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EXECUTIVE SUMMARY

My senior thesis is based on analysis of the James J. Whalen Center for Music at Ithaca College in Ithaca, NY. I selected this building after researching several projects designed by HOLT Architects and other regional design firms. This building first intrigued me with the unique way which designers fused a new steel framed building to a monstrous concrete auditorium. Also, through my five years at Penn State I have been a member of the Penn State Glee Club, and in high school I performed in several instrumental ensembles and appeared in school musicals. I love music, and I jumped at the opportunity to examine a facility designed for the creation of music. I was able to visit the building twice, which is about 40 miles from my hometown in Elmira, NY. During my visits I was able to get a feel for the music program at Ithaca College and the overall attitude of the facility.

For this thesis I am analyzing four spaces from the Whalen Center; the façade where the Whalen Center and the existing Ford Hall connect, the large instrumental rehearsal room, the Hockett Recital Hall, and the two level corridor on the south end of the facility. For each of these spaces, design criteria will be established, and a complete lighting design will be developed, documented and analyzed. This thesis also contains the analysis and redesign of a portion of the emergency power system.

In the large instrumental rehearsal space, skylights were added as part of the lighting design. The addition of roof penetrations will affect the structural design of this space. An analysis and redesign of the roof structure to reflect the addition of the skylights is included in this thesis. Also, the addition of glazing in an instrumental rehearsal room may have adverse effects on the acoustic quality of the space. This thesis includes an analysis of reverberation times in this space before and after the addition of the skylights.

This thesis represents much of what I have learned through my five years at Penn State and my time in the Department of Architectural Engineering. Yet there is much that I have learned, through my friends, through my professors, and through my experiences, that simply cannot be translated onto paper.

INTRODUCTION

PROJECT STATISTICS

Building Name

– James J. Whalen Center for Music

Location and Site

– Ithaca College, Ithaca, NY, Addition to existing Ford Hall

Building Occupant Name

– Ithaca College School of Music

Magnitude

– Four stories plus elevated pedestrian walkway to parking area, 69,000 sf

Primary Project Team

– Architect and PM

HOLT Architects P.C., Ithaca, NY, www.holt.com

– General Contractor

Welliver McGuire, Inc., Elmira, NY, www.welliver-mcguire.com

– Electrical/Mechanical Engineer

M/E Engineering P.C., Rochester, NY, www.meengineering.com

– Structural Engineer

Ryan-Biggs Associates. Skaneateles, NY, www.ryanbiggs.com

– Owner

Ithaca College, Physical Plant, Ithaca, NY, www.ithaca.edu

Dates of Construction

– December 1997 to August 1999

Cost Information

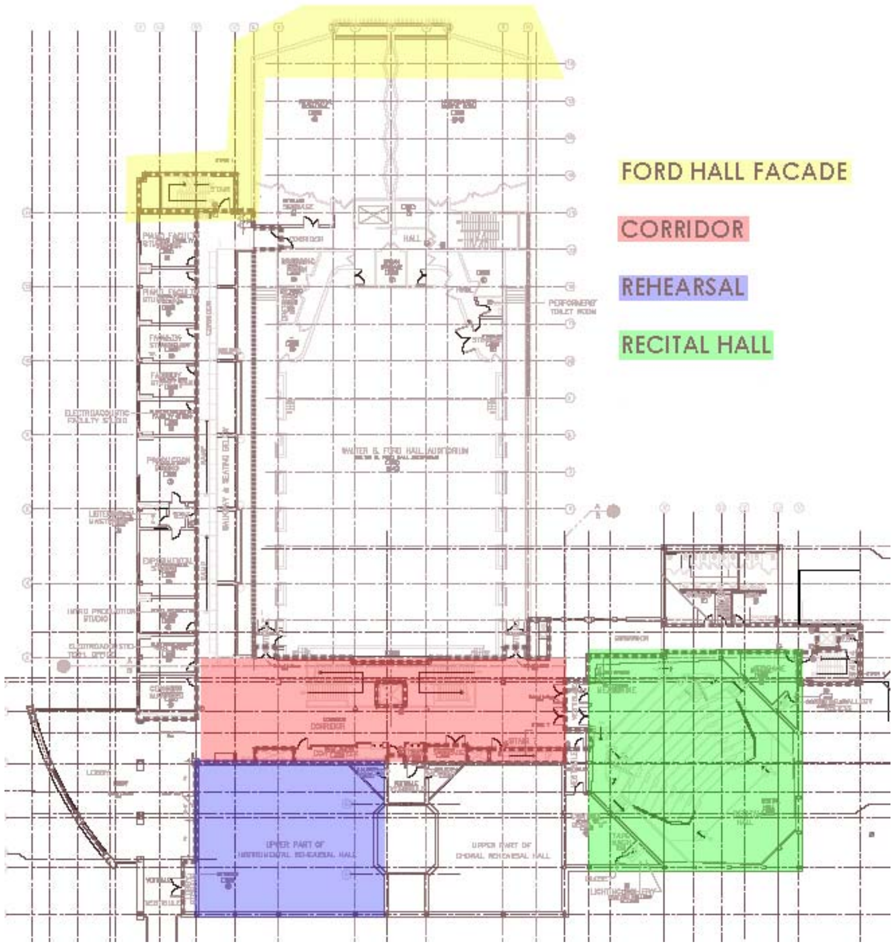
– $11.5 million total construction cost, $4 million M/E contract cost

Project Delivery Method

– Design-Bid-Build

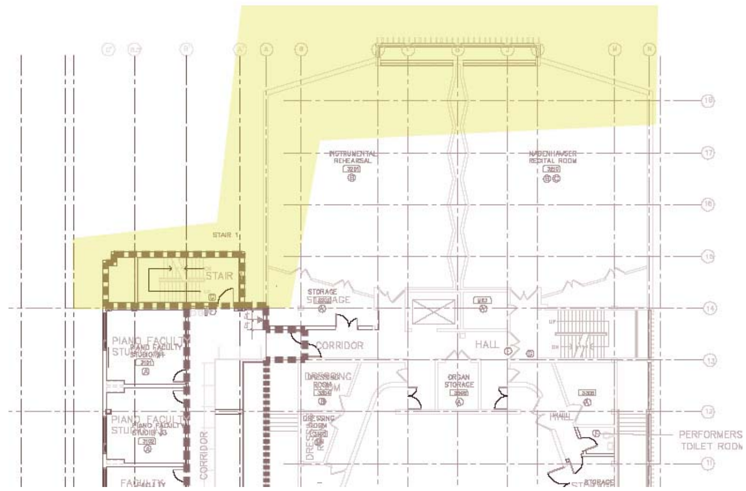
BUILDING INFORMATION

The James J. Whalen Center for Music is a 69,000 sf addition to the 1964 Ford Hall, on the south side of the Ithaca College campus in Ithaca, NY. The building is named for the sixth president of Ithaca College, James J. Whalen, who passed away in 2001. The building is designed to be an all-in-one home for the School of Music at Ithaca College. The college was initially founded in 1867 as the 'Ithaca Conservatory of Music' and the music program remains the staple of the Ithaca College campus. The new facility contains 30 new faculty studios, a 250-seat recital hall, designed primarily for solo and chamber music recitals, choral and jazz rehearsal rooms, a professionally equipped recording studio that will also serve as a laboratory/ classroom for a new major in audio recording, an electroacoustic music suite, a music education resource center with an attached observation room for student teacher preparation, a music technology classroom and laboratory, a user-friendly library for the ensemble music collection, and a covered walkway from the upper parking lot that will provide easier access to concerts and recitals. Parts of the existing Ford Hall were also renovated including a redesign of the front and west entrances that will eliminate obstructions for people with disabilities.


FORD HALL FACADE
CORRIDOR
REHEARSAL
RECITAL HALL

EXTERIOR

DESIGN GOALS



concrete façade ρ=.4

medium brick façade ρ=.3

The north façade of the Whalen Center is where the new construction interfaces with the weathered concrete face of Ford Hall. There is great potential for this façade along the campus mall to be the main visual icon for the School of Music. The lighting design for this exterior space should reinforce the strength and stability of the School of Music, and the strength and stability of Ithaca College as a whole. The building should present a well grounded, serious, powerful attitude while remaining attractive and easily identifiable. On performance nights the facility should have the ability to come alive and draw students, faculty, and visitors to the building. The implementation of color and motion will surely achieve the goal of attracting patrons, yet caution should be taken in the application of color and motion. This building is part of a college campus, and therefore has a responsibility to respect the architectural context of its surroundings.

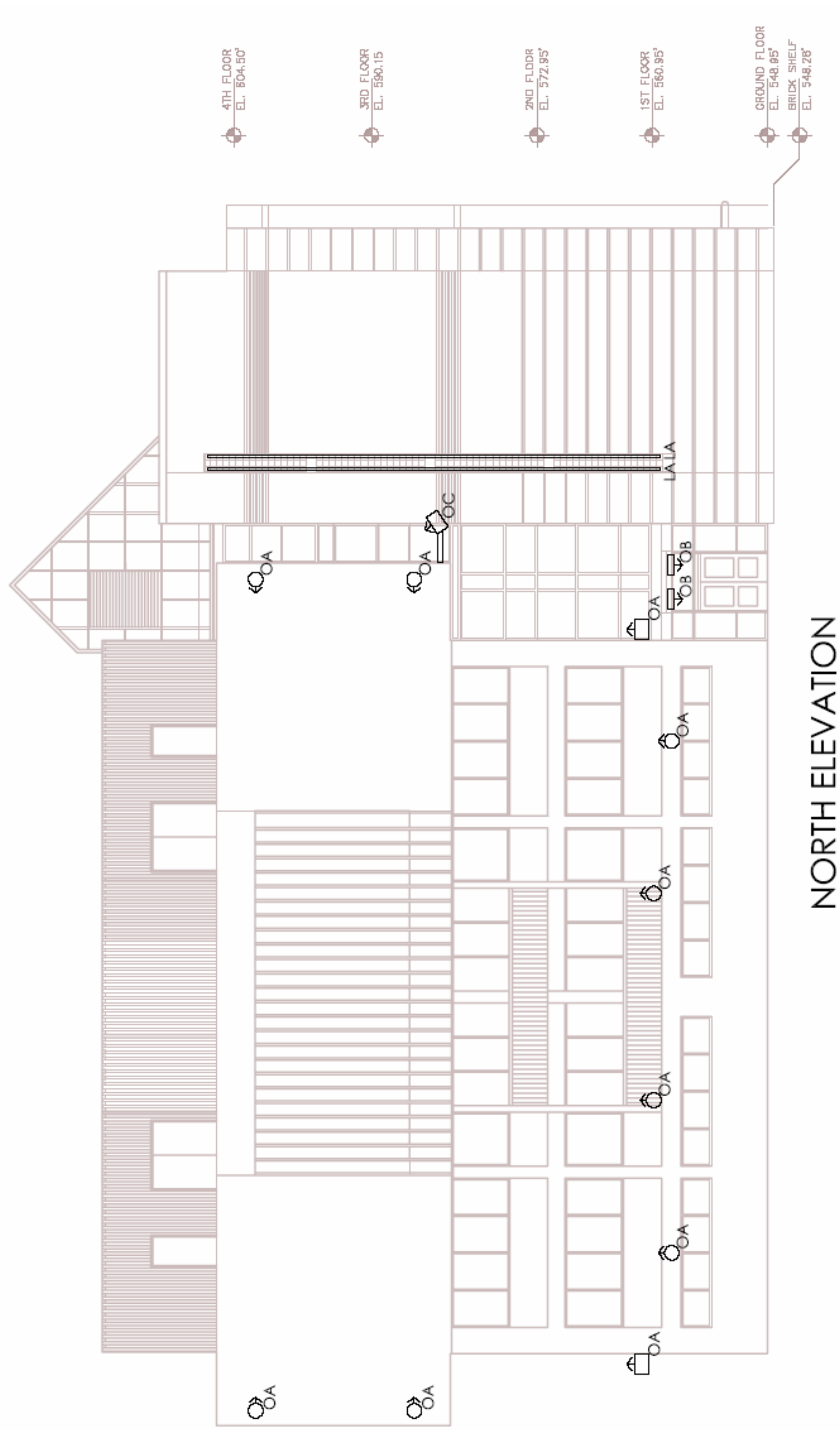
DESIGN SCHEMATIC

The Ford Hall façade will primarily be lit using the VSI luminaire (type OA) from BEGA. (www.bega-us.com) This luminaire is designed to evenly illuminate the surface on which it is mounted. Eight of these luminaires will be mounted roughly at the first floor level with the distribution pointed upwards. Four of these luminaires will be mounted on the high flat faces of the Ford façade pointing in towards the protruding balcony. Adjacent to the intersection of the new Whalen Center and the old Ford Hall, there is a stairway tower which runs the full four stories of the building. A unique architectural element of this stair tower is a 1'-10" wide glass block section in the exterior wall. Two 14.5 meter sections of VersaTUBE LED color changing luminaires (type LA) from Element Labs (www.elementlabs.com) will be placed behind the glass block insert. Subtle motion will be incorporated with the 30-bit color capability of the luminaires to further enhance visual attraction. Four glass-lens, surface mount luminaires (type OB) from BEGA will be mounted under a slightly sloped metal overhang that protects the entrance at the base of the stair tower. Finally, an asymmetric signlight (type OC) from Elliptipar (www.elliptipar.com) will be placed on the upper west wall of the Ford Hall façade which has raised metal lettering identifying the facility.

