# JACK H. MILLER CENTER FOR MUSICAL ARTS

Hope College | Holland, Michigan

## PROJECT DESCRIPTION

The completed project fulfilled the requirements of an international architectural engineering student design competition. This project brought together Master of Architectural Engineering students to create an interdisciplinary design team consisting of structural, mechanical and electrical. Each discipline was assisted by industry professional engineer mentors and evaluators. Teams were provided with architectural plans, project requirements, and owner challenges. The final project submittals met the following requirements:

- Superior Building Acoustics
- Timber Structure Design
- Addition of a Rooftop Amenity Space
- Building Integration Submittal
- Structural Design Submittal
- Mechanical Design Submittal
- Electrical Design Submittal

### BUILDING SUMMARY

The Jack H. Miller Center for Musical Arts is located on the Hope College campus in Holland, Michigan. It is a 64,000 square foot facility that houses an 800-seat concert hall with floor and raised seating as well as a 125-seat recital hall for small performances. A specialty rooftop amenity space allows guests to enjoy the facility in a social setting before and after performances and for special events involving both university and community members. Additional spaces include rehearsal and recording rooms, faculty studios, practice rooms, offices, and a large two-story atrium off the main concourse of the university.

**LOCATION:** Holland MI
**AREA:** 64,000 SF
**SPACES:** 800 seat concert hall, recital hall, classrooms, studios, atrium

### DESIGN CHALLENGES

**Acoustics**
- Variable Concert Hall Acoustics
- Innovative Components to Address Acoustical Performance
- Provide Flexible Acoustics Design

**Timber Structure**
- 25% Structural Timber
- Easily Visible for Aesthetics
- Using Glulam Members
- Sourced Within 2 Miles of the Site

**Rooftop Amenity Space**
- Prefunction Space
- 100+ People
- Weather Responsive Design
- Priority for Safety & Security
- For University and Community Use

## MULTIDISCIPLINARY PARTICIPATION

### INTEGRATION

**Rooftop Amenity Space**
- Reflects architectural elements
- Safety
  - Access control
  - Stairwell access near main entry
- Structural deflection criteria for retractable wall system

**Atrium**
- Expose more timber through raised ceiling, bulk head for MEP.
- Hidden engineered systems through the use of hydronic mullions, radiant underfloor air distribution and a focus on material selection
- Fritt pattern for daylight control

### MECHANICAL

**Heat Recovery Chillers**
- Utilizes rejected heat from condenser loop

**Active Chilled Beams**
- Temperature and humidity monitoring
- Zone-controlled pump module
- Low noise generation

**Energy-Saving Control Strategies**
- $CO_2$-based demand control ventilation
- Occupancy sensors integrate HVAC and lighting
- Mixed-mode ventilation for rooftop
- Energy recovery for 100% dedicated outdoor air handler

### ELECTRICAL

**Power**
- All battery emergency systems
- 12.5KVA lighting inverter
- 160KVA centralized UPS for optional standby
- 30KW photovoltaic array for rooftop

**Lighting**
- Lighting concept of Influential Flow related to famous musicians
- Lighting that accentuates use of timber
- Fully networked lighting controls
- Daylight analysis for atrium space

**Systems**
- Data and voice system design
- Security with IP based access control and CCTV
- Functional and flexible AV design

