AEI Student Design Competition
Team 2020-03
April 15, 2020
War Memorial Hall

Project Description

Virginia Tech University

- 1924 Head House
- 1972 addition
- Over 200,000 sq. ft
- $45 million
Slide 3

DR3  Possibly make a better graphic for this slide like the Team Roster and Project Goals
Dalton Rabe, 3/8/2020

Slide 4

DR13  Background is made. Just needs to be inserted
Dalton Rabe, 3/10/2020
War Memorial Hall

Client's Requests

LEED Silver

30% Façade Energy Improvement

sDA 40%

Façade Design Integrates 1924 Head House

Natural Ventilation Strategies

Sandy Hall on Virginia Tech Campus

Project Goals

• Overall Team Goals
  • Update the user experience
  • Promote all forms of wellness
  • Create a Heart of campus
  • Be sure to bring these up throughout the presentation as often as possible
mess with opacity or outline for callout boxes

Meredith Butler, 3/8/2020
## Codes & Standards

### General:
- 2015 Virginia Construction Code with Amendments
- 2015 IECC – Virginia Revisions

### Structural:
- ASCE 7-10 – Minimum Design Loads
- AISE Steel Construction Manual 14th Edition
- AIC 318-14

### Electrical:
- 2014 NFPA 70
- IES Handbook 10th Edition

### Mechanical:
- Applicable ASHRAE Standards
- Indoor Swimming Pools - ASHRAE
- Geothermal Heating & Cooling – ASHRAE
Site Orientation

45° West of North
- North façades have eastern and western sun exposure.
- Southern facades glare potential due to low angles of the sun.

Not Provided at Site
District Chilled Water

Central Plant Utilities

Provided at Site
High Pressure Steam
12.47 kV 3-Phase

https://www.facilities.vt.edu/energy-utilities/central-steam-plant.html
Hydrant Flow Test

Fire Protection System Demand

Domestic Water System Demand

Flow Hydrant Test Curve

Electrical Site Plan
Geotechnical and Geothermal

Geotechnical report
- Soil composition: disintegrated rock
- Allowable soil bearing: 6,000 PSF
- Frost depth: 2.5ft
- Lateral earth pressure: 42psf/ft

45'-60' Silt, clay, & sand
240'-255' loose limestone

4 other vertical bore projects on campus
Source: Rorrer Drilling

(2015) Department of Conservation and Economic Development

Rainwater Harvesting

- Capture **2.6M gallons** per year
- Savings of **$23,035**
Construction Considerations

- Worker safety on site
- Ease of installation
- Minimize construction time
Lighting Concept

Virginia Tech invents the **FUTURE** but does not forget the **PAST**

Façade

Head House

Original 1924 West Elevation
Façade Lighting

- Lantern effect
  - Façade preservation
  - Enhances windows
  - Draws people inwards

- Uplighting
  - Enhance vertical elements

Daylighting

Addition of Glazing

- Glazing in exercise spaces
- Operable windows in office and classrooms
- Clerestory in the natatorium
Daylighting

Addition of Skylights

- Gymnasium
- Spinning Room
- Corridors
- Collaboration Space
- Open Offices

Skylight Layout

Daylighting

Analysis

Spatial daylight autonomy
- sDA of existing building: 17%
- sDA of the Goliath's Design: 48%
Daylighting

Glare Mitigation

Honeycomb glass
  • Thin inserts to maximize view to the outdoor
  • Reduces HVAC load

Automated shading
  • Classrooms and offices

Natural Ventilation

Foehn Wind Capture

Dissipating Clouds
Foehn Winds
Adiabatic Heating
5 1/2°F per 1000'

Strategically placed louvers
Natural Ventilation
Operable Windows

Operable windows in office and classrooms

Natural Ventilation
Active Green Walls

Active green walls in Link and bouldering room
Plants selection

- Upright growing habits
- East entrance and bouldering room requires 25 to 80 footcandles
- West entrance requires 80 to 400 footcandle
- Recommended illuminance for 12 to 15 hours a day