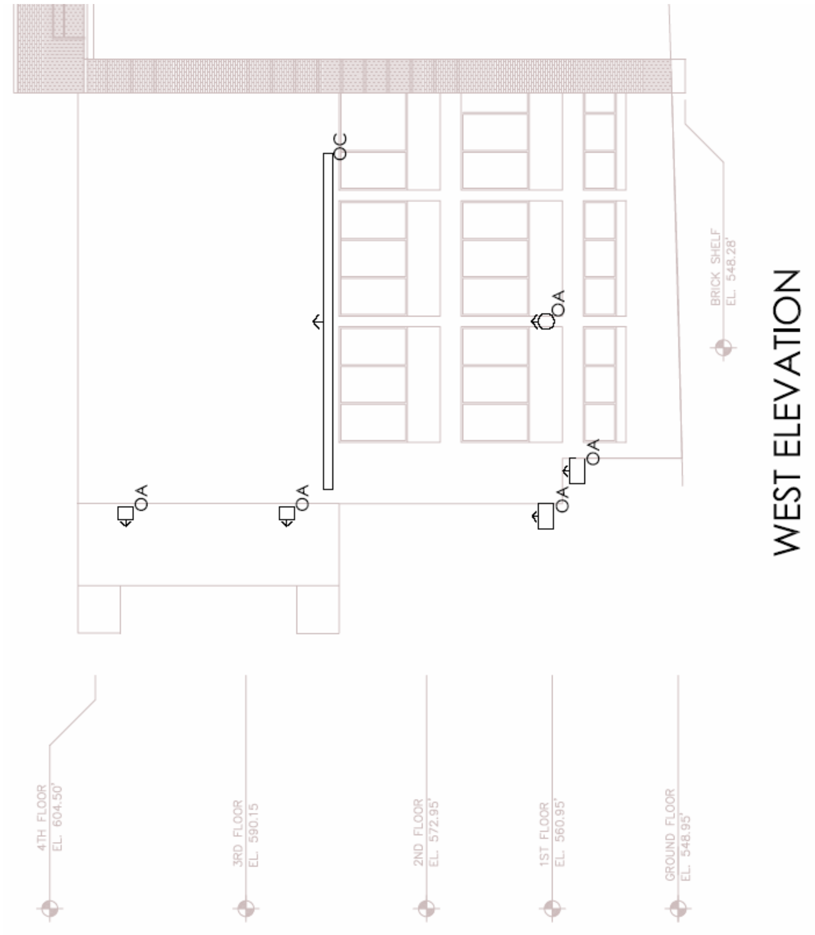
LIGHTING ANALYSIS

The rich hues of the color changing LED luminaires are distorted and diffused through the glass block and create a strong vertical element which will draw attention to the building and vertically down to the ground level entrance. The BEGA glass block luminaires create a bright and smooth pool of light at this entrance and help identify the entrance to the facility from the adjacent campus mall. The sharp photometric distribution of the VSI luminaires gives great detail with light and shadow, utilizing the geometry of the concrete structure of Ford Hall. Although the VSI is very effective at illuminating the surface on which it is mounted, there is still a significant amount of light that never reaches the vertical surface. This stray light is caught by the concrete overhang, giving a strong, dependable appearance to the facility.

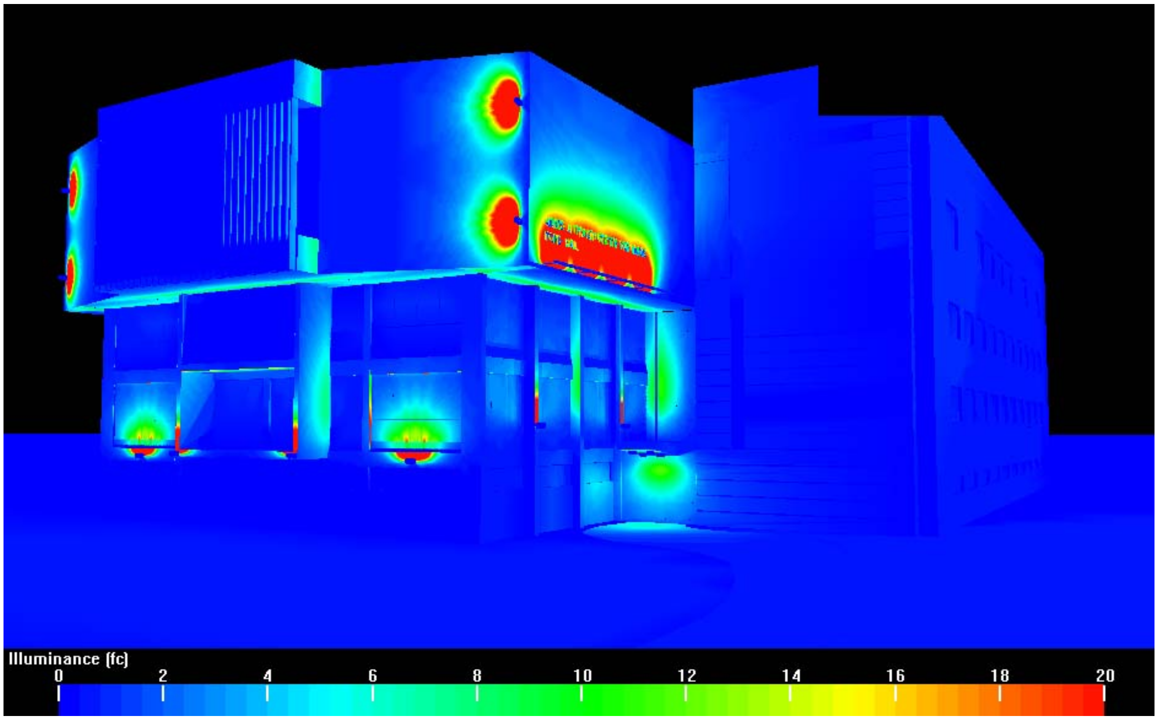
LIGHTING ELEVATION



LIGHTING ELEVATION



LIGHTING ANALYSIS



ASHRAE/IESNA 90.1-1999 Compliance

Façade Illumination (9.3.2)

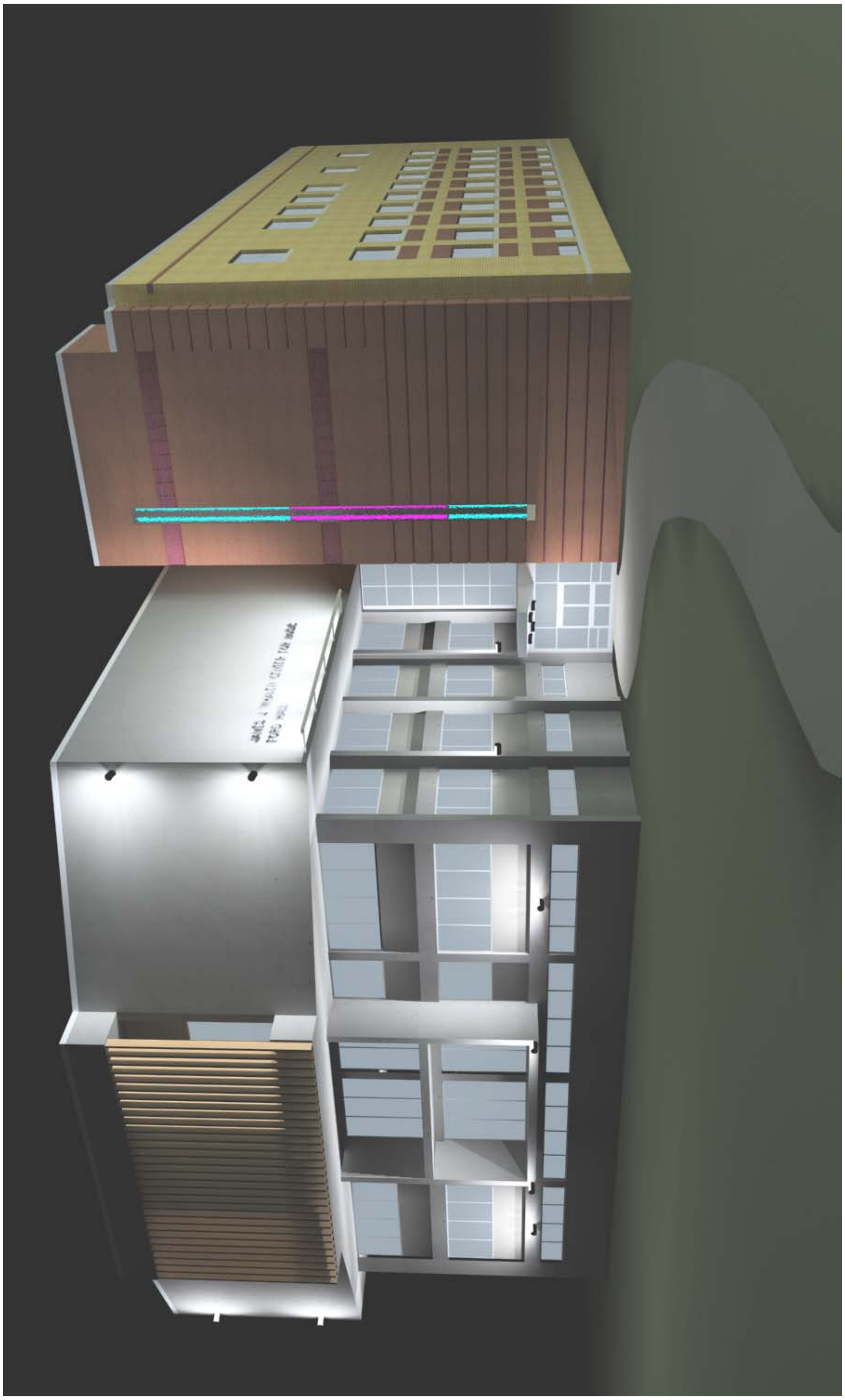
Area Illuminated	9500	sf
Allowed Density	0.25	W/sf
Allowed Wattage	2375	W
Luminaire Count	12	ea
Ballast Input Watts	185	W
Actual Wattage	2220	W
Actual Density	0.23	W/sf
% Difference	6.53	% Below 90.1

Canopied Illumination (9.3.2)

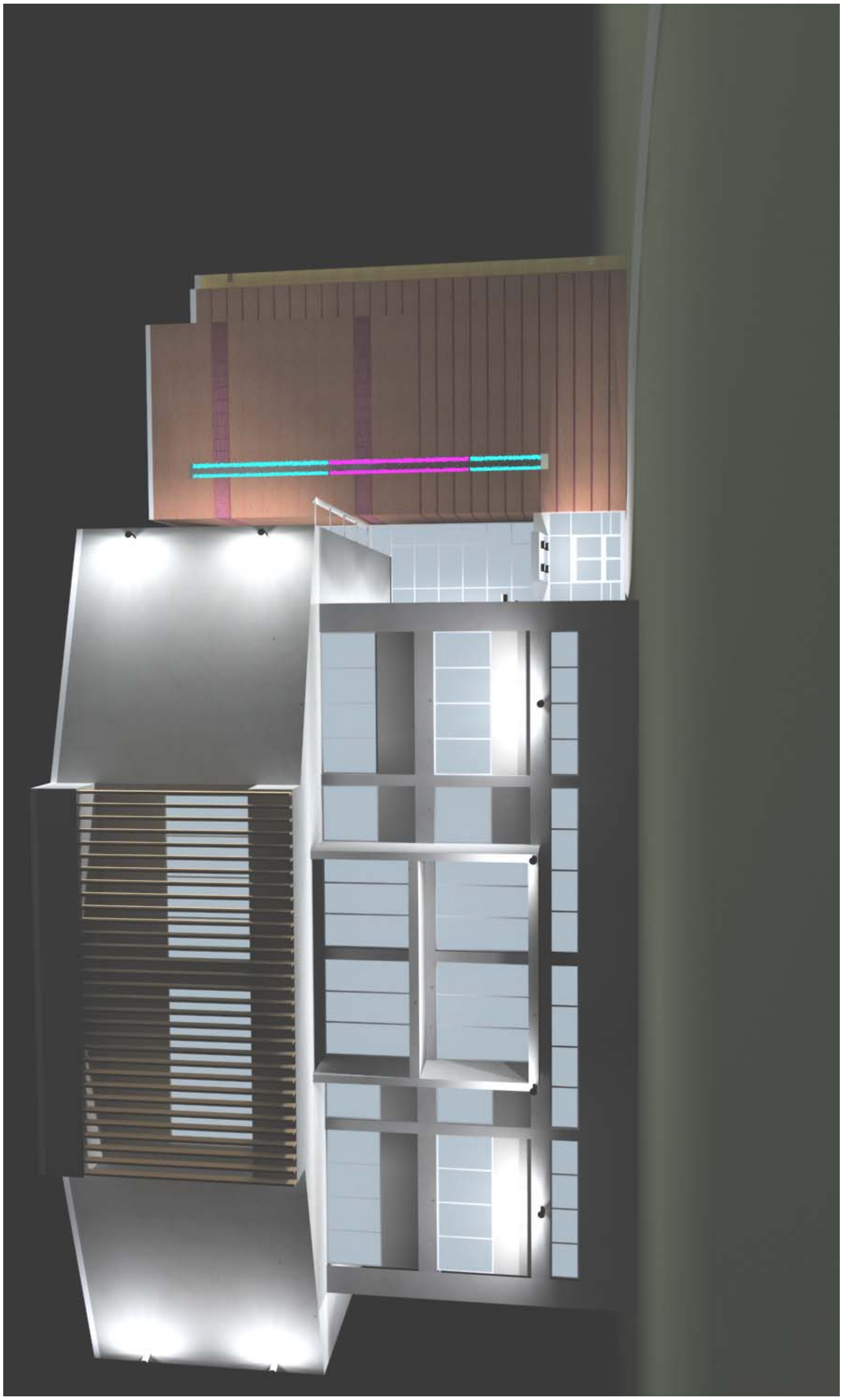
Canopy Area	48	sf
Allowed Density	3	W/sf
Allowed Wattage	144	W
Luminaire Count	4	ea
Ballast Input Watts	27	W
Actual Wattage	108	W
Actual Density	2.25	W/sf
% Difference	25.00	% Below 90.1

Advertising/Sign Lighting Exempt 9.2.3(c)