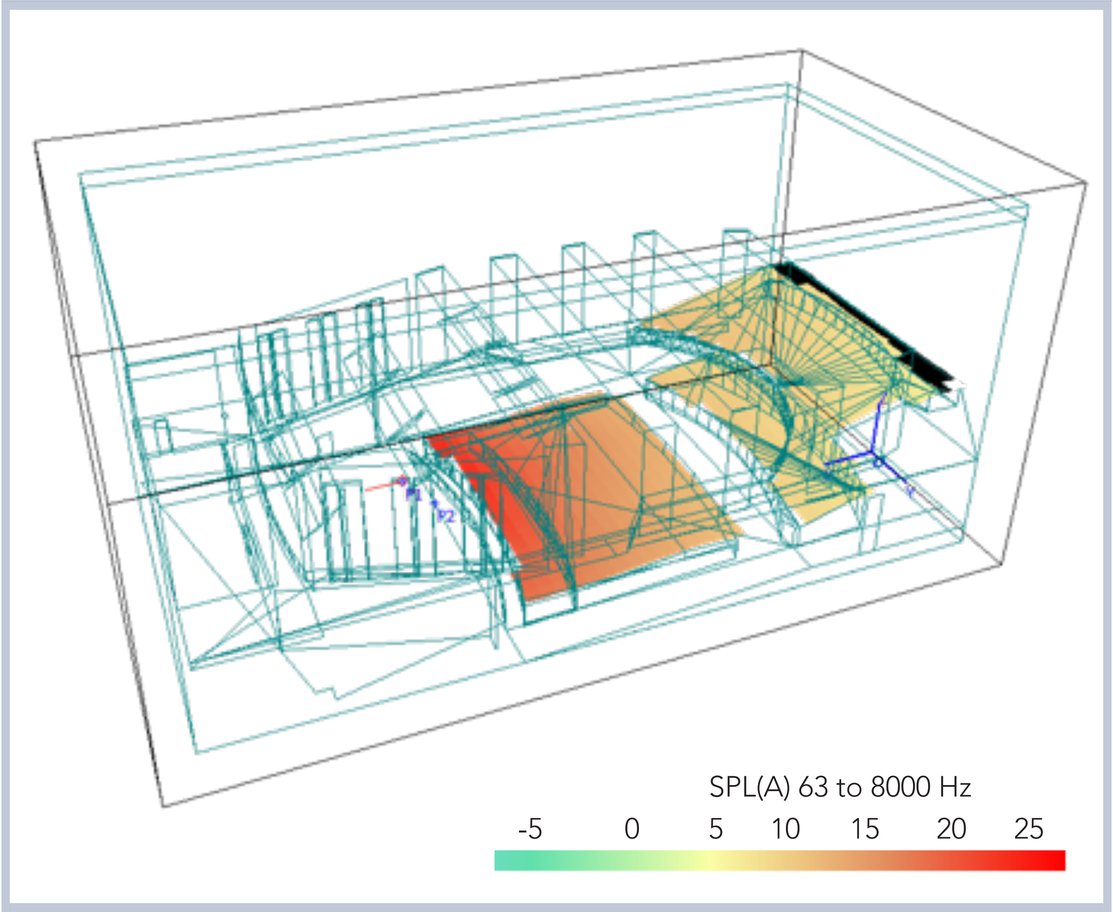
### STRUCTURAL

**Foundation System**
- Vibrio-compaction
- Spread & strip footings

**Gravity System**
- Steel & timber hybrid system
- Column-less concert hall balcony design

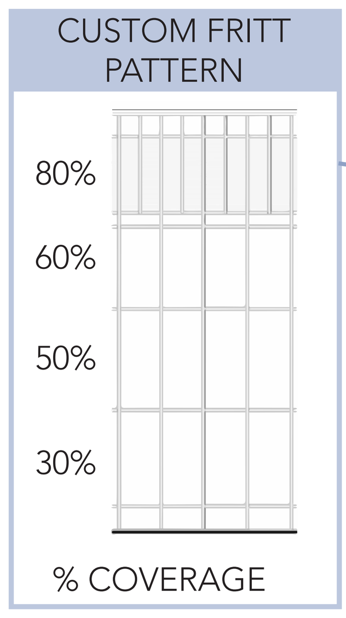
**Lateral System**
- Precast concrete shear walls
- Steel brace frames
- Timber moment frames

