Team River
Winter Presentation
<table>
<thead>
<tr>
<th>Category</th>
<th>Strategy</th>
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<tr>
<td>Architecture</td>
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<td>Low VOC Materials &amp; Finishes</td>
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<tr>
<td>Structural</td>
<td>Sustainable Timber</td>
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<tr>
<td>Construction</td>
<td>Dust Minimization</td>
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<tr>
<td>Life Cycle Financial</td>
<td>Consistent Filter &amp; Equipment Maintenance</td>
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</tbody>
</table>

Air Quality Challenge
Weimar, Germany
Normal water level

Worst flood last 100 years - 8'

Worst case future scenario - 12'

Potential Flooding Challenge

Source: http://www.ukrivers.net/climate.html 10 Feb 2016
‘No Building’

S.M.A.R.T

Architect
University 1960

University 2016

University 2070

‘No Building’ Idea
New ways of learning
Adaptable Spaces Reduce Floor Area by 40%
Integration in Urban Area
‘No Building’
Clustered functions

S.M.A.R.T Structurally, Mechanically, Architecturally & Resourcefully Thoughtful
Maslow's Hierarchy of Needs

Architectural Needs of Learning

S.M.A.R.T Architecture
S.M.A.R.T Zone divided Floor Plans
S.M.A.R.T Facades
S.M.A.R.T in Context
‘No Building’

S.M.A.R.T

Structural Engineers
● Steel frame + Composite Slab
● Concrete shear wall for lateral resistance

● Glulam columns/beams + CLT slab
● CLT shear wall for lateral resistance

‘No Building’ Concept
Wind Load: 0.65kN/m^2 (~13.6psf)
<table>
<thead>
<tr>
<th>Member</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete slab</td>
<td>6” thick</td>
</tr>
<tr>
<td>Steel girder (radial)</td>
<td>W24x55</td>
</tr>
<tr>
<td>Steel girder (circumference)</td>
<td>W18x35</td>
</tr>
<tr>
<td>Steel column</td>
<td>HSS 8.625x0.375</td>
</tr>
<tr>
<td>Concrete shear wall</td>
<td>8” thick</td>
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<tr>
<td>Member</td>
<td>Dimension</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Timber slab</td>
<td>CLT 4” thick</td>
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<tr>
<td>Timber joist</td>
<td>Glulam 3.125 x16</td>
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<tr>
<td>Timber girder (radial)</td>
<td>Glulam 10.5 x33</td>
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<tr>
<td>Timber girder (circumference)</td>
<td>Glulam 8.75x24</td>
</tr>
<tr>
<td>Timber column</td>
<td>Glulam 8.75 x10.5</td>
</tr>
<tr>
<td>Timber shear wall</td>
<td>CLT 6” thick</td>
</tr>
</tbody>
</table>
- Steel frame + Composite Slab (concrete + metal deck)
- Steel braces for lateral resistance

- Glulam columns, beams + CLT shear wall + CLT-Concrete slab
- CLT shear walls for lateral resistance

S.M.A.R.T Concept
Steel/Concrete Load Path

North Elevation of the Steel + Concrete system
East Elevation of the Timber + Concrete system

Timber Load Path
- Frames overly designed for three floors
- Ready for adding boxes in the future

Possible connection ideas:
- Bolt connections for steel
- Mechanical connections for timber
- Easy panel connections for CLT slab

Easy to remove in the future!

S.M.A.R.T Adaptability - *Ready for the Future*
<table>
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<th>Member</th>
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<td>Concrete slab</td>
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<tr>
<td>Steel beam</td>
<td>W18x35</td>
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<td>Steel column</td>
<td>W14x99</td>
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<tr>
<td>Steel brace</td>
<td>W8x10</td>
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<tr>
<td>Member</td>
<td>Dimension</td>
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<tr>
<td>------------------------</td>
<td>--------------------</td>
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<tr>
<td>CLT-Concrete slab</td>
<td>4&quot; concrete 8&quot; CLT</td>
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<tr>
<td>Timber girder</td>
<td>Glulam 8.75 x24</td>
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<td>CLT shear wall</td>
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</tbody>
</table>