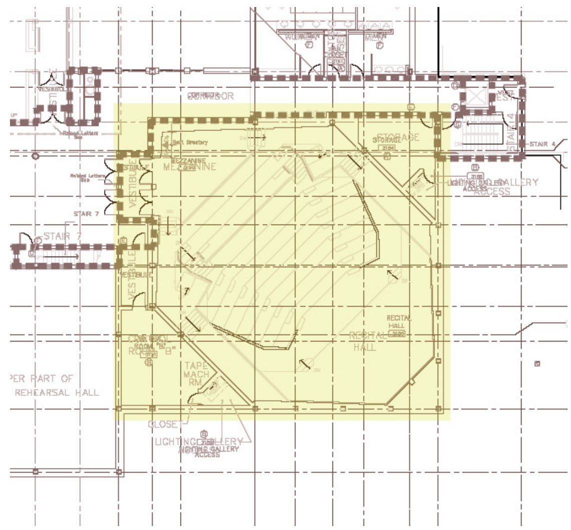
LIGHTING RENDERING



LIGHTING RENDERING



DESIGN GOALS



carpet ρ=.3 gray paint ρ=.5
wood paneling ρ=.4
painted gypsum ceiling ρ=.7

The Hockett Recital Hall is a key feature of the Whalen Center. The new 250 seat auditorium is intended as a supplement to the 1200 seat Ford Auditorium which the Whalen Center surrounds. The intent was to have a more intimate venue for performances by soloists and small ensembles. The dark wood panels surrounding the stage evoke a warm and calm feeling. The sloping white gypsum ceiling has a large air plenum in the center which is designed to avoid the noise associated with traditional HVAC air diffusers. The ceiling and upper walls are detailed with alternating gypsum panels recessed 4”. This is a design element which reduces direct sound reflections and scatters the sound through the space. A floating ‘acoustic cloud’ visually frames the stage and provides a mounting location for stage lighting. The architectural lighting in the recital hall should enhance the intimate feeling this space was intended for. Warm light sources and smooth luminance distributions will achieve this effect. The architectural lighting in this space must be dimmable in order to achieve the different appearances and transitions required in a professional performance venue. The recital hall will be used for student performances as well as workshops where there will be interaction between the performer and the audience. This requires that an illuminance of approximately 20 fc reach the audience seating level to support reading of program materials and for presenters to interact with the audience.

DESIGN SCHEMATIC

The functional light in the space will be provided by 100 W PAR-38 halogen infrared adjustable downlights (type IB) from Kurt Versen. (www.kurtversen.com) Nine of these luminaires will be mounted on each of the three panels suspended below the openings to the air plenum in the center of the ceiling. The fully adjustable and lockable assemblies will be aimed to give even distribution of illuminance across the audience seating area. Eight F28T5 striplights (type FE) from Columbia (www.columbialighting.com) will also be mounted on each suspended panel. The suspended panels will be connected to lowering equipment which will bring the panels down to the seating level for luminaire maintenance and relamping. Continuous rows of FE luminaires will also be placed along a decorative ledge approximately 4' below the wall/ceiling intersection. The FE luminaires will be fitted with dimming ballasts so they can be controlled with the house dimming system along with the IB luminaires.

LIGHTING ANALYSIS

The IB luminaires will provide easily adjustable amounts of task illuminance on the audience seating area. This will ensure patrons will safely find their way to their seats and be able to read the provided program materials. The warm color temperature and direct distribution will provide detailed facial rendering and add to the calm, almost residential feel sought in this space. The FE luminaires mounted on the suspended panels will enhance the depth and detail of the recessed air plenum and will help reduce the glare from the halogen downlights. The FE luminaires encircling the recital hall on the decorative ledge will throw a gradient of light on the ceiling and create bright surfaces and dark shadows in the details of the alternating recessed gypsum panels This lighting scheme will result in a professional, intimate space for students and faculty to exhibit their skills developed at Ithaca College.

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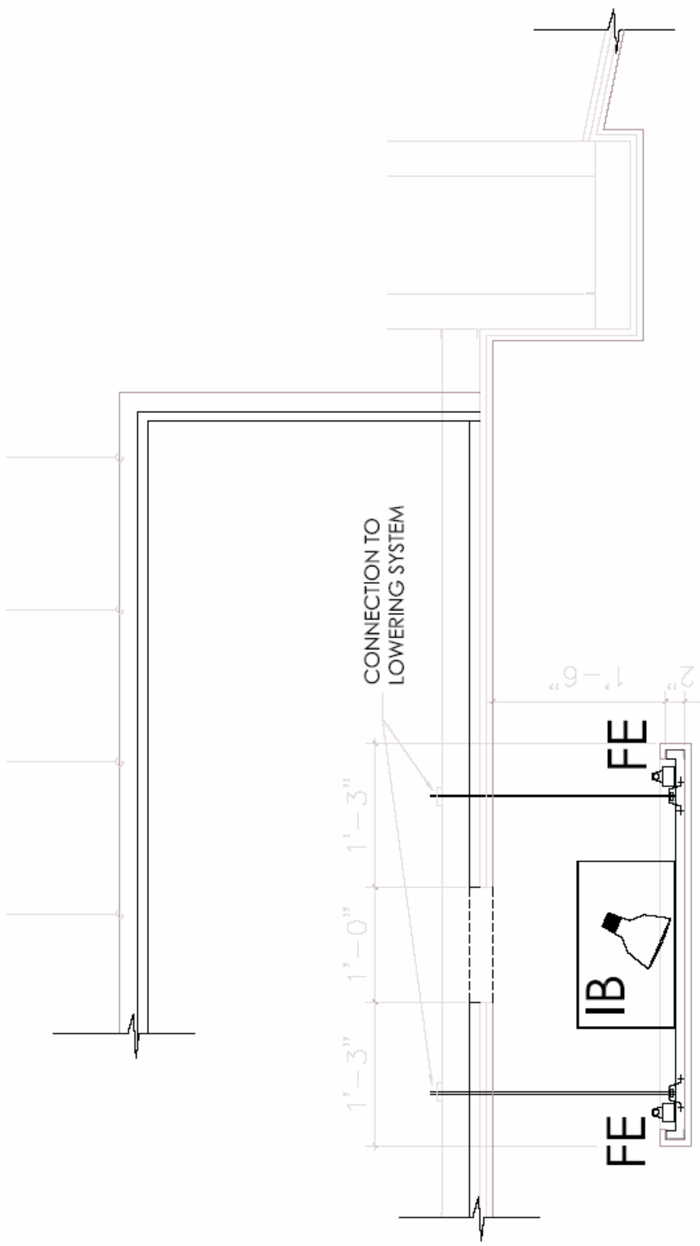
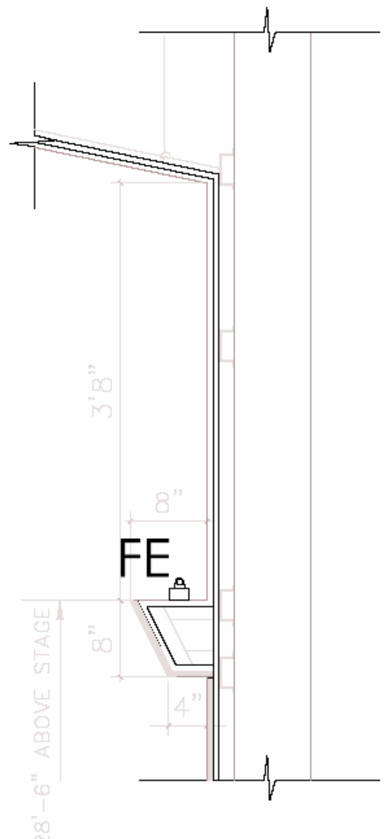
LIGHTING DETAIL



A) CEILING PLENUM DETAIL

LIGHTING DETAIL



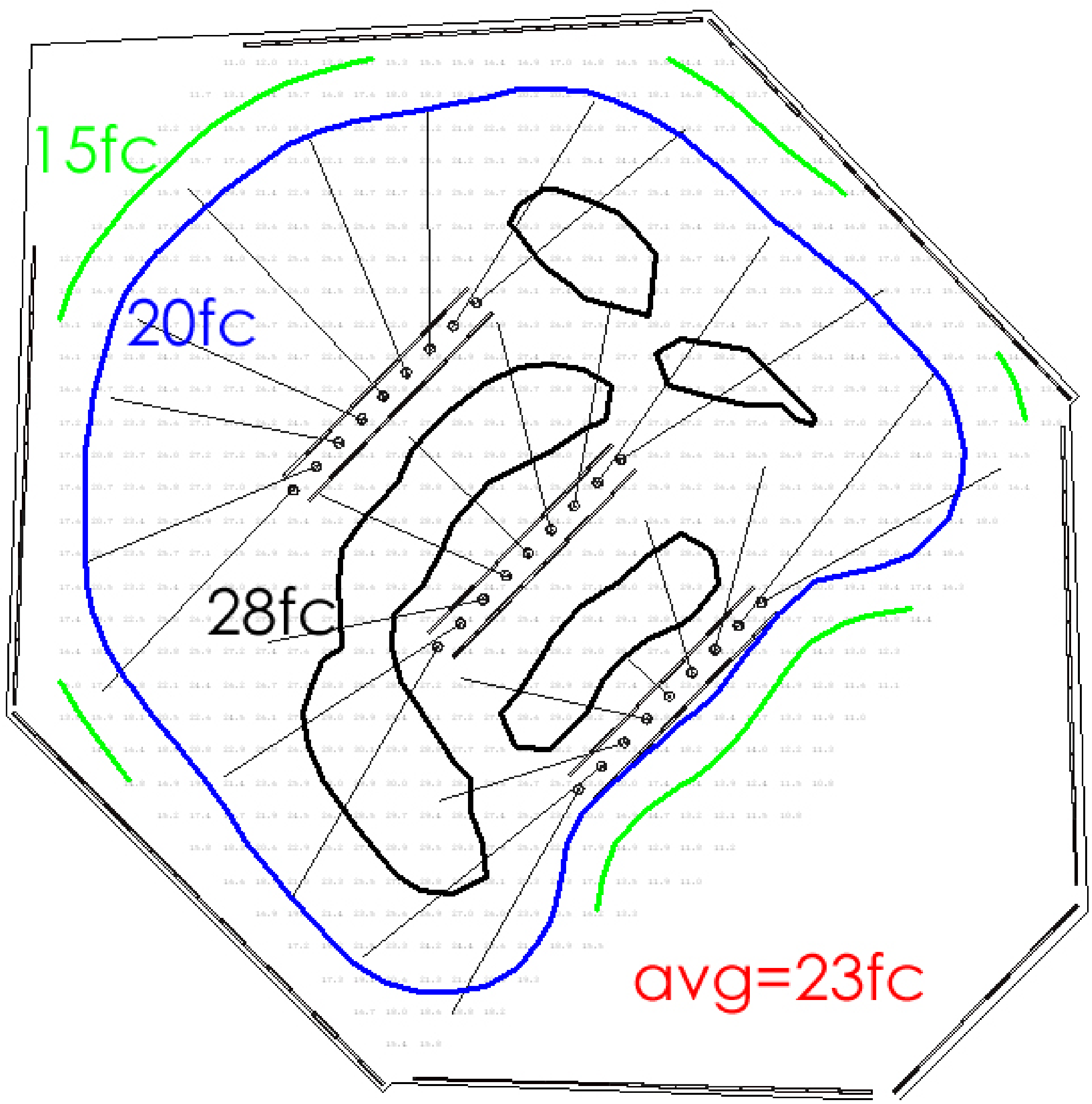
B) WALL LEDGE DETAIL

ASHRAE/IESNA 90.1-1999 Compliance

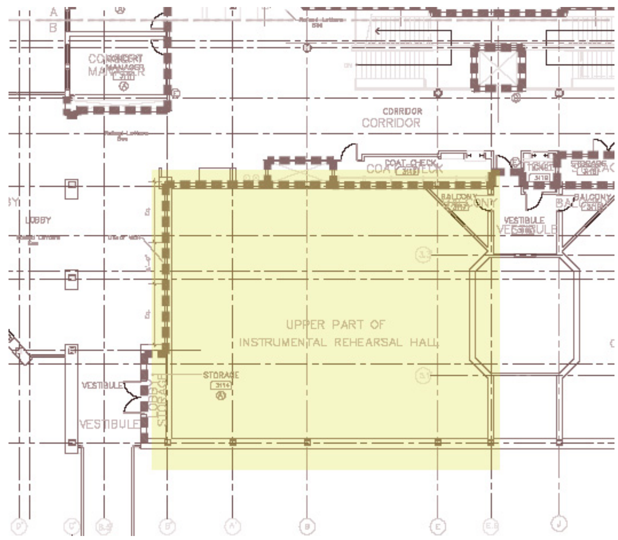
Performing Arts Center Audience Seating (9.3.1.2)

Room Area	3670	sf
Allowed Density	1.8	W/sf
Allowed Wattage	6606	W
Luminaire FE	72	ea
FB Input Watts	33	W
Luminaire IB	27	ea
FB Input Watts	100	W
Actual Wattage	5076	W
Actual Density	1.38	W/sf
% Difference	23.16	% Below 90.1

