymnasium, allowing light from the first and second floor to enter the space as well.

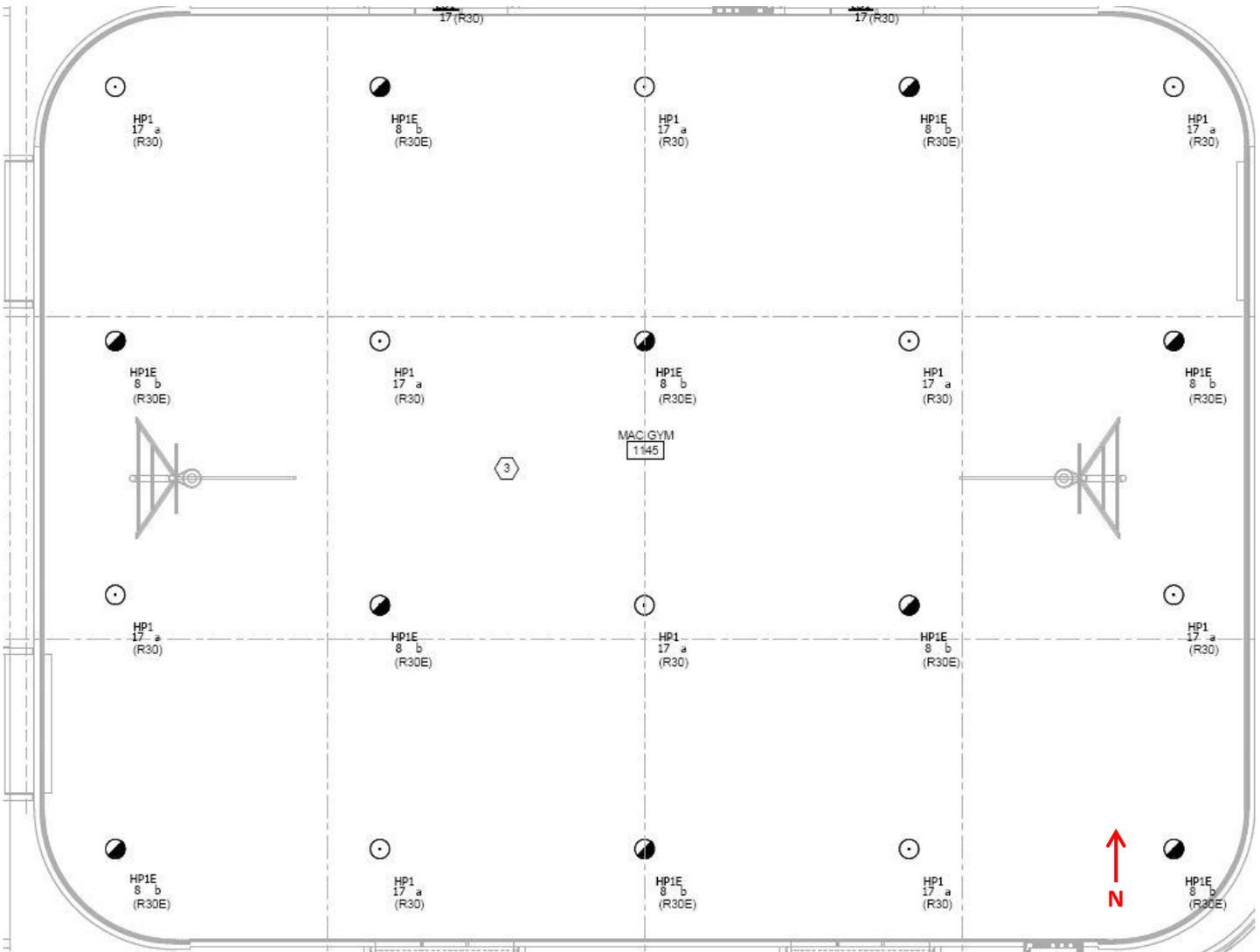


Figure 27: Gymnasium Lighting Plan

TYPE	DESCRIPTION	MOUNTING	LAMP	BALLAST	VOLTAGE	INPUT WATTS	MANUFACTURER
HP1	METAL HALIDE INDUSTRIAL PENDANT	SUSPENDED	(1) 315W MH	HIGH EFFICIENCY ELECTRONIC	277	341	HOLOPHANE ENDURATRON SERIES

*Note: Luminaires on plan with E at end of type indicate emergency luminaires.