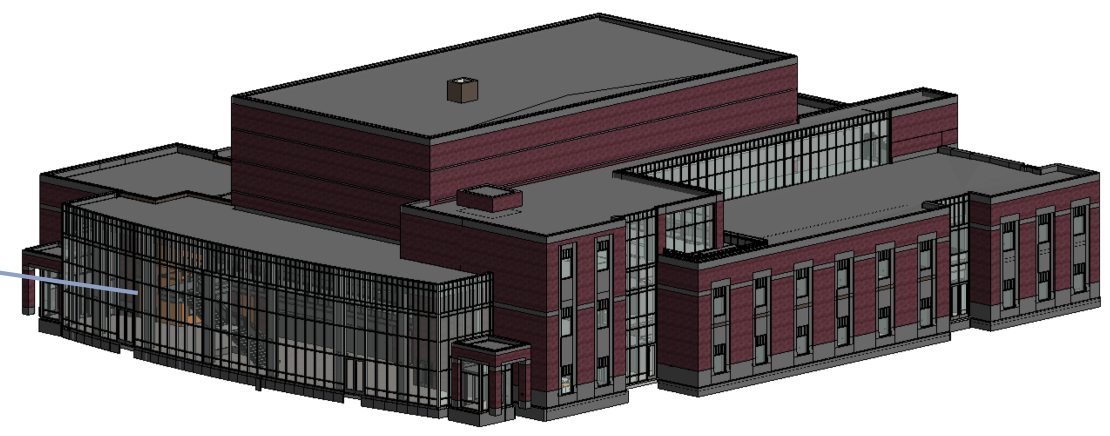
## CONCERT HALL ACOUSTICS



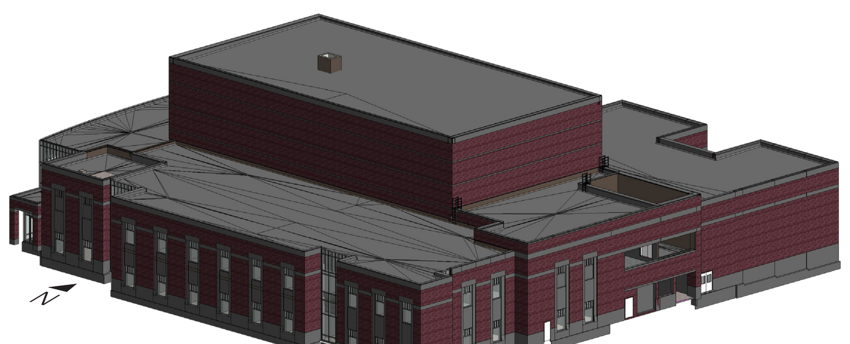

The design offers an acoustically superior concert hall. Reflectors were designed with the use of the acoustic modeling software Odeon. The image to the right illustrates reflector sound coverage. With the use of the reflectors, complete sound coverage can be achieved without the use of electric amplification. The reflectors are also movable, offering a variable nature of the acoustic design for different types of performances, lectures, and events.