ILLUMINANCE CONTOUR



DESIGN GOALS



light wood floor ρ=.5

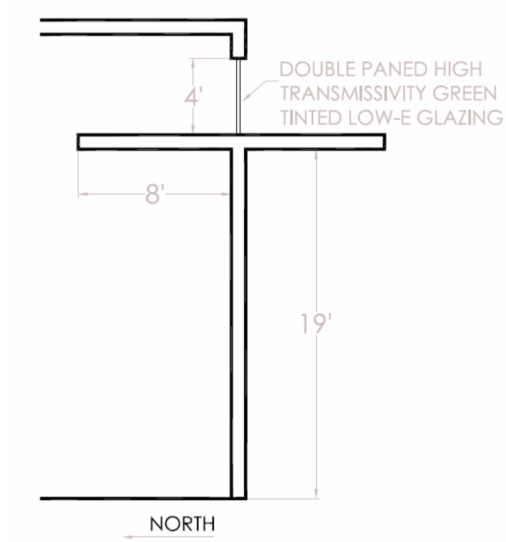
painted gypsum walls ρ=.7

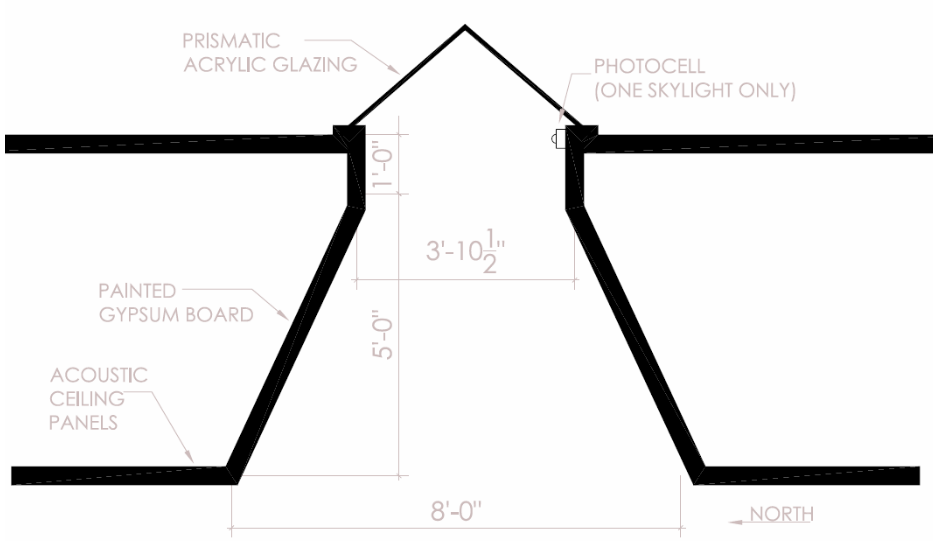
acoustic ceiling tiles ρ=.8

The large instrumental rehearsal room in the Whalen Center is a primarily functional space. During large ensemble rehearsals in this space it is important for the musicians to be able to read their music, and to see and clearly understand the visual direction provided by the conductor. The lighting system in this space must provide adequate levels of functional illuminance while preserving facial detail and color quality. A horizontal task plane illuminance of 30fc is sufficient considering the visual tasks and the average age and visual ability of the college students using this space. Since this space has an unobstructed south facing wall and a ceiling with no floor above it, the lighting design should attempt take advantage of the electric lighting energy savings and productivity enhancing potential of daylight. Yet direct sunlight is visually distracting and should be avoided. Automatic lighting controls that are both simple and flexible should be incorporated to take advantage of the daylighting system and to comply with ASHRAE automatic shutoff guidelines. There is an observation balcony in the northeast corner of the room and a audio recording studio on the east wall which has windows for observing the space. The lighting design for this room must preserve the views from both of these vantage points. Aesthetically, the lighting system needs to find a balance between sterile function and dramatic emotion. Like most spaces in the Whalen Center the appearance of this rehearsal space should not be overpowering. The mood of the room should be determined by the music being created, rather than by the lighting system.

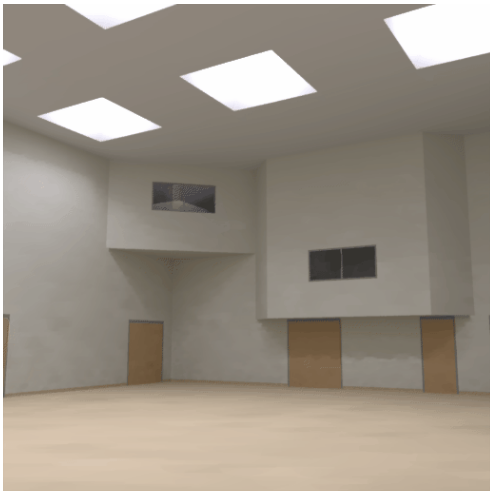
DESIGN COMPARISON

To develop a lighting design appropriate for this space, two distinct systems will be compared, and one of these designs will be selected and fully developed. One system to be compared will incorporate a continuous lightshelf along the south wall of the space, coupled with dimmable semi-direct linear fluorescent pendants (type FF) from Litecontrol. (www.litecontrol.com) The lightshelf is solid, and the top surface is a specular material. The interior overhang of the lightshelf is designed to eliminate any penetration of direct sunlight to the task plane. Three continuous rows of FF luminaires will be suspended at 12' AFF in the east/west direction. The second system for comparison includes nine splayed skylights arranged symmetrically in the ceiling of the rehearsal room. Each skylight will have a diffuse glazing area of 4'x4' and will splay out to 8'x8' as it travels through the 6' plenum. These skylights will be paired with electric lighting by compact fluorescent downlight pendants (type FA) by ERCO (www.erco.com) placed in a symmetrical 8' OC array, 12' AFF.





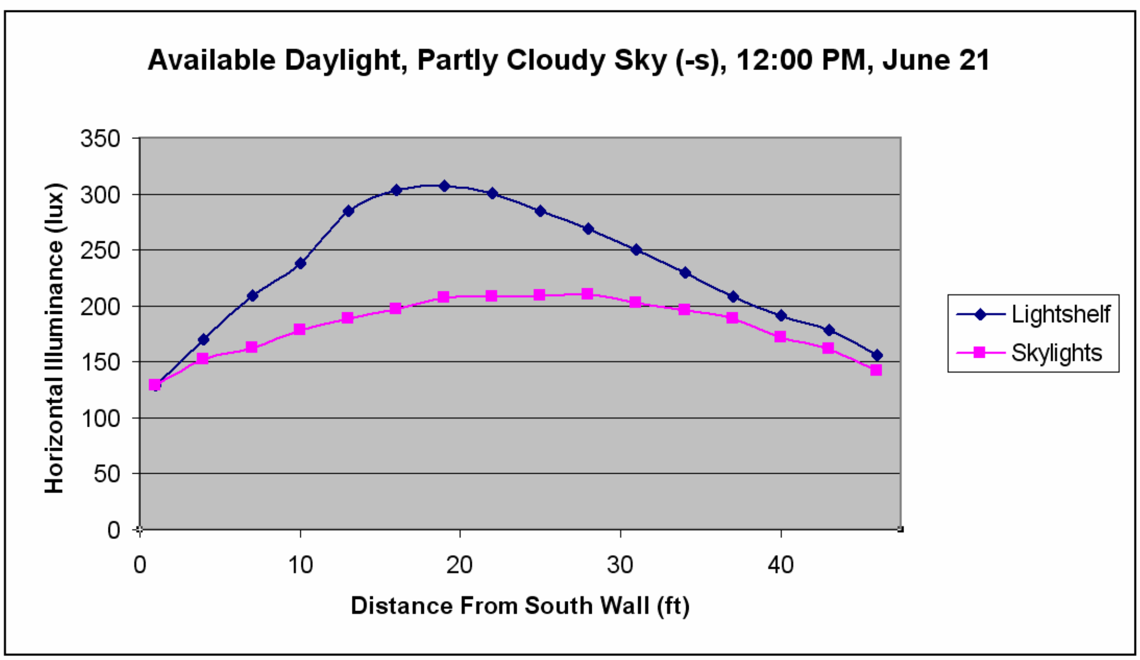
COMPARISON DATA



SKYLIGHT

LIGHTSHELF

SKYLIGHT		LIGHTSHELF
144 sf	glazing area	244 sf
208 lux	available daylight	270 lux
359 lux	available electric light	508 lux
0.72 W/sf	power density	0.82 W/sf
65%	daylight well efficiency	47%



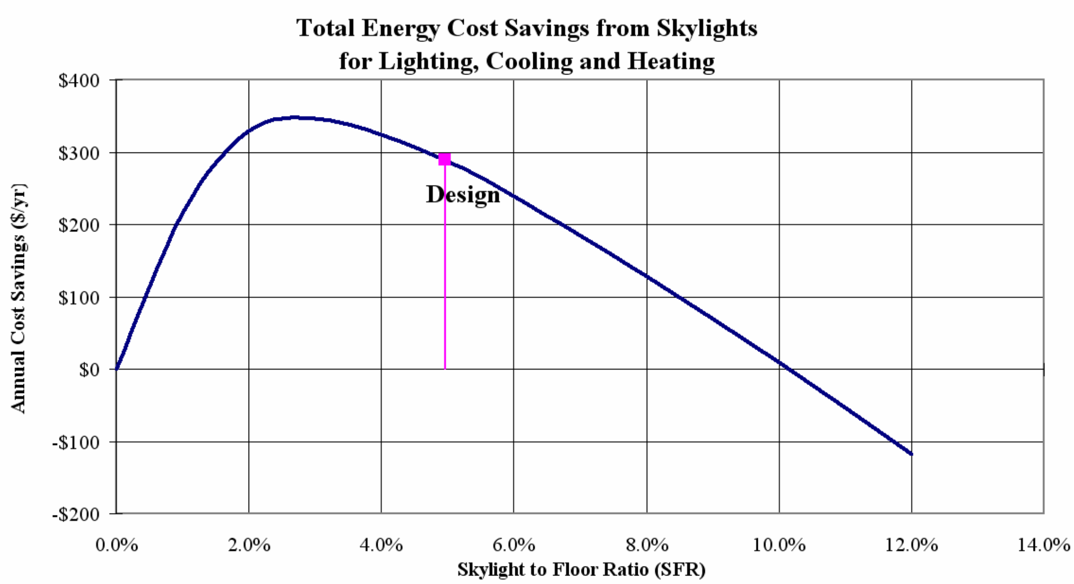
COMPARISON ANALYSIS

The analysis of the two lighting systems reveals that the splayed skylight system is the best system for this application. This is due to the relatively low daylight well efficiency of the lightshelf when compared to the splayed skylights. The diffuse skylights bring in more illuminance per square foot of glazing area than the lightshelf. More glazing results in more negative impact on building HVAC loads. Also, the illuminance provided by the skylights is much more uniform across the task plane, whereas the lightshelf provides fairly uneven illuminance. This discontinuity will be even more pronounced under clear sky conditions when direct sunlight hits the lightshelf. The uneven daylight illuminance can be accounted for by 'zoning' the electric lighting system, but this would require multiple photocells connected to a complex control system. The lightshelf system luminaires provide more horizontal illuminance than is necessary in an instrumental rehearsal room occupied primarily by 18-24 year old college students. Also, the continuous rows of type FF luminaires may create awkward and distracting banding on the specular finishes of instruments. The skylight system luminaires will provide appropriate levels of crisp, direct light with a 40° cutoff. This distribution will enhance facial rendering and reduce glare from distant fixtures.

SELECTED DESIGN SCHEMATIC

Daylight will be brought into the space through splayed skylights. The skylights are laid out in a symmetrical pattern which fits within a 2'x2' acoustic ceiling tile grid. The skylight glazing is a 4'x4' pyramid-shaped triple glazed prismatic acrylic unit manufactured by Sunoptics. (www.sunoptics.com) The inside of the splayed well will be gypsum board with high reflectance non-specular paint. The electric lighting system in this space will consist of pendant mounted compact fluorescent downlights (type FA) from ERCO (www.erco.com) symmetrically spaced at 8' on center and mounted at 12' above the floor. This mounting height virtually eliminates the considerable reflectance losses that would be experienced if the luminaires were mounted at or near the 25' ceiling height. This room cavity loss is amplified when the low reflectance acoustic velour curtains are drawn. Also, bringing the luminaires closer to floor level makes maintenance of the luminaires much easier. The electric lighting will be controlled by an occupancy sensor and an open loop photocell dimming control. The electric lighting must be triggered on by an automatic wall switch at the room entrance and then a dimming level will be determined by the photocell signal and setpoints. The electric lighting will stay on as long as the occupancy sensor detects activity. This 'manual on, automatic off' control scheme allows for occupancy with no electric light if that is what is desired by the occupant. Open loop photocell control results in a nearly linear signal to output relationship. The photocell setpoint should ensure there is always a horizontal task illuminance of 30fc. All of the electric lighting in this space will be controlled by the photocell and occupancy sensor combination.

According to SkyCalc, a daylighting analysis spreadsheet provided for free by HMG (www.h-m-g.com) shows that although this integrated daylighting system loses roughly 6,400 kWh/year of energy, there is an energy cost savings of around $290/year. Although this energy cost savings is virtually negligible when compared to the energy costs of the entire building, it is important to recognize that there would be no energy cost savings at all if the skylights were not paired with a photocell based control system.