Finishes & Glazing

While the walls of the gymnasium are comprised of multiple materials, the ceiling and floor are uniform. The ceiling is painted with a flat white paint in order to have a high reflectance. The floor is finished wood athletic flooring made of maple. The lower portion of the north wall is the same interior flat glass that is used throughout the rest of the building. To the left and right of the glazing are concrete masonry units and above it are acoustic wall panels with two smaller windows of glazing. The south wall has the same glazing and acoustic wall panel configuration on the upper portion of the wall while the lower portion is made up of concrete masonry units. The east and west walls are completely made up of concrete masonry units.

TYPE	DESCRIPTION	MANUFACTURER	COLOR	REFLECTANCE
ACOUSTIC WALL PANEL	PERFORATED INTEGRAL COLOR MDF PANELS	INTERLAM	BROWN	0.10
CONCRETE MASONRY UNIT	WHITE CONCRETE MASONRY UNIT	ANGELUS	GLACIER WHITE	0.65
PAINT	FLAT FINISH	DUNN EDWARDS	WHITE	0.90
FLOORING	WOOD ATHLETIC FLOORING	CONNOR	MAPLE	0.30

TYPE	T_{vis}	U_{winter}	U_{summer}	SHGC	SC
FLAT GLASS	0.80	-	-	-	-

Design Criteria

The design criteria for this space come from recommendations from the Illuminating Engineering Society Tenth Edition Lighting Handbook and Title 24. Specific design criteria are listed below in order of importance.

Lighting Power Density

Title 24 requires that all outdoor spaces comply with lighting power density requirements. These requirements are the most important to meet because they are code requirements and the building cannot be occupied without complying. The applicable lighting power density is specified in the table below.

Description	Allowance
Exercise Center, Gymnasium	1.0 W/SF

Controls

Title 24 specifies that indoor spaces must have certain lighting controls. This ensures that energy is being saved when the lighting is not needed. A list of control requirements can be seen below.

- The general lighting of any enclosed space 100 square feet or larger that has a connected load of 0.8 watts per square foot or larger must have multi-level controls with at least one step between 30 and 70 percent of design load.
- All spaces must have a device to automatically shut off luminaires.

Illuminance

The IES Tenth Edition Lighting Handbook provides illuminance recommendations for space where occupants play sports. While these recommendations are not required by code, they should be followed so that adequate light is provided in the space. IES recommendations are summarized in the table below.

Space	E_h (lux)	E_v (lux)
General Activities	150	50

Uniformity

The IES Tenth Edition Lighting Handbook also provides illuminance uniformity recommendations. These recommendations are not required by code but should be followed to provide a comfortable space for the occupants. IES recommendations are summarized in the table below.

Space	$E_{max}:E_{avg}$	$E_{h,avg}:E_{h,min}$	$E_{v,avg}:E_{v,min}$
General Activities	-	3:1	3:1

Sustainability

This project is striving to attain a LEED Gold rating, but at minimum attain a LEED Silver rating. For this reason it is important to use efficient light sources.

Evaluation of Existing Lighting

The current lighting system provides adequate illumination for the tasks being performed in the space. The target illuminance for the current lighting system is 50 footcandles, or about 500 lux. The average illuminance in the space is 45.31 footcandles and is within ten percent of the target illuminance. However, if only the points on the actual playing surface are taken into account, the average illuminance is 49.81 footcandles. This value is much closer to the target value of 50 footcandles and will be where the players are actually competing, which is the primary purpose for the space. The system uses metal halide lamps which are very efficacious but are not able to be dimmed. This space meets code by having two zones that can be switched independently from each other. Renderings of the space can be seen below.

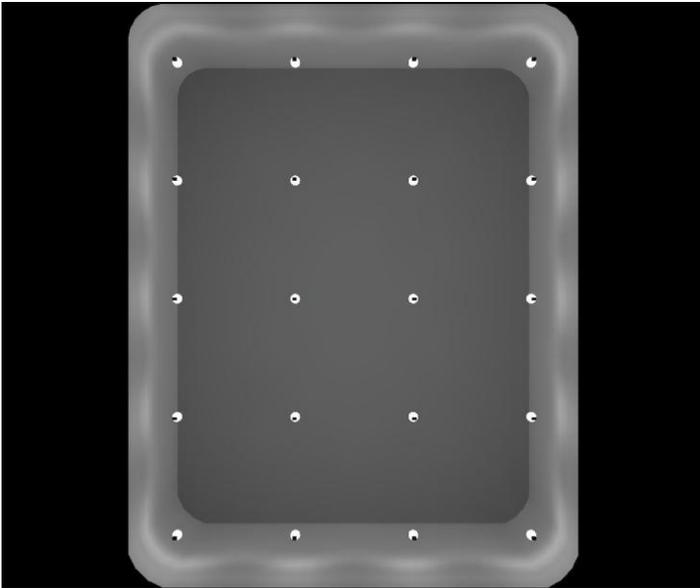


Figure 28: Top view rendering of gymnasium.