## ATRIUM LIGHTING/DAYLIGHTING

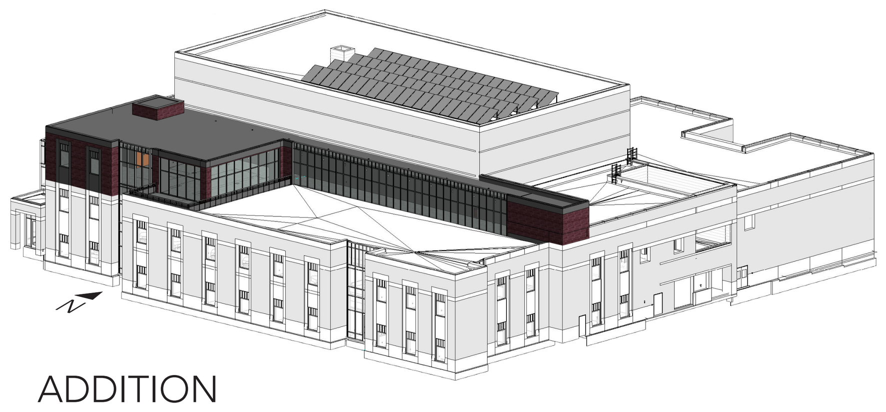


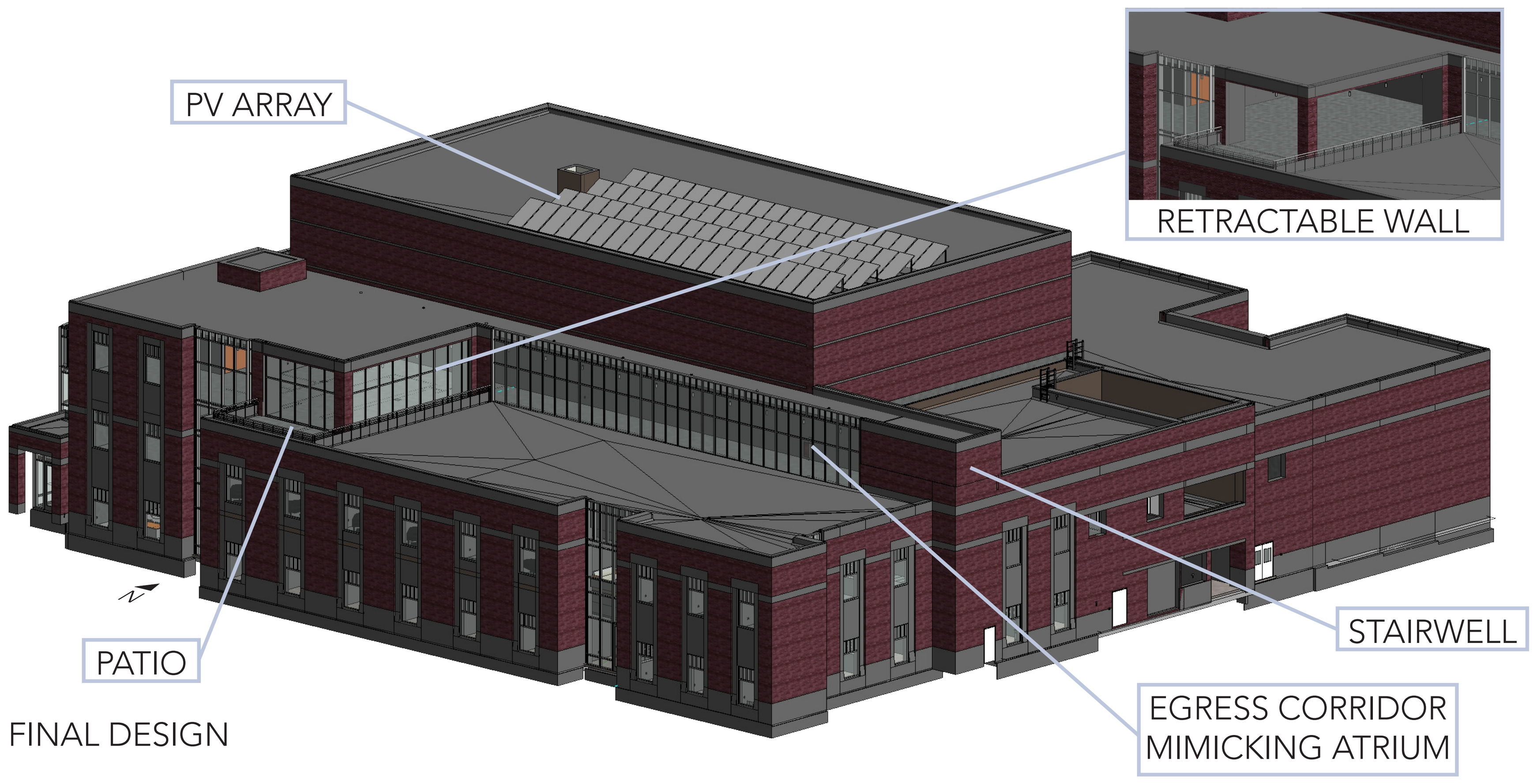
## ROOFTOP AMENITY SPACE



BEFORE



ADDITION




FINAL DESIGN

## INDUSTRY COLLABORATION

28 INDUSTRY MENTORS + 23 INDUSTRY EVALUATORS

$551,250.00

WORTH OF DONATED TIME

**MENTORS:** Three teams of mentors consisting of Architects, Structural Engineers, Mechanical Engineers, and Electrical Engineers supported the three student teams in the course. The mentors attended class and provided weekly guidance and direction to the students through each phase of the design.

**SPECIALTY MENTORS:** One expert in acoustics and one expert in construction were available to students as needed.

**EVALUATORS:** Professional Engineers and Architects reviewed student documents and presentations at each milestone. Through written comments and Q&A opportunities after presentations the evaluators challenged students to continuously improve their designs.

## KNOWLEDGE & SKILLS GAINED

Working on the project over two semesters provided Horizon Engineers the opportunity to practice soft and technical skills related to the Architecture/Engineering design industry.

**SOFT SKILLS:**
- Communication
  - Written, Verbal & Nonverbal
  - Public Speaking
- Critical Thinking
  - Interactive Design
  - Problem Solving
- Leadership
  - Conflict Resolution
  - Delegation
- Teamwork
  - Accept Feedback
  - Team Building
  - Working Collaboratively
- Work Ethic
  - Punctuality
  - Time Management

**TECHNICAL SKILLS:**
- Structural
  - Software: Revit 2019, RAM Structural System, Tedds
  - Timber Design
  - Diaphragm Rigidity Analysis
- Mechanical
  - Software: Revit 2019, Trane Trace 700, Autocad 2019, Odeon 14
  - Primary and Secondary System Calculations and Design
  - Plumbing System Calculation and Design
  - Acoustic Modeling
- Electrical
  - Software: Revit 2019, Navisworks, 3DS, SKM Powertools, Honeybee
  - Power Distribution Design
  - Lighting Design
  - Special Systems Design

## HEALTH, SAFETY & WELFARE

The rooftop amenity space was designed to be accessible to students year round as well as serving as an event space for community involvement. This posed a programmatic challenge when determining access points for both students and community while keeping secured parts of the building inaccessible. Additional design decisions are listed below:

**MECHANICAL:** With acoustics as a driving decision for design, mechanical systems, including plumbing and fire protection, are designed for low noise generation to eliminate distraction from fans, ductwork, and piping. Air supplied at low velocities from the underfloor air systems helps reduce HVAC noise in the concert hall and atrium, improving the occupant experience. CO2 sensors are used to integrate demand control ventilation in high density spaces such as the concert hall and recital rooms and provides healthy levels of outdoor air based on the CO2 generated in the space. A wet-pipe fire protection system serves the entire building and provides safety in case of a fire.

**ELECTRICAL:** Fire alarm systems were designed in conjunction with a emergency communication system to give the university a means to communicate in emergency situations. Access control and CCTV systems allow for ease of secured access and monitoring of the facility while allowing for community involvement in the facility.

## LIGHTING DESIGN

ATRIUM

ATRIUM

CONCERT HALL

ROOFTOP AMENITY SPACE

ROOFTOP AMENITY SPACE

| PROJECT ISSUED | COORDINATION PLAN | CODE ANALYSIS | SCHEMATIC DESIGN | DESIGN DEVELOPMENT #1 | DESIGN DEVELOPMENT #2 | CONSTRUCTION DOCUMENTS |
|---|---|---|---|---|---|---|
| July 2018 | September 2018 | September 2018 | October 2018 | December 2018 | February 2019 | April 2019 |

# *Jack H. Miller Center for Musical Arts – Hope College*

**Project Description**

As a capstone exercise, student architectural engineering teams, working with a budget of $25 million, were tasked with completing engineered designs of the structural, mechanical, and electrical systems for the Jack H. Miller Center for Musical Arts, a new addition to the Hope College campus in Holland, Michigan. The center is to provide Hope College with a building that has superior acoustics, integrated timber or engineered wood throughout 25% of the building, and a rooftop amenity space that can be used year-round. Student teams were challenged to find integrative and innovative design solutions to meet these criteria. Emphasizing user experience, acoustic performance, and sustainability, the design scope included the entirety of the building, with special focus on the concert and recital spaces.