LIGHTING ANALYSIS

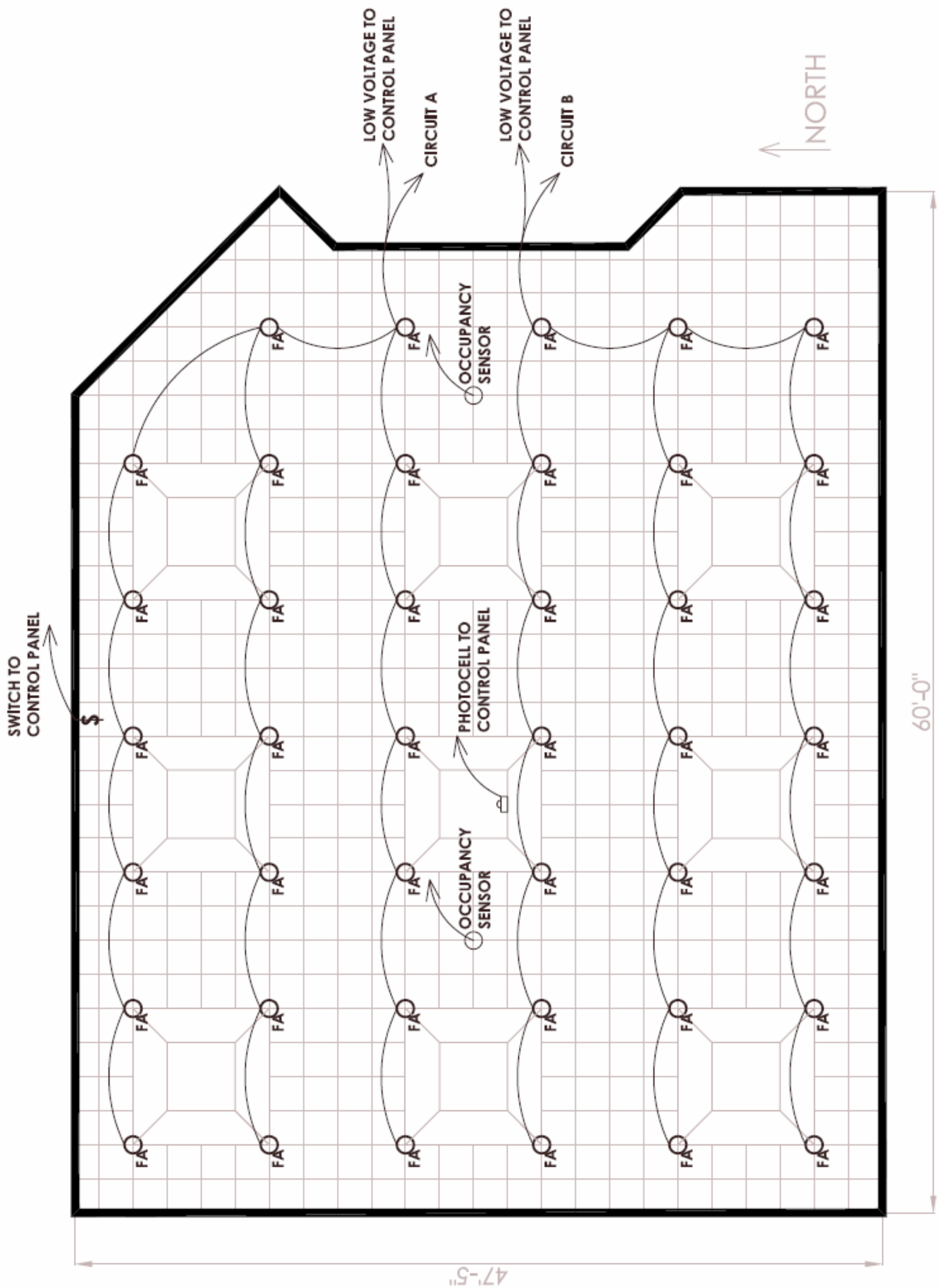
The considerable height of the space and the use of prismatic skylight glazing results in uniform daylight illumination. The splayed skylights provide visual detail to the ceiling while also remaining fairly anonymous, not necessarily drawing attention to themselves. Although the designed 'skylight to floor ratio' is larger than the ratio of peak efficiency, the location and scale of the skylights fuse well with the physical constraints of the room. The chromatic quality and uniformity of the daylight will make this a very appealing and productive rehearsal space during daylight hours. The 8' spacing and intentionally clean profile of the pendants succeed in preserving the view of the rehearsal space from the observation room and sound room. The electric lighting system provides sufficient illuminance for the primary tasks while also serving as an architectural element of the space. The complete lighting system achieves the design goals of functional, efficient lighting while also adding an element of detail and interest to this potentially bland space.

ASHRAE/IESNA 90.1-1999 Compliance

University Classroom (9.3.1.2)

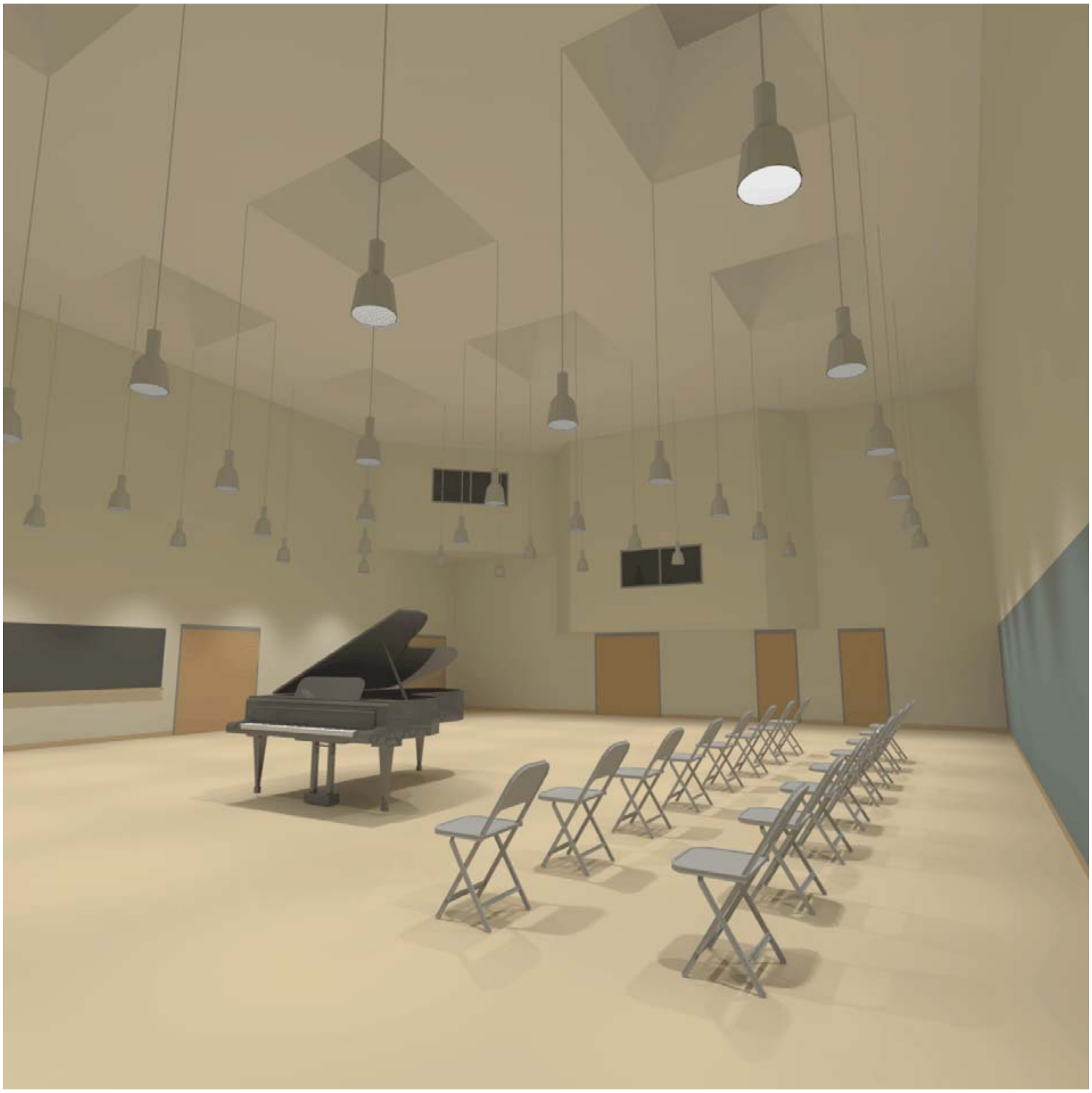
Room Area	2850	sf
Allowed Density	1.6	W/sf
Allowed Wattage	4560	W
Luminaire Count	41	ea
Ballast Input Watts	50	W
Actual Wattage	2050	W
Actual Density	0.72	W/sf
% Difference	55.04	% Below 90.1

LIGHTING PLAN



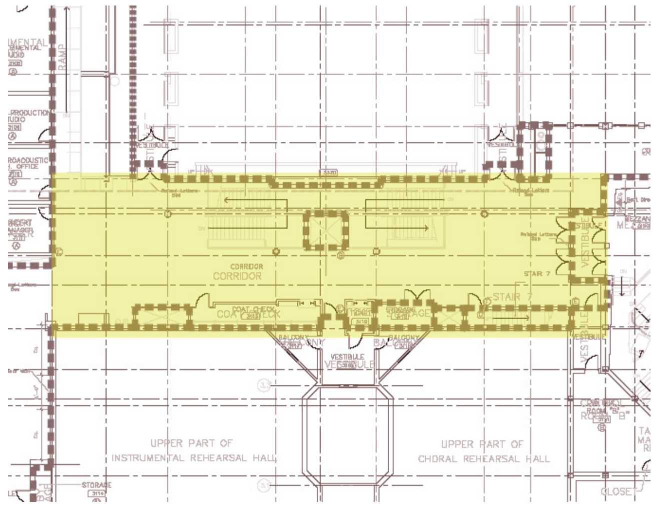
DAYLIGHT ONLY

ELECTRIC LIGHT ONLY



CIRCULATION

DESIGN GOALS



carpet $\rho=.3$ wallpaper $\rho=.5$
acoustic ceiling tiles $\rho=.8$
painted gypsum ceiling $\rho=.7$

The two story corridor along the south wing of the Whalen Center serves two distinct functions. This transition space, during most hours, is simply an educational facility corridor. Ambient light levels of 10-15fc are required to safely usher students and faculty from adjacent hallways, classrooms, and rehearsal spaces. Direct glare should be minimized to prevent distraction while moving through the space. Also, good facial modeling is important for casual conversations. While it is very important to satisfy the design requirements for the 'hallway' function of this space, the most critical use of the space is as a lobby before and during performances in either of the adjacent auditoriums. This two story corridor area is adjacent to two major approach routes for visitors to the Whalen Center. First, the west end of the 2nd floor corridor leads to an exterior vehicular drive where patrons can be dropped off. Also, people may park their cars in an elevated parking lot on the hill to the south of the Whalen Center and enter through a pedestrian bridge and elevator which leads to the west end of the 3rd floor corridor. Most visitors to the Whalen Center will be going to the Hockett Recital Hall, and visitors must be able to easily identify their goal over one hundred feet down the corridor. The lobby of a performing arts venue is not task oriented, and should feel dramatic and intimate. The mood of the space should be light enough, however, that the energy of the space is developed from the anticipation and appreciation of the performance taking place just a few feet away. The appearance of luminaires in lobbies is critical, and appropriate luminaires must be considerate of the visual context of the space. The wood surfaced ticket booth, coat check, and information area should be delineated to attract visitors who may not know where they are going. The unique dual stairway and entresol with adjacent metal panel wall and blue clad elevator shaft are visually appealing, and should be brought to the attention of patrons. Ambient light levels in the space should be kept low so that important signage and architectural elements will stand out and fulfill their design purpose.

DESIGN SCHEMATIC

The 2nd floor entrance from the drop off circle will have two continuous rows of a louvered recessed direct fluorescent luminaire (type FB) from Linear Lighting. (www.linearltg.com) The louvers of this luminaire have translucent acrylic tips which protrude slightly below the ceiling plane. This helps reduce the glare and the 'institutional' feeling of most recessed linear louvered luminaires. The high color rendering of the F28T5 and the direct distribution of this luminaire enhances facial detail and directs light efficiently to the floor. The archway connecting the entrance to the corridor will be marked on both sides by a 26" kiln formed glass sconce (type FD) from Translite Sonoma. (www.translitesonoma.com) The decorative texture and appropriate scale of this luminaire make a visual statement which is repeated further along the 2nd floor corridor. More FB luminaires are placed in the adjacent corridor to provide ambient light levels. Ceiling recessed wallwash luminaires (type FC) from Peerless (www.peerless-lighting.com) wash the south wall of the corridor, providing an open feel to and ambient light to the space. The ceiling in this part of the corridor is 12' AFF, but the entresol level surrounding the elevator shaft impedes the natural flow of the space. The ceiling drops to 7'6" AFF under the entresol, and virtually cuts off visual contact with the recital hall at the end of the corridor. To draw people under the entresol and through this area, low voltage halogen recessed floor luminaires (type IA) from ERCO (www.erco.com) will be placed in the floor along the south wall. This luminaire uses 20W MRC-11 lamps with 30° distribution, which will be aimed slightly towards the wall will make soft scoops of light on the wall and provide a soft warm glow on the low ceiling above. This effect will help reduce the 'cave' feeling caused by the drastic change in ceiling height by giving texture and detail to the wall and making the gypsum ceiling appear more open and spacious. In the center of the area below the entresol is the elevator shaft which is clad in a rich blue paneling. More FC luminaires will be placed around the elevator shaft to bring out the vibrant color of the paneling and to provide safe ambient light levels for walking in this area. In the area past the entresol the ceiling returns to 12' AFF and will have continuous rows of FB luminaires and the south wall is washed by FC luminaires. Wall protrusions that are meant to physically separate the "hallway" from the "lobby" will be detailed with FD sconces. The row of FB luminaires will continue into the lobby area and the remaining ambient light will come from the FD sconces located around the space. On the 3rd floor, visitors exiting the elevator will are greeted with a picture of James Whalen and information on his contributions to Ithaca College. This memorabilia wall will be illuminated with recessed FC luminaires. Directly to the right of this wall is the main corridor. Angled rows of FB luminaires will be placed in the 10'0" AFF gypsum ceiling and will grab visitors attention and draw them into the space. The south wall will be washed with FC luminaires, adding to the apparent volume of the space. Halfway along the south wall of the corridor is the protruding wood surfaced ticket booth, coat check, and information area. This area will continue to be washed from the ceiling by FC luminaires. The actual booths where patrons will interact with school personnel will be highlighted with in floor IA luminaires. The warm color of the halogen sources and the soft scoops of light will help accent these specific points of interest. To the north of the ticket area is the entresol and the upper portion of the elevator shaft. The large metal panel wall at the north of the entresol will be washed from above with FC luminaires. The stairways will be lit from the ceiling above with

desired effect under entresol

square apertured, glass lensed 70W MH downlights (type HA) from Kurt Versen. (www.kurtversen.com) The high CRI T6 lamps combined with the soft but direct distribution of the luminaire will provide high levels of crisp light for safe travel on the adjacent stairways. A square apertured, glass lensed 70W MH wallwahser (type HB) from Kurt Versen will be placed on the east and west side of the elevator shaft, helping to bring out the rich color of the elevator shaft and add ambient light to the entresol stairways. The area beyond the entresol should be considered a lobby space. In the area, FB luminaires will be arranged in the gypsum ceiling to gently direct patrons towards the entrance to the recital hall. The double doors leading to the recital hall will be framed with the same FD sconce used in the 2nd floor corridor.