<table>
<thead>
<tr>
<th>Light Level</th>
<th>Location in the Building</th>
<th>Artificial Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intense Light</td>
<td>Unshaded light for most of the day</td>
<td>Range of 400 fc to 600 fc for 12 to 15 hours</td>
</tr>
<tr>
<td>Bright Light</td>
<td>Direct sun from south or west exposure where 2 or hours of direct sun</td>
<td>Range of 400 fc to 600 fc for 12 to 15 hours per day</td>
</tr>
<tr>
<td>Medium Light</td>
<td>Direct Light in morning and afternoons</td>
<td>Range of 80 fc to 400 fc for 12 to 15 hours per day</td>
</tr>
<tr>
<td>Low Light</td>
<td>North and east daylight exposure</td>
<td>Range of 25 fc to 80 fc for 12 to 15 hours per day</td>
</tr>
</tbody>
</table>

Lamp beam angle

- 30° beam angle is used toward the top of the wall
- 15° beam angle is used for half of the wall
Façade Intervention
Phase Change Insulation

Locations
• 1972 replacement
• In addition to normal insulation in wall assembly

Benefits
• Shifts peak times
• Made from renewable sources

Façade Performance

• WTWR: 0.07<0.26
• Energy Savings of 33%
  • 22% from Phase Change Insulation

1972 WALL SECTION 1972
PROPOSED WALL SECTION
Why are the bullet points on this side?
Dalton Rabe, 3/8/2020
Roof Coordination

Cooling Tower 12.6 kips
L: 8’, W:12’, H:15’

Property line sound level goals:
- Day – 60 dBA
- Night – 50 dBA

Sound barrier walls not needed
- Cost savings
- Improved equipment performance
- Reduced structural load

Total: <47 dBA
Storm Drainage Plan

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPHEMIC DRAIN</td>
</tr>
<tr>
<td></td>
<td>STORM DRAIN</td>
</tr>
<tr>
<td></td>
<td>OVERFLOW DRAIN</td>
</tr>
<tr>
<td></td>
<td>DIRECTION</td>
</tr>
</tbody>
</table>

Natatorium

**Structural**
- DLH joist depth

**Daylighting**
- Clerestory
- Frosted glazing

**Mechanical**
- Aluminum duct
- Condensation

**Electrical**
- PV modules

**Acoustics**
- Ceiling baffles
- Acoustical spray

**Lighting**
- Indirect
DR6 Adjust to match the Client Goals slide or vice versa?
Dalton Rabe, 3/8/2020
Natatorium

Natatorium Unit & Condensers

Natatorium unit
- Designed to maintain 55% RH
- 75-ton total cooling capacity
- 500 MBH heat recovery/heat rejection

Condensers
- Air-cooled

Pool pumps
- Full redundancy
- Sized for 6-hour circulation time
  - Section 407.2 2015 ISPSC

Steam heat exchanger
- 120 GPM capacity
- Sized at partial load because of heat recovery
Natatorium

Pool Foundations

Considered Conditions

8" Reinforced slab
- Minimize cracking and leaking
- Transfer the weight of water to soil

Cantilevered retaining wall

Indirect lighting
- Minimize glare
- Ease of maintenance

Class IV Illuminance
- 300 Lux required
- 392 Lux achieved
Slide 45

MB11 update detail and revit image
Meredith Butler, 3/8/2020

Slide 46

DR7 Inconsistent Key Plan
Dalton Rabe, 3/8/2020
Natatorium

Acoustics

- RT goal: 1.5 sec
- Calculated RT: 1.35 sec

Wall panels

Baffles

Acoustical spray finish

Head House

Expansion Joints

4" Floor Joints

4" Wall Joints

Floor expansion joint

Wall expansion join
Slide 47

**MB12** match large call out style (nat section & client needs)
Meredith Butler, 3/8/2020

Slide 48

**DR9** Why is the blended picture frame only used here?
Dalton Rabe, 3/8/2020

**MB13** update the images
Meredith Butler, 3/8/2020

**AL1** DONE
Ali Mujtaba Mohamed Al Lawati, 3/8/2020
Head House
Helical Piles

- Optimizing geothermal header location
- Maintaining structural integrity of Head House
Head House