The Jack H. Miller Center for Musical Arts is a 64,000 $ft^2$ facility with an 800-seat concert hall, a 125-seat recital hall for small performances, and additional spaces including academic spaces, rehearsal and recording rooms, faculty studios, and offices. The finished design will feature a rooftop amenity space to provide a social setting before and after performances or for special events. Situated on the northeast edge of campus bordering downtown, the center serves as a gateway to Hope's campus.

Student engineers addressed unique design challenges with a collaborative approach, fully integrating the structural, mechanical, acoustical, and electrical and lighting systems. Each team consisted of two mechanical, three structural, and five electrical engineering students who were assigned a mentoring team of professional architects and engineers. The overarching goal of this two-semester immersive activity was to develop excellence in architectural engineering students and prepare them for realistic career experiences by carrying out a fully-integrated, multi-disciplinary approach to the planning and design of cutting edge, operational, high-quality building systems under the guidance of a total of 51 industry volunteers. These volunteers included 36 licensed PEs and other professionals who acted as either mentors (28) or evaluators (23) for the following team presentation deliverables:

- Collaboration Plan
- Architectural Design
- Past Projects Research
- Research
- Schematic Design (SD)
- Design Development 1 (DD1)
- Design Development 2 (DD2)
- Design Development 3 (DD3)
- Construction Documents (CD)

Each team's integrated approach was applied to engineering system decisions during preliminary research, schematic design, and design development phases. 3D Autodesk Revit models were utilized, and engineering designs were developed to enhance occupant health, safety, and comfort with daylighting, acoustic design, mechanical ventilation for indoor air quality, and controlling structural vibration. Through interdisciplinary collaboration and conscientious design choices, teams were able to create cohesive and quality designs that achieved both LEED and WELL Silver Certification requirements. Design highlights showing extensive consideration of user experience and sustainability are detailed in the sections below.

*Superior Acoustics*

The designs offer an acoustically superior concert hall that can serve as a speaking or music venue. Though built in to the design as an option, electronic amplification during performances can be avoided due to adjustable wooden reflector panels that were designed using the acoustic modeling software Odeon. These will fill the audience space with full and vibrant sound while creating a functional aesthetic and integrating locally-sourced timber into the design. Since the reflectors are movable, they offer variable acoustics for different types of performances, lectures, and events. To amplify the enjoyment of the center, the mechanical systems were designed to provide quiet, comfortable spaces that allow users to express their creativity and to fully experience the artistic music of students, faculty, and visitors.

*Integrated Timber or Engineered Wood*

Much of the timber was showcased in the atrium as it is considered the focal point of the center, serving as a gateway to the Hope College campus. Teams generally chose exposed structural dowel laminated timber (DLT) panels in high-traffic building areas and DLT acoustic squares to integrate structural timber with acoustic properties. Hollow glulam battened columns in the lobby were also designed to promote integration of timber throughout the high-traffic spaces, providing aesthetics to structural and acoustical considerations. In each design, the main staircase in the atrium was designed entirely of timber, choosing woods with sustainable and local sourcing a priority.

*Rooftop Amenity Space*

For the requested rooftop amenity space, which is to hold at least 100 occupants. The teams designed the architectural elements as well as the engineered systems. As such, each team featured a retractable wall system to be both flexible and weather responsive. When the retractable wall is open, the space expands onto a patio, in some cases doubling the occupancy.

The lighting design carries the musical theme of the building to the rooftop space with inspiration from Chopin while a 30 kW photovoltaic system offsets the additional electrical load of the space and feeds back into the entire distribution system.

Structural elements were increased framing member sizes to resist the higher loads, a raised deck system to allow for better drainage and to better dissipate vibrations, and increased deflection criteria to L/720 for the framing members that support the retractable wall system.

To accommodate the weather responsiveness of the rooftop amenity space, mixed-mode ventilation was designed. This ventilation strategy utilizes natural ventilation when the retractable wall system is open, and terminal boxes are reduced to minimum airflow to circulate air within the space. When the retractable wall system is closed, the air handler functions to maintain the space setpoint using a dedicated variable air volume air handler with a chilled water coil, and variable air volume boxes with hot water reheat.

**Collaboration of Faculty, Students, and Licensed Professional Engineers**

Students and their engineering and architectural mentors addressed design challenges and developed solutions through extensive use of in-person meetings, phone calls, emails, cloud-storage document sharing, and teleconferencing. This allowed for rich collaboration with industry professionals, maximizing access to their valuable time and input. Team members utilized these methods for subdiscipline discussions and seamless discipline integration. The presentation of progress points throughout the process were evaluated by licensed professionals both in person and from around the united states using teleconferencing.