LIGHTING ANALYSIS

The careful application of suitable luminaires is essential for a corridor space to work. The blend of standard hallway lighting and dramatic lobby lighting satisfies the dual nature of this space. Highlighting unique architectural elements gives texture and detail to the space while reflected light contributes to ambient light levels. Recessed luminaires keep the focus on the architecture and the visual goals of the space. The life of the MRC-11 lamps is quite short, but the luminaires are very accessible and will be easily maintained. The square HID luminaires are 14’6” above the entresol floor and will be difficult to maintain, but the long life of the metal halide lamps will reduce the need for maintenance of these fixtures, and a group re-lamping scheme can be adopted to further ease the burden. The recessed linear louvered and wallwash fixtures make up the bulk of the lighting in this space. Both fixtures can easily be maintained from a ladder and both use the same T5 lamp, which avoids confusion during re-lamping. The decorative wall sconce has a two lamp design so if one lamp fails, the appearance of the sconce will change slightly, but the appearance of the overall design will not suffer drastically. The comprehensive design is both moody and functional. Students and faculty can safely and efficiently travel through this space during the day, and visitors will be greeted with a dynamic and goal oriented design that will gently guide them to their goal.

LIGHTING ANALYSIS

Average Floor Illuminance (fc)	
corridor areas	21
lobby areas	16
under entresol	9
above entresol	18

ASHRAE/IESNA 90.1-1999 Compliance

University Corridor (9.3.1.2)
Performing Arts Center Lobby (9.3.1.2)

Corridor Area	4030	sf
Lobby Area	2885	sf
Corridor Allowed Density	0.7	W/sf
Lobby Allowed Density	1.2	W/sf
Total Allowed Wattage	6283	W
Luminaire FB	65	ea
FB Input Watts	33	W
Luminaire FC	45	ea
FC Input Watts	33	W
Luminaire FD	11	ea
FD Input Watts	34	W
Luminaire IA	11	ea
IA Input Watts	20	W
Luminaire HA	4	ea
HA Input Watts	94	W
Luminaire HB	2	ea
HB Input Watts	88	W
Total Wattage	4776	W
Total Density	0.69	W/sf
% Difference	23.99	% Below 90.1

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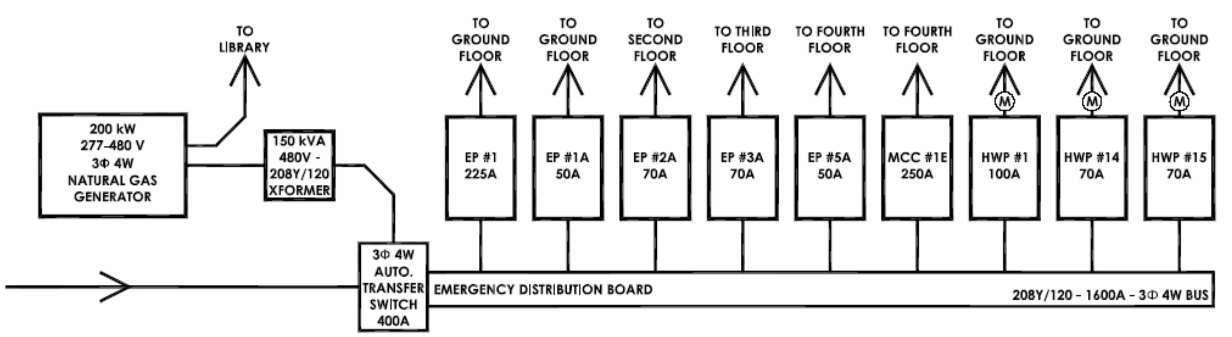
ELECTRICAL

REDESIGN DESCRIPTION

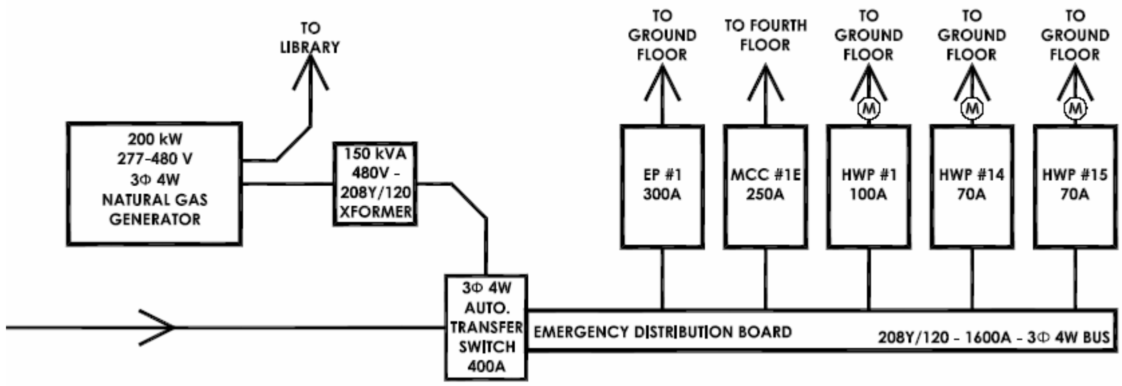
The current electrical system utilizes a 200kW natural gas generator to supply power for emergency mechanical and lighting loads in the facility. Emergency lighting loads are hard wired to the emergency power panel on each floor. This method of powering emergency lighting results in long wiring runs to just a small percentage of the luminaires all across the building. An alternative to this method of emergency lighting is to incorporate emergency ballasts with the emergency lighting luminaires. In this method, all lighting, including emergency lighting, is connected to the normal lighting circuits. The emergency ballast only requires that an un-switched hot lead is connected so that the luminaire may be controlled along with other luminaires in that control zone without the emergency ballast thinking it has lost power. This lead can be run along with the standard controlled wiring. Making the emergency luminaires self sufficient will result in a significant first-cost savings because the cost of wiring the emergency lighting loads separately from the normal lighting will be eliminated.

ANALYSIS

Existing Condition Emergency Riser Diagram



All lighting loads were removed from panels EP-1, EP-1A, EP-2A, EP-3A, and EP-5A. The remaining critical mechanical loads from these panels were combined into the new EP-1, below is the new emergency riser diagram;



Emergency Panel EP-1

Equip	Serves	Volt	Phase	HP	3Φ Amps	Watts	Inverse Time-Delay Circuit Breaker (A)
CUH-1	Vestibule G01	120	1	0.10	1.47	528	15
CUH-2	Vestibule 215	120	1	0.10	1.47	528	15
CUH-3	Vestibule 225	120	1	0.10	1.47	528	15
UH-1	Recycle Closet 231	120	1	0.05	1.47	528	15
UH-2	Elev. Mech. Tower-2	120	1	0.05	1.47	528	15
UH-3	Elev. Mech. 236	120	1	0.05	1.47	528	15
RS-1	Rolling Fire Shutter	120	1	0.25	1.93	696	15
P-3	Elev. Sump Room	120	1	0.33	2.40	864	15
EF-12	Mech. Room G19	208	3	5.00	16.70	6012	50
HWP-5	Fin Radiation	208	3	7.50	24.20	8712	70
HWP-6	Fin Radiation	208	3	7.50	24.20	8712	70
HWP-16	Boiler #1	208	3	3.00	10.60	3816	30
HWP-17	Boiler #2	208	3	3.00	10.60	3816	30
UH-6	Boiler Room G21	120	1	0.25	1.93	696	15
UH-8	Telephone Equipment E20A	120	1	0.05	1.47	528	15
B-1	Boiler 1	208	3	2.00	7.50	2700	20
B-2	Boiler 2	208	3	2.00	7.50	2700	20
JP-1	Jockey Pump	208	3	5.00	16.70	6012	50
AC-1	Air Compressor Control	208	3	15.00	46.20	16632	125
P-4	Boiler Room G21	208	3	5.00	16.70	6012	50
						71076	total
						71.08	kW
						78.97	kVA @ PF=.9
						219.37	full load current
	90°C XHHW 4/0 wire in 2" conduit protected by a 300A circuit breaker.					232.20	ampacity minimum

A panelboard layout for the new EP-1 is included in the appendix.

COST ANALYSIS

The chart below shows the cost savings associated with the change in the emergency lighting system. All costs were taken from the RS Means 2004 Electrical Cost Data and are total cost including overhead and profit. Multiple runs of armored cable wiring and four 100A panelboards were eliminated in this redesign. The cost of the new EP-1 and the emergency ballasts from Bodine (www.bodine.com) were added.

Item	Quantity	Units	Cost/unit	Total Cost
#8 AWG Armored Cable	-126	Average Runs	$585.00	-$73,710.00
100A 20 Circuit Panelboard	-4	each	$715.00	-$2,860.00
400A 42 Circuit Panelboard	1	each	$1,850.00	$1,850.00
Bodine model B33	49	each	$230.00	$11,270.00
Bodine model B84c	77	each	$100.00	$7,700.00
			Cost difference	-$55,750.00

MOTOR CONTROL CENTER

In the control sequence section of the mechanical spec, it is specified that;

> - The DDC system shall monitor a signal from the emergency generator via a set of dry contacts at the emergency generator control panel. If the emergency generator is energized and AHU-7 is indexed to the smoke evacuation mode, the DDC control system shall disable the boilers and place all hot water pumps in the off position. When AHU-7 is indexed to the smoke evacuation mode, the outside air and the exhaust air dampers shall be in the full open position and the return air damper shall close fully. The supply air and return air variable frequency drives shall increase fan speed to provide supply and exhaust at the full design capacity.

This can be interpreted to mean that the AHU-7 fans would never be running off of the generator at the same time as the boilers and hot water pumps. This would result in two emergency operation cases, A and B.

Emergency Case A

Equip	Serves	Volt	Phase	HP	3Φ Amps	Watts	
MCC-1E	AHU-7 - Atrium	208	3	113	323.96	116626	
						116626	total
						116.63	kW
						323.96	full load current

Emergency Case B

Equip	Serves	Volt	Phase	HP	3Φ Amps	Watts	
EP-1	Emergency Loads	208	3	56.33	197.43	71075	
HWP-1	AHU Heating Coils	208	3	15	46.2	16632	
HWP-14	Boiler Hot Water Loop	208	3	10	30.8	11088	
HWP-15	Boiler Hot Water Loop	208	3	10	30.8	11088	
						109883	total
						109.88	kW
						305.23	full load current

Luminaires Removed From Generator

Name	Type	Lamp	Quantity	Wattage	Total	
FB	2x4' Recessed Static Troffer	(2) F32/T8	2	70.4	140.8	
FC	2x4' Recessed Parabolic Troffer	(3) F32/T8	2	105.6	211.2	
FD	2x4' Recessed Parabolic Troffer	(2) F32/T8	14	70.4	985.6	
FE	1x4' Recessed Static Troffer	(2) F32/T8	7	70.4	492.8	
FF	6" Round CF Downlight	(1) 26W HTT	12	28.6	343.2	
FG	9" Round CF Downlight	(2) 26W HTT	55	57.2	3146	
FI	9"x4' Recessed Parabolic Troffer	(2) F32/T8	5	70.4	352	
FL	9" Round CF Downlight	(2) 13W HTT	2	28.6	57.2	
FQ	1x4' Surface Wraparound	(2) F32/T8	18	70.4	1267.2	
FR	2x2' Recessed Static Troffer	(2) F32/U6	1	70.4	70.4	
FS	9" Round CF Downlight	(2) 18W DTT	6	39.6	237.6	
I	Wall Mounted Decorative CF	(1) 18W TT	2	19.8	39.6	
					7343.6	1Φ Power
					61.19667	1Φ Amps
					20.39889	3Φ Amps

This shows that the critical load from the Emergency Distribution Board will be 324 A after the removal of approximately 20 A of emergency lighting loads. The size of the load reduction is relatively small compared to the other loads supported by the emergency generator. Therefore the generator, transformer, and automatic transfer switch should not be resized. The following calculations determine feeder size, protection size, voltage drop requirements and short circuit current.

Motor Control Center - MCC-1E

Equipment Designation	Motor Rating				Fuse Size
	HP	Voltage	Phase	FLC	(A)
AHU-7 Supply Fan	60	208	3	169.4	250
AHU-7 Return Fan	50	208	3	143	225
Prehat Pump, HWP-21	3	208	3	10.56	20

Required Feeder Ampacity= $1.25 * LOAD_{MAX} + 1.0 * \sum LOAD_{REMAINING}$ = 365.31 A

- select 90º XHHW 400 MCM in 2.5” conduit

Maximum Breaker Trip Size= $2.5 * LOAD_{MAX} + 1.0 * \sum LOAD_{REMAINING}$ =577.06 A

- select 600A

Voltage Drop Maximum=3%

$$LENGTH = 175(FT)$$
$$LENGTH_{ADJUSTED} = 1.1 * LENGTH = 192.5(FT)$$
$$V_{DROP} = .051\left(\frac{V}{1000 * A * FT}\right)$$
$$CURRENT = 365(A)$$
$$V_{DROP(L-N)} = .051 * 192.5 * 365 * \frac{1}{1000} = 3.58(V)$$
$$V_{DROP(L-L)} = \sqrt{3} * V_{DROP(L-N)} = 6.2(V)$$
$$V_{DROP(\%)} = \frac{V_{DROP(L-L)}}{V_{(L-L)}} * 100 = 2.98\% < 3\% \quad \therefore \quad OK$$

Short Circuit Current

$$I_{ASY} = 110{,}000(A)$$
$$K_0 = 1.3$$
$$I_{SYM} = \frac{I_{ASY}}{K_O} = 84{,}615(A)$$
$$84{,}615(A) < 100{,}000(A) \quad highest\ \ frame\ rating\ availalbe \quad \therefore \quad OK$$

CONCLUSION

A significant first cost savings of almost $56,000 is achieved by removing the emergency lighting loads from the existing emergency power distribution system. The emergency motor control center should be a Square D Model 6 (www.squared.com) with a 600A bus and a 100,000 frame. It is important that the motor control center is operated in a way that the AHU fans will not operate at the same time as the hot water pumps when running on emergency power. Otherwise, the transformer and automatic transfer switch connected to the generator will be overloaded and are likely to fail.