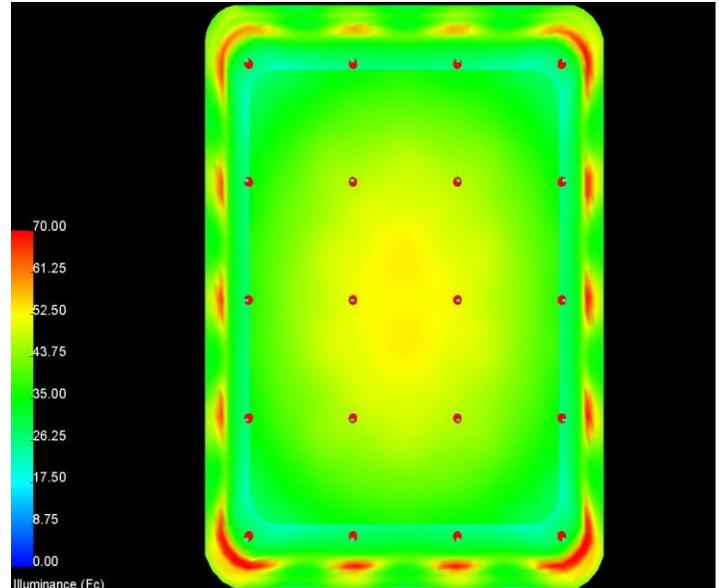


Figure 29: Top view pseudo color rendering of gymnasium.

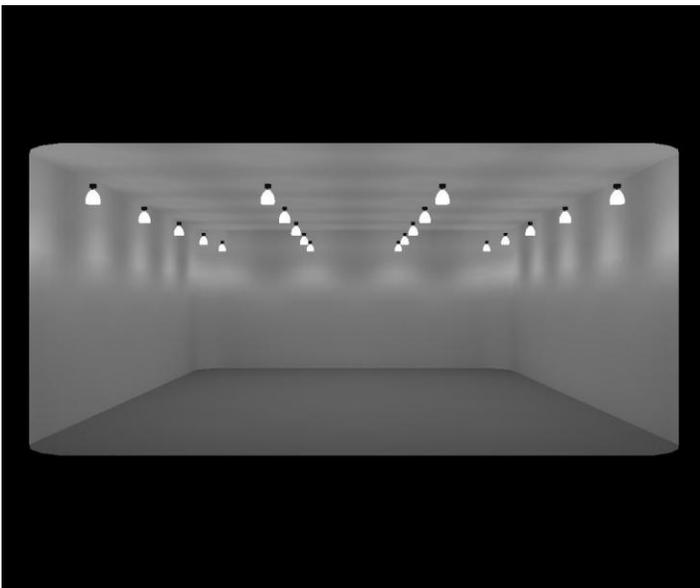


Figure 20: Rendering of gymnasium.

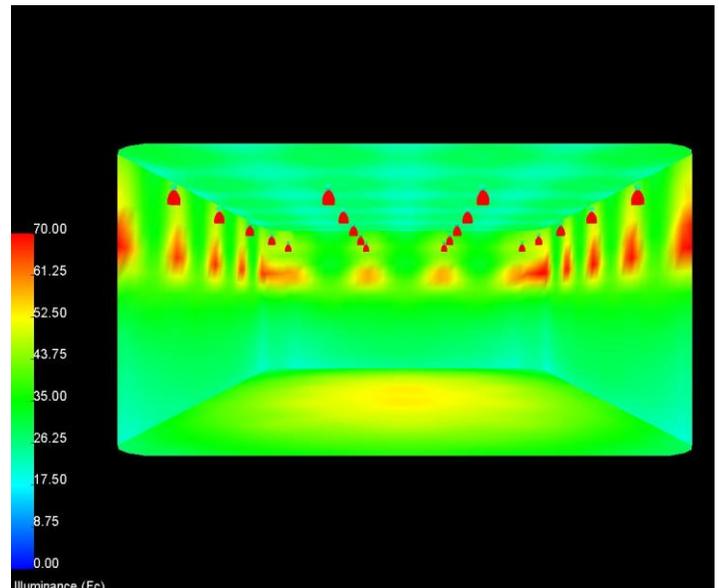


Figure 21: Pseudo color rendering of gymnasium.