Over the two semesters the student teams worked with their mentors, progress point deliverables were documentation and presentation of a Coordination Plan, Project Research, Schematic Design (SD) with an SD progress report, two Design Development (DD) submissions, both with progress reports, and two Construction Document (CD) submissions, both with progress reports. All the submissions and presentations were evaluated with significant feedback from the evaluation professionals.

*Structural*

The structural team designed the foundation systems of spread and strip footings, gravity systems of steel and timber framing members, and the lateral systems with shear walls, brace frames, and moment frames. There was a focus on timber design and a columnless balcony for the concert hall.

Per the geotechnical report provided, a high bearing pressure of 4500 psf was able to be used. To be able to adequately resist applied forces teams designed shallow foundations. Under columns, spread footings were used, and under precast shear walls, strip footings are used.

For the gravity system, all loads were found using ASCE 7-10 and designed in RAM Structural System. To meet the owner's goal of using 25% timber for the structure, timber was designed for areas that would better showcase aesthetics and have lower loads. Timber moment frames were utilized in the atrium and were completely framed using glulam members. Other spaces throughout the building used wide flange framing members and HSS columns, except the concert hall framing where the members are steel joists.

The systems selected for resisting lateral loads were precast concrete shear walls, steel brace frames, and timber moment frames. The structural team decided to locate precast concrete shear walls around the concert hall, recital, orchestral rehearsal, choral rehearsal, and on the south side of the building. The shear walls were designed to be 15" thick around concert hall to have the desired acoustic rating, and 12" thick everywhere else. Steel brace frames were utilized in the south and east side of the building to provide further stability to the building.

Two locations that provided extra challenges to the design were the concert hall and the rooftop amenity space. To accomplish the columnless balcony design, one major beam was used to support most of the load with cantilevers supporting the rest. This caused a very large member of W40X167 to be used. To help with the massive bearing stress at the end of the beam, pilasters are used to spread the load into the foundation. An expansion joint was located around the entire perimeter of the concert hall at every level, totally isolating the concert hall from the rest of the building and limiting the amount of vibrations that transfer into the space.

The rooftop amenity space has much higher load and vibration considerations for the minimum 100-person capacity. To handle the higher loads, framing members below the space were increased in size. The foundations below the columns are increased as well to adequately transfer loads into the ground. Increased floor vibrations coming from the space were largely dissipated through a raised deck system before they transfer to the main structure.

*Mechanical*

The mechanical teams designed the heating, ventilation, air-conditioning, plumbing, and fire protection systems and led the design of acoustic system solutions.

With a focus on the end-user experience of each space, these systems were designed for low generation, maximum occupant comfort, and sustainability. The primary heating and cooling systems included heat recovery chillers and high efficiency condensing boilers. Secondary systems included variable volume air handlers with chilling and heating water coils, active chilled beams, variable air volume terminal boxes with hot water reheat, and hydronic radiant heating. Plumbing systems include domestic water, sanitary and storm drainage, and natural gas. Fire protection systems include a wet pipe system and fire and smoke dampers.

*High level acoustic systems*

Heat recovery chillers recover heat from the condenser loop that would normally be rejected to the atmosphere. To utilize the recovered heat, the condenser operates at higher temperatures than normal operating temperatures when simultaneous heating and cooling loads occur. Heat recovery also reduces the amount of gas consumed for the heating system because the boilers are not used as frequently for heating. This solution leads to a more sustainable primary system.

Because of the noise sensitivity of most of the spaces within the building, active chilled beams are used to reduce noise from fans and rely on less ductwork. The outdoor air supplied to the active chilled beams is provided by an energy recovery unit that uses return air from the spaces to precondition the outdoor air before it is rejected outdoors. This solution improves energy efficiency and sustainability, while improving occupant acoustic comfort.

An underfloor air system is used in both the atrium and concert hall. This system supplies air from the floor and returns overhead. Ducts are routed underground using BlueDuct which meets insulation requirements for underground ducts. These ducts are routed to air distribution boxes which are evenly embedded in the slab to act as a duct. As the air moves throughout the slab, it either heats or cools the slab using conduction and radiation. As the air travels through the metal forms, it is introduced into the space through a linear slot diffuser around the perimeter of the atrium and concert hall seating area. In the tiered seating and balcony, linear slots are located under the seating, provides a high level of comfort due to proximity.

Specialty building acoustic systems are included throughout the building. Sound absorption panels are located on the walls to reduce reverberation in musical spaces. Sound and vibration control measures were taken for all electrical and mechanical equipment to reduce noise throughout the building. Vibration isolators, inertia base pads, and acoustic hangers were all selected based on the specific piece of equipment they correspond to.