ACOUSTICS

DESCRIPTION

In the lighting design portion of this thesis, skylights were added to the large instrumental rehearsal room to include daylight as an integral part of the lighting system. This space is mainly functional, focused on the creation and perfection of instrumental music. Therefore, this space is very concerned with acoustics. It is important that both the conductor and the musicians can hear each part of the ensemble clearly. It is also important that the sound is allowed to blend within the space so that the gestalt characteristic of music develops. The reverberation time of a space is a key indicator to the acoustic performance of a space. The addition of skylights will affect the reverberation time of this space. The following analysis will show the impact of the addition of skylights in this space.

ANALYSIS

Reverberation times were calculated using Eyring's equation;

$$T_{60} = \frac{55.2 * V}{c * S * \ln(1 - \overline{\alpha_{sab}})^{-1}}$$

$$\overline{\alpha_{ab}} = \frac{\sum (S_i * \alpha_i)}{\sum S_i}$$

$T_{60} = \textit{reverberation time}$

$V = \textit{room volume}$

$c = \textit{speed of sound}$

$S = \textit{total surface area}$

$\overline{\alpha_{sab}} = \textit{sabine absorption coefficient}$

Existing Condition

Curtains Drawn

ΣSα by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
2728.963	3689.974	4615.381	5798.484	5975.95	5871.286

ΣS 11518.37

α avg. by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0.236923	0.320356	0.400697	0.503412	0.518819	0.509732

T60 by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1.084753	0.759512	0.572889	0.419022	0.400968	0.411491

α avg.	0.41499	
T60 avg	0.547097	seconds

No Curtains

ΣSα by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
2613.363	2822.974	3199.281	3919.984	4213.05	4223.986

ΣS 11518.37

α avg. by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0.226886	0.245084	0.277755	0.340324	0.365768	0.366717

T60 by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1.139833	1.043262	0.901418	0.705066	0.644162	0.642049

α avg.	0.303756	
T60 avg	0.810133	seconds

These results show the range of reverberation times (T60) available in the rehearsal room with the use of the velour curtains. This range is in accordance with the desired acoustic properties for a professional rehearsal space. The ceiling in this space is a 2x2' grid and is filled with a checkerboard pattern of alternating panels of gypsum board and acoustic ceiling panels. The skylights will remove 576 sf of 2x2' grid area, and will be replaced with a skylight well and glazing which are considerably less absorptive than suspended ceiling panels. To accommodate for the addition of the skylights, all remaining 2x2' ceiling grid spaces will be filled with acoustic ceiling panels rather than gypsum board.

New Condition

Curtains Drawn

ΣSα by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
2952.007	3802.816	4714.982	5906.407	6076.027	5977.893

ΣS 12413.67

α avg. by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0.237803	0.306341	0.379822	0.475799	0.489463	0.481557

T60 by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1.00224	0.74406	0.569669	0.421376	0.404822	0.414291

α avg.	0.395131
T60 avg	0.55715

No Curtains

ΣSα by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
2836.407	2935.816	3298.882	4027.907	4313.127	4330.593

ΣS 12413.67

α avg. by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0.228491	0.236499	0.265746	0.324473	0.34745	0.348857

T60 by Frequency

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1.049158	1.00859	0.881056	0.693816	0.637572	0.634364

α avg.	0.291919
T60 avg	0.81143

CONCLUSION

This analysis shows that by compensating for the addition of skylights by using only acoustic ceiling panels in the remaining ceiling grid there is virtually no change in the acoustic performance of this space. The scattering effects of the skylight wells are hard to anticipate and have not been accounted for. Yet it can be assumed that any adverse effects of the splayed skylight wells will be less severe than if standard, straight wells were used.

STRUCTURAL

DESCRIPTION

In the lighting design portion of this thesis, skylights were added to the large instrumental rehearsal room to include daylight as an integral part of the lighting system. The existing roof over this space is composed of a PVC membrane on rigid insulation supported by 1-1/2" steel deck which rests on the steel beams. There are notable structural implications in penetrating this roof to create daylight apertures. First, structural framing must be placed between the beams to support the skylight glazing. This will distribute the load of the glazing to the beams which span the width of the rehearsal space. Also, the beams must be re-spaced to accommodate the location and size of the skylight wells. The new beam spacing is slightly wider than what exists, making a longer span for the steel deck. This new beam spacing will also result in asymmetrical loading of the girders at the end of the beam spans. The following analysis will determine if any changes to the roof structure need to be made due to the addition of skylights as set forth previously in this thesis.

ANALYSIS

Roof design loads;

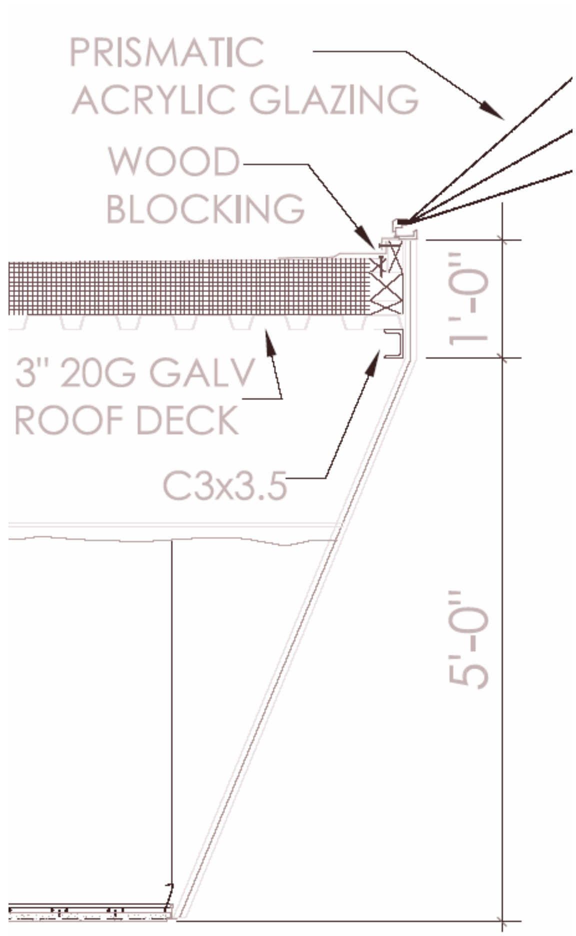
- live snow load – 30 psf
- dead load – 35 psf
- skylight unit weight - 0.24 kip
- loading factors, dead – 1.2, live - 1.6

Framing selection;

- loading applied in a STAAD model
- max shear – 0.676 kip
- max moment – 1.26 kip-ft
- select C3x3.5

Beam testing;

- loading applied in a STAAD model
- existing member size W24x68
- max shear – 17.7 kip
- max moment – 214 kip-ft
- W24x68 member size sufficient



Girder testing, case A;

- loading applied in a STAAD model
- existing member size W21x44
- max shear – 10.9 kip
- max moment – 53.9 kip-ft
- W21x44 member size sufficient

Girder testing, case B;

- loading applied in a STAAD model
- existing member size W21x44
- max shear – 24.3 kip
- max moment – 63.6 kip-ft
- W21x44 member size sufficient

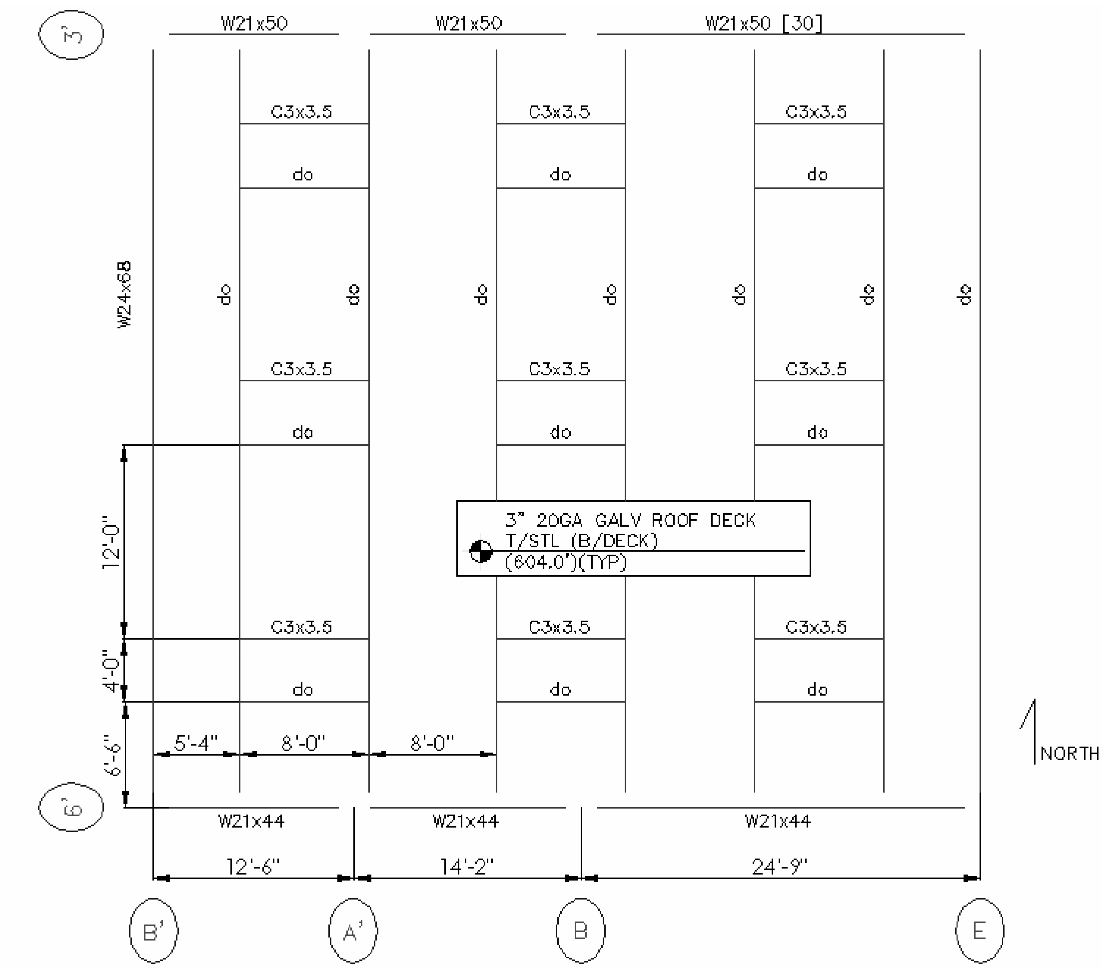
Girder testing, case C;

- loading applied in a STAAD model
- existing member size W21x44
- max shear – 32.4 kip
- max moment – 180 kip-ft
- W21x44 member size sufficient

Steel deck testing;

- roof decking must be changed from 1-1/2” 20 gauge deck to 3” 20 gauge deck to accommodate the 8’ span caused by the new beam spacing
- determined using Wheeling Deck Product Selection Guide

STRUCTURAL PLAN



CONCLUSION

The addition of skylights and the associated framing (C3x3.5) does not require the existing structural design to be changed. However, the spacing of the north-south beams at 8' on center is too wide for the original steel deck to be used. The critical condition is in between the skylight penetrations, where there is a single 8' span. This condition requires 3", 20 gauge steel decking to safely support the roof live and dead loads. STAAD analysis for each loading case is included in the appendix.

APPRECIATION

This thesis would not have been possible if it were not for my classmates who bore the same burden of preparing such a massive amount of work. Learning how to deal with stress through humor, respect, and teamwork is the true lesson learned through this project.