Historical Preservation - Lobby

- No conditioning prior
- Underfloor air

Historical Preservation - Lighting

- Keep chandeliers from 1924
- LED replacement lamps
DR10 inconsistent key plan
Dalton Rabe, 3/8/2020
• NW concrete slab on metal deck
• Composite beams at 9'-3" O.C. maximum for floor system
• Joist at 5'-0" O.C. for roof system
**Structural – Example Columns**

- **HSS6x6x1/4**
- **W10x33**

**Truss**

- **91'-2" Span**
- **Panel points**
  - interior 9'-3"
  - end span 8'-7"
Structural

Transfer Beams Above Truss

Benefits
- Eliminates moment in chord
- Axial load member analysis

Design
- Span between floor beam where columns bear
- Carries column load to panel points

Structural – Lateral Locations
Structural – Typical Lateral Braced Frames

Typical Footing Design:

**Typical sizes:**
- 4'x4'
- 5'x5'
- 6'x6'

**Footing thickness:**
- 12 – 30''

**Footing depth:**
- 16'' below top of slab on grade
Why are bullet points on the right?
Dalton Rabe, 3/8/2020
Emergency Electrical Room

Normal Power One-Line
- 336 Photovoltaic modules
- 110,880 Nameplate wattage
- 15 Year payback
Lighting Controls

Layering lighting components
• Ambient lighting
• Task lighting
• Accent lighting

Lighting controls
• Occupancy sensors
• Daylight responsive controls
• Scene controls

Special Systems Overview

• Communications
• Fire Alarm
• Access Control
• Security
• Audiovisual
• Lightning Protection

Restriction Access Level 0
Restriction Access Level 1
Restriction Access Level 2
Restriction Access Level 3
Telecommunication Riser Diagram

Stacked telecommunication rooms
HVAC Load Calculations

- **Head House**
  - 63 Tons
  - 436 MBH

- **Natatorium**
  - 75 Tons
  - 316 MBH

- **Offices/Classrooms**
  - 340 Tons
  - 3477 MBH

- **Gymnasiums**
  - 57 Tons
  - 661 MBH

- **Summaries**
  - 355 SF/Tons
  - 26 BTUH/SF
Mechanical System Schematic

- HVAC System Schematic

Geothermal

- (218) ¾” bores
- 300’ depth
- 12 zones
Cooling Tower

- Sized for 26% of cooling demand
- Remaining heat rejection is covered by the bore field

Energy Recovery Ventilators

- Wheel type
- Condenser water connection for dehumidification at unit
- Effectiveness of 84-92%
- Instant to 2.5-year simple payback
- Provides +$34,000 energy savings per year
Mechanical Noise

- Silencers at intake and discharge of ERVs

Secondary Systems

- Water Source Heat Pumps
  - 1-1/2" CSR SERVING WSHPs (16 GPM)
- Water Cooled VRF
Energy Performance of the System

- 33% “free energy”
- 64% energy savings per year

Domestic Water Riser

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Demand</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUS</td>
<td>769</td>
<td>208 GPM</td>
<td>5” CW Entrance</td>
</tr>
<tr>
<td>CWFU</td>
<td>688</td>
<td>177 GPM</td>
<td>4” CW</td>
</tr>
<tr>
<td>HWFU</td>
<td>224</td>
<td>95.5 GPM</td>
<td>3” HW</td>
</tr>
<tr>
<td>WFU</td>
<td>684</td>
<td>-</td>
<td>6” SAN</td>
</tr>
</tbody>
</table>
Domestic Hot Water