In the concert hall, variable acoustics are provided through adjustable absorptive curtains along the back and side walls as well as wooden reflectors over the stage and audience space to control and direct sound in the concert hall. The curtains and reflectors are easily controlled from a single user interface panel.

*Lighting and Electrical*

The electrical team designed innovative systems to integrate with the structural and mechanical considerations. These designs included a battery backup power system, inspirational lighting, and support for low-voltage systems, including audio-visual (AV).

In order to support the emphasis on sustainability mentioned above, the electrical team not only designed the previously mentioned photovoltaic system, an all battery backup system was implemented to carry emergency and optional standby loads, avoiding a more common but noisier, less environmentally friendly generator. Three battery systems were designed per specific emergency requirements outlined in the National Electrical Code.

One system for emergency illumination and exit signage was powered by a 12.5 kW lighting inverter system. The lighting inverter utilizes a battery cabinet to power loads for 110 minutes in the event of a normal power failure. An optional standby system was designed for two functions: to power IT and AV equipment in the event of a normal power failure, and to power the concert hall. Around 95% of all utility power failures last only a few seconds. This system was designed to prevent a minor power failure from interrupting lighting and receptacle loads in the concert hall during a performance. It will carry the load for twenty minutes to allow for normal power to be restored and stabilize but not require backup of other building systems such as mechanical equipment or restrooms.

The optional standby system is comprised of a centralized UPS and batteries. The UPS has double-conversion, interactive typology with a manual bypass feature for maintenance. This will provide power conditioning to sensitive IT and AV loads while also providing backup during normal power failure. This system has an automatic bypass which is only used in the event of an inverter failure. The UPS has been sized to 160 KVA to provide 20-minute backup of concert hall loads and IT/AV loads.

All batteries in the UPS are lithium-ion type. Lithium-ion batteries have numerous benefits over typical VLRA batteries including reduced volume and weight, faster charging time and longer life. According to a study conducted in 2013 by the NFPA, lithium-ion batteries do not vent and their use will minimize the ventilation needs in the location where batteries are being stored.

In terms of inspiration, music is an art form with an impressive and recognizable list of grand masters. One team's lighting concepts were built around the words "Influential Flow." The aim was to add an influencing aspect to some spaces within the building for not only the musicians, but all visitors, and to enhance and promote the purpose of the building: learning. Each main space's lighting design is influenced by musicians' characters such as Ludwig van Beethoven, Frederic Chopin, and Wolfgang Amadeus Mozart. Different colored LED lights are used throughout the building as subtle highlights to areas of interest. The team's lighting approach is to have a design that is used to direct the flow of traffic and create a clear and easy understanding of space and the movement of people within. The pathways to the main spaces have a visual rhythm, like musical bars in the ceiling. The main spaces of the building are highlighted to direct visitors and students. Those highlighted spaces include the atrium, concert hall, recital halls, and the rooftop.

The Audio/Visual (AV) design supports the functionality of the concert hall, music spaces, atrium, and classroom spaces. The AV system can broadly be divided into two main functions: sound reinforcement and visual display. All A/V systems are controlled with an integrated display that is easy for the end-user to understand. The system can turn devices on and off, select which inputs to display, and control volume.

**Protection of Public Health, Safety and Welfare**

The safety and security measures necessary in this project made clear to students the weight that engineering decisions carry. Public safety is of utmost concern and must be considered in all design decisions. Since every design decision made impacts other facets of the project, interdisciplinary coordination is key. Layered safety and security design solutions provide a range of safety and security measures to allow for the variety of occupancies in a multi-use space.

In order to protect occupants and the property a fire sprinkler system was a high priority and was designed according to NFPA 13 2010 edition and adhere to local AHJ codes and standards. The fire alarm system utilizes a range of smoke, heat, and mechanical equipment fire detection devices that tie back into the fire alarm control panel for activating the notification and evacuation devices in the building in the case of an emergency evacuation procedure. Fire alarm systems were designed in conjunction with the university emergency communication system. The rooftop amenity space was designed to be accessible to students year-round as well as serving as an event space for community involvement. This posed a programmatic challenge when determining access points for both students and the public while keeping secured parts of the building inaccessible. An integrated network-based security system was designed. Access control, CCTV systems, and network connectivity allow for security monitoring and management of surveillance cameras, card readers, and other security equipment. Emergency lighting powered by an emergency inverter provides egress illumination.

Conservative loading was used to size structural members. A minimal floor load of 100 psf was applied throughout the first and second floors, with 150 psf for mechanical spaces. Additionally, knee braces were added to timber frames to ensure each frame can resist wind loads, and an expansion joint was added to ensure the integrity of the first-floor diaphragm.

Public health and welfare were further addressed by designing for occupant health, productivity, and comfort through mechanical, acoustical, daylighting, and structural floor vibration design, pursuing WELL certification. Design features that incorporate indoor air quality standards were met for the mechanical system design with proper ventilation and exhaust movement. Daylighting also promotes occupant well-being, while decreasing energy use, which in turn decreases the potential public health effects due to energy production. Additionally, design decisions were made to present an attractive gateway to the Hope campus. The atrium design, which includes a large curtain wall, exposed timber, and accent lighting, was designed as a beacon to draw members of the public into the building and to encourage attendance at performances and events.