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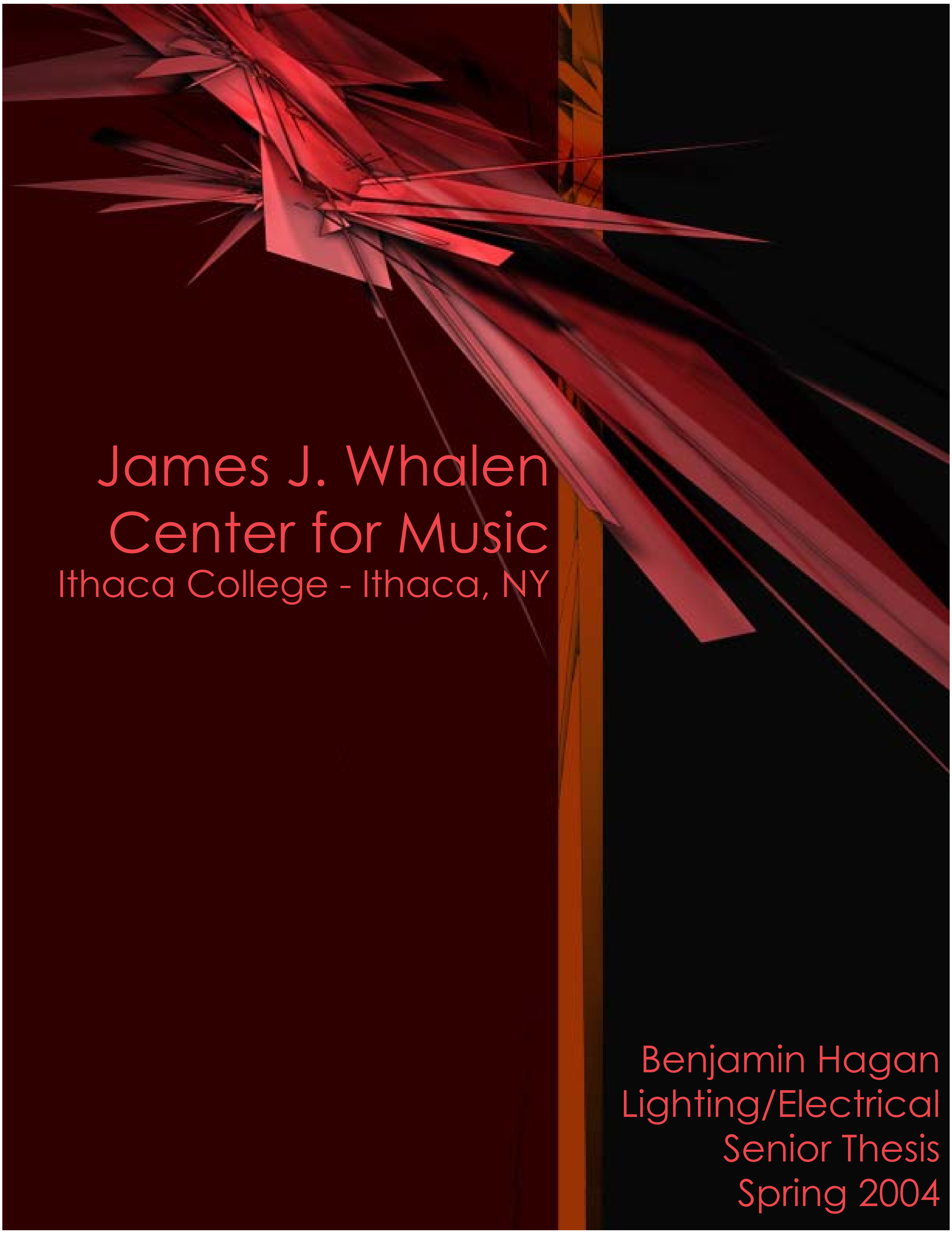
James J. Whalen
Center for Music
Ithaca College - Ithaca, NY
Benjamin Hagan
Lighting/Electrical
Senior Thesis
Spring 2004


ACOUSTICS
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APPENDIX
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CIRCULATION
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ELECTRICAL
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EXTERIOR
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INTRODUCTION
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OPEN
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SPECIAL
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STRUCTURAL

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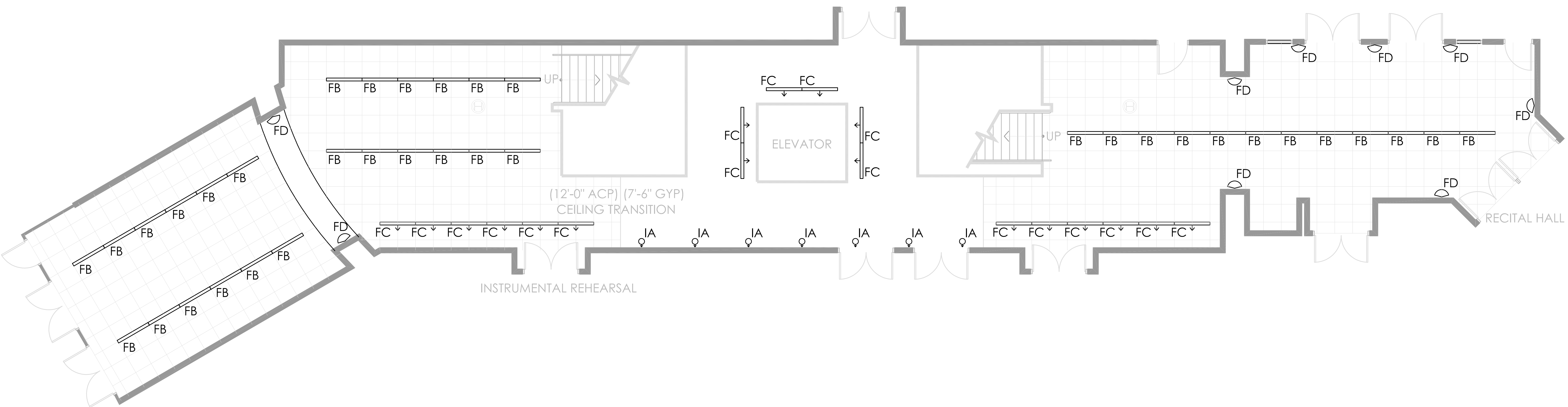
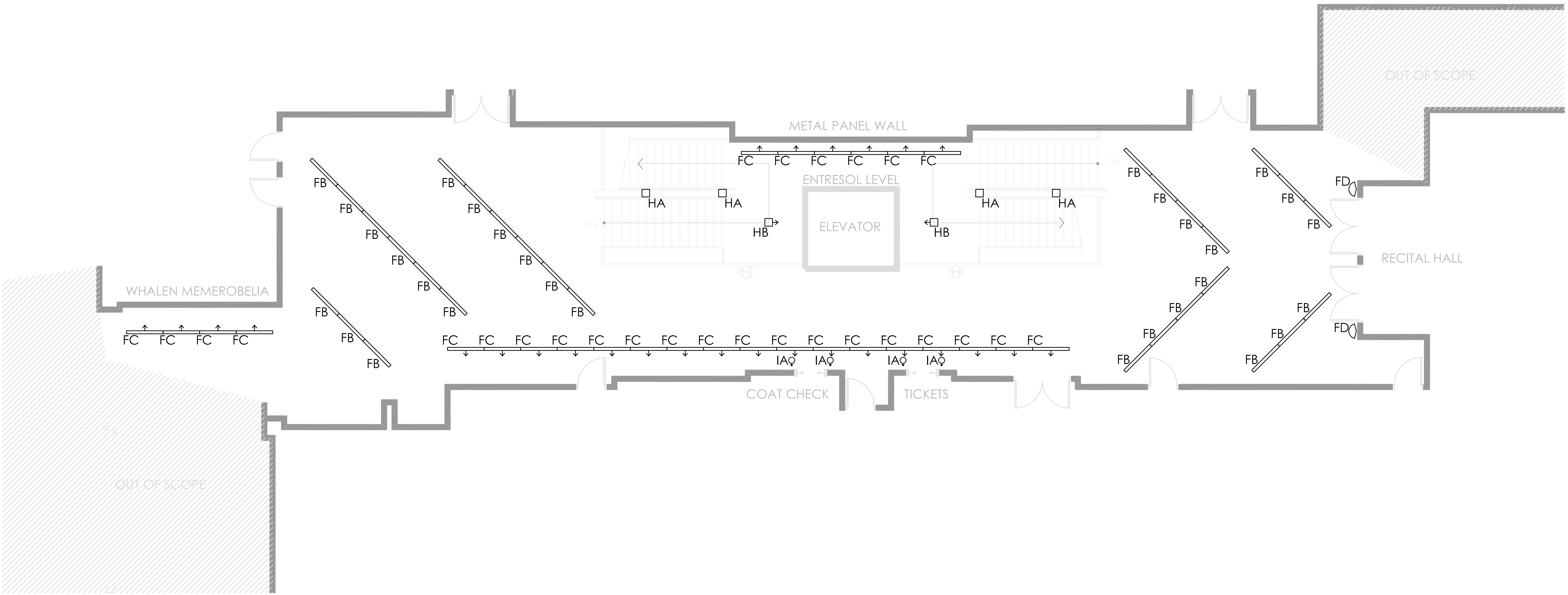
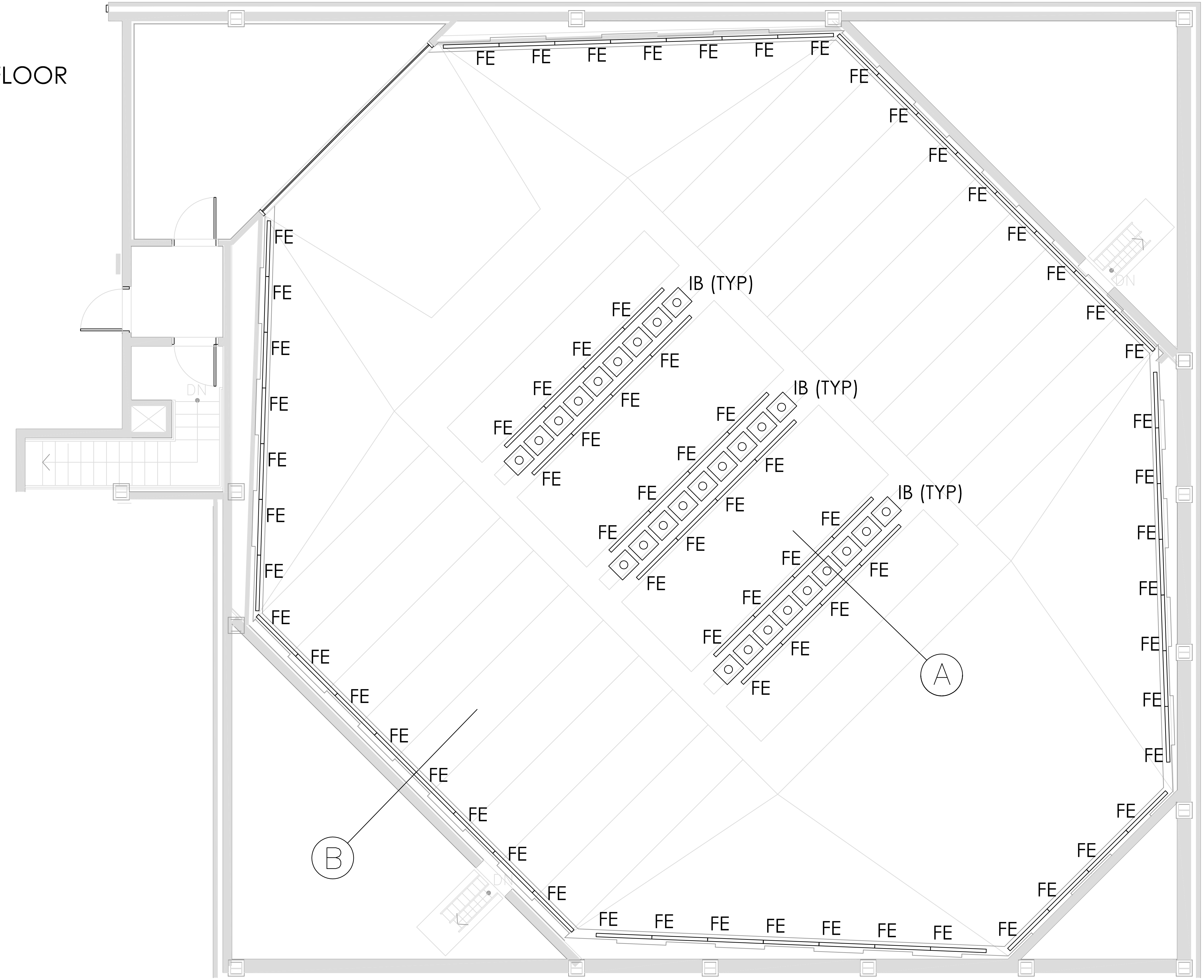
LIGHTING PLAN - 2ND FLOOR



LIGHTING PLAN - 3RD FLOOR



LIGHTING PLAN - 2ND FLOOR



James J. Whalen Center for Music

Ithaca College, Ithaca, NY

Project Data

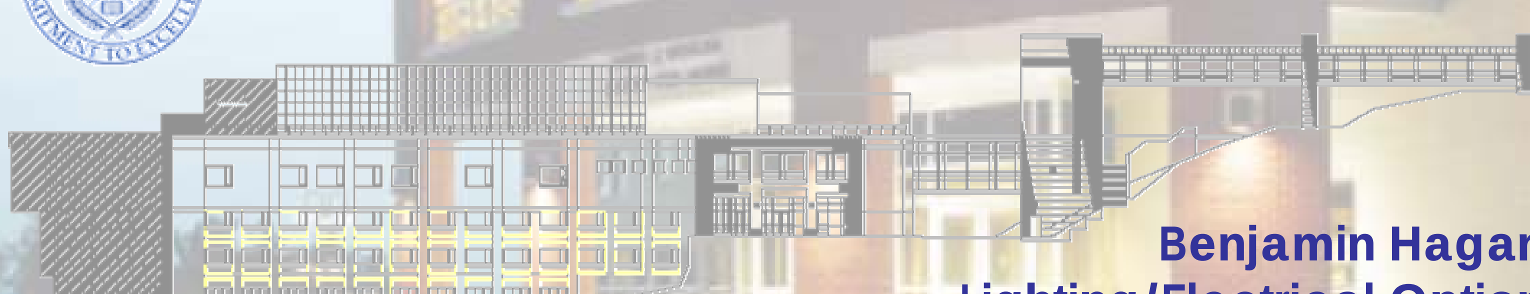
- 69,000 sf addition to existing Ford Hall
- Four stories plus elevated walkway to parking lots
- Final project cost $14.4 Million
- Constructed from December 1997 to August 1999
- Project Team
    - Architect and PM – HOLT Architects, Ithaca, NY
    - Owner – Physical Plant, Ithaca College, Ithaca, NY
    - Engineering Consultant – M/E Engineering, Rochester, NY
    - Structural Consultant – Ryan-Biggs, Skaneateles, NY
    - General Contractor – Welliver-McGuire, Elmira, NY

"The building uplifts me. It keeps me soaring and keeps all of our expectations high."

-Arthur Ostrander, Dean of the School of Music

Building System Features

- Building envelope of brick with limestone accents, and aluminum glazing system
- Unique four story atrium with sloped walkways and supplemental HID lighting system
- Low distortion IGBT dimming lighting control system in new recital hall
- 1050 kVA electric supply from campus utility loop
- 277/480 supply to mechanical systems, 120/208 supply for lighting systems
- 200 kW natural gas backup generator
- VFD controlled cooling tower feeding building chiller
- Oversized HVAC ductwork with acoustic insulation
- Steel structure with concrete slabs on metal deck
- Structural integration system to tie new structure to existing Ford Hall structure



Benjamin Hagan
Lighting/Electrical Option

More information on this project can be found at the thesis e-Studio at http://www.arche.psu.edu/thesis/2004/bmh157