Semi-instant steam water heater
• 84 GPM capacity

Acoustics

Sound Transmission Class (STC)

STC 50
Classrooms

STC 55
Exercise

STC 60
Mechanical

STC 40-45
Offices
### Acoustics

**Impact Insulation Class (IIC)**

**Gyms and exercise classrooms**
- Floating wood floor
- IIC 64

**Teaching weight room**
- Rubber athletic flooring and underlayment
- IIC 75

**Open exercise**
- Rubber athletic flooring
- IIC 58

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### Acoustics

**Reverberation Time**

#### Gym
- Impact-resistant wall panels

#### Classrooms
- Acoustical ceiling tile
- Wall panels
- Carpet

<table>
<thead>
<tr>
<th>Room</th>
<th>Max Recommended RT (sec)</th>
<th>Calculated RT (sec)</th>
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</thead>
<tbody>
<tr>
<td>Level 1 Gym</td>
<td>1.5</td>
<td>1.07</td>
</tr>
<tr>
<td>Level 2 Gym</td>
<td>1.5</td>
<td>1.10</td>
</tr>
<tr>
<td>Classrooms</td>
<td>0.6</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Selected Systems

**Structural**

- **Gravity System**: Non composite roof and composite floor systems supported by steel framing and steel columns.
- **Lateral System**: Lateral loads are supported using steel braced frames and a single moment frame.
- **Foundation System**: The design includes shallow foundations, helical piles, and composite foundations.)
### Electrical

**Power**
- 2500 A, 480/277V, 3Φ, 4 w main
- 200 kW generator

**Lighting**
- LED Fixtures were selected for life, efficiency and occupants’ comfort
- 48% sDA was achieved

**Systems**
- Lightning Protection System
- Speaker/Strobe Fire Alarm System

### Mechanical

**Primary Systems**
- Geothermal field + cooling tower + steam heat exchanger = Hybrid System

**Secondary Systems**
- Water Source Heat Pumps
- Water Cooled VRF

**Rain Harvesting**
- Cistern
## LEED Certification

### LEED v4 for BD+C: New Construction and Major Renovation

**Project: CheckMark**

### LEED Certification Points

- **Materials and Resources:**
  - **Storage and Collection of Recyclables:** Required
  - **Construction and Demolition Waste Management:** Planning Required
  - **Building Lifecycle Impact Reduction:** New Material Product Disclosure and Optimization (Environmental Product) Required
  - **Building Lifecycle Impact Reduction:** New Material Product Disclosure and Optimization (Material Transparency) Required
  - **Building Lifecycle Impact Reduction:** New Material Product Disclosure and Optimization (Material Innovation) Required
  - **Construction and Demolition Waste Management:** Construction and Demolition Waste Management Planning Required

- **Innovation:**
  - **LEED Accredited Professional:** 1

### Cost Considerations

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
<th>Percentage of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>$7.95 million</td>
<td>18%</td>
</tr>
<tr>
<td>Electrical</td>
<td>$6.73 million</td>
<td>15%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>$12.02 million</td>
<td>27%</td>
</tr>
<tr>
<td>Architectural</td>
<td>$18.00 million</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$44.70 million</strong></td>
<td><strong>40%</strong></td>
</tr>
</tbody>
</table>

### Breakdown

- **Electrical Breakout:**
  - Power: 37%
  - Lighting: 37%
  - Communications: 13%
  - Emergency: 5%
  - Lighting: 4%

- **Mechanical Breakout:**
  - Mechanical: 76%
  - Plumbing: 17%
  - Mechanical: 13%
  - Electrical: 11%

- **Fire Protection:**
  - Detection: 3%
  - Suppression: 7%

- **Building Systems:**
  - Structural: 18%
  - Architectural: 40%
  - Mechanical: 27%
  - Electrical: 15%
  - Counterfort Wall: 6%
  - Basement Wall: 7%