**Multidiscipline and/or Allied Profession Participation**

For this engineering capstone project, three student design teams, consisting of nine or ten mechanical, structural, and electrical option students each, received support and constructive feedback from professional engineers, professional architects, acoustical consultants and faculty advisors in architectural and construction engineering. Each team was assigned a full set of professional mentors to include one or two architects, several engineers (structural, mechanical, and electrical) and an acoustical consultant. There were 28 non-faculty mentors in all – 20 PEs or SEs, 3 EIs, four professional architects and an acoustical consultant.

After each design milestone, teams were required to present a narrative showcasing the progress of their designs within each discipline. Another set of professionals participated as evaluators, providing feedback on presentation and document submissions. This group included 16 PEs or SEs and 7 EIs, for a total of 23. They graded the presentations according to a competition rubric. Follow-up questions and comments were then discussed with the professionals. This allowed students the opportunity to defend and improve their design. The presentation and discussion process was designed to simulate a professional setting.

**Knowledge or Skills Gained**

The student participants gained real-world skills as a result of this collaborative effort. First, using an actual building design project provided an opportunity to consider synthesis and integration outside of theoretical parameters. It gave the students the opportunity, not only to form their own interdisciplinary approach, but to witness and learn from people who have made their life's work on this very basis. By having industry mentors, the students became better prepared to enter the profession with a clear understanding of the skills a “Complete Engineer must develop and possess.

Further, professionals gave feedback at periodic phase presentations, which challenged the students to accept criticism, learn from it, and continue to fine-tune their projects for a wholly realistic design. Finally, this close relationship illuminated the different opportunities and specializations available to pursue as a career and created potential connections for future employment or collaboration when the students have transitioned into professional engineers, themselves. The significant guidance and evaluation of over 50 experienced professionals raised the bar by having the expectation of real, workable solutions to inherent problems in design. The value of professional input was made clear from day one, which made students take this investment in their work very seriously.

ESSENTIAL SKILLS:

- Communication
- Written, Verbal & Nonverbal
- Public Speaking
- Critical Thinking
- Interactive Design
- Problem Solving
- Leadership
- Conflict Resolution
- Delegation
- Teamwork
- Accept Feedback
- Team Building
- Working Collaboratively
- Work Ethic
- Punctuality
- Time Management

TECHNICAL SKILLS:

- Structural
- Software: Revit 2019, RAM Structural System, Tedds
- Timber Design
- Diaphragm Rigidity Analysis
- Mechanical
- Software: Revit 2019, Trane Trace 700, Autocad 2019, Odeon 14
- Primary and Secondary System Calculations and Design
- Plumbing System Calculation and Design
- Acoustic Modeling
- Electrical
- Software: Revit 2019, Navisworks, 3DS, SKM Powertools, Honeybee
- Power Distribution Design
- Lighting Design
- Special Systems Design

# Jack H. Miller Center for Musical Arts – Hope College


**Abstract**

This project brought together Master of Architectural Engineering students to create an interdisciplinary design team consisting of structural, mechanical, and electrical subdisciplines. Each team, and each discipline, was assisted by industry professional engineering mentors, and presentations of important milestone phases were evaluated by other professional volunteers. Three separate multidisciplinary teams of nine or ten students each were challenged to design the structural, mechanical, and electrical systems for the new Jack H. Miller Center for Musical Arts on the Hope College campus in Holland, Michigan. This new facility is 64,000 $ft^2$ and houses an 800-seat concert hall with floor and raised seating as well as a 125-seat recital hall for small performances. Additional spaces include rehearsal and recording rooms, faculty studios, practice rooms, offices, and a large two-story atrium off the main concourse of the university. The center is to provide Hope College with a building that has superior acoustics, integrated timber or engineered wood throughout 25% of the building, and a rooftop amenity space that can be used year-round. Student teams were challenged to find integrative and innovative design solutions to meet these criteria. Emphasizing user experience, acoustic performance, and sustainability, the design scope included the entirety of the building, with special focus on the concert and recital spaces.

Over 50 professionals, consisting of 36 PEs, 10 EIs, 4 Architects, and one other specialist, volunteered their time to mentor student teams or serve as evaluators for presentations of milestone deliverables. So the students could have a clear understanding and appreciation of the significance of input from industry mentors and evaluators, they estimated the monetary value of volunteers' time using an average standard hourly rate and determined professionals' contributions to this two-semester capstone experience was valued at over a half-million dollars! The overarching goal of this immersive activity was to develop excellence in architectural engineering students and prepare them for realistic career experiences by carrying out a fully-integrated, multi-disciplinary approach to the planning and design of cutting edge, operational, high-quality building systems.