Auditorium
- **Arch. section**: Glulam 3.215”x18”
- **Arch. Spacing**: 2.5 ft

Timber Auditorium Solution
Soil Condition

Our Solution:
- Avoid excavating too much
- Use pile foundations

Water Table at 4ft below grade
- Frost line at 4’ below grade (1500 psf Bearing)
- Bearing Capacity of 5000 psf at 5’ below grade and 8000 psf at 7’ below grade

Medium shell limestone
(5ft below grade)

‘No Building’ & S.M.A.R.T
Foundation Design

Single-pile/Double-pile cap

Pile Selection: Helical pile
- Length: 10ft
- Size: shaft 2-7/8", helical plate 10"
- Bearing capacity: 223 kips

Why choosing it:
- Smaller size
- Less noise (smaller environmental impact)
- Avoid dewatering (save money)

‘No Building’ & S.M.A.R.T
‘No Building’

S.M.A.R.T

Mechanical Engineer
Weather Challenges
<table>
<thead>
<tr>
<th></th>
<th>VRF Heat &amp; Cool</th>
<th>UFAD + Radiant Heat</th>
<th>VRF + Radiant Heat</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
<td>Primary</td>
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<tr>
<td>Ventilation Dehumidification</td>
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<td><img src="image2.png" alt="Image" /></td>
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<td>Heating</td>
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<td><img src="image8.png" alt="Image" /></td>
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**HVAC Equipment**
## HVAC Decision Matrix

<table>
<thead>
<tr>
<th>Distribution Sizes</th>
<th>VRF Heat &amp; Cool</th>
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<th>VRF + Radiant Heat</th>
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<tbody>
<tr>
<td>Sizes</td>
<td>20” x 12” Supply, 20” x 12” Exhaust</td>
<td>14” x 8” Exhaust</td>
<td>2” HHW Pipe, 18” x 10” Supply, 18” x 10” Exhaust</td>
</tr>
</tbody>
</table>

### Pros

<table>
<thead>
<tr>
<th>VRF Heat &amp; Cool</th>
<th>UFAD + Radiant Heat</th>
<th>VRF + Radiant Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest Overall First Cost</td>
<td>Lower HVAC Costs - $1 to $2/SF Less</td>
<td>Excellent user control and comfort</td>
</tr>
<tr>
<td>Potential for net-zero carbon (all electric)</td>
<td>Best Flexibility - Adaptable Floor Diffusers</td>
<td>Least space requirements for ductwork</td>
</tr>
<tr>
<td>Least Equipment Needed</td>
<td>Best Indoor Air Quality - stratification</td>
<td>Good energy efficiency</td>
</tr>
<tr>
<td>Smallest equipment rooms</td>
<td>Lowest Energy - Low friction (fan energy)</td>
<td></td>
</tr>
<tr>
<td>Least roof space required</td>
<td>Meets STV with minimal PV</td>
<td></td>
</tr>
<tr>
<td>~2” Pipe 12” Floor Supply Plenum</td>
<td>Very Quiet System</td>
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</tbody>
</table>

### Cons

<table>
<thead>
<tr>
<th>VRF Heat &amp; Cool</th>
<th>UFAD + Radiant Heat</th>
<th>VRF + Radiant Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Energy Consumption</td>
<td>Higher Floor Cost - $7 to $8 More</td>
<td>Higher upfront costs</td>
</tr>
<tr>
<td>Most carbon emission (without onsite renewable generation)</td>
<td>Most vertical height needed</td>
<td>Unable to meet net-zero carbon with on-site boiler emissions</td>
</tr>
<tr>
<td>Costly PV to meet STV target</td>
<td>Highest maintenance costs</td>
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</tr>
<tr>
<td>~2” Pipe 12” Floor Supply Plenum</td>
<td>Boiler emissions on-site</td>
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</tr>
<tr>
<td>Floor Sandwich Impact</td>
<td>VRF Heat &amp; Cool</td>
<td>UFAD + Radiant Heat</td>
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<tr>
<td>-----------------------</td>
<td>----------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>20” x 12”</td>
<td>14” x 8”</td>
</tr>
<tr>
<td>AVERAGE</td>
<td></td>
<td>WORST</td>
</tr>
</tbody>
</table>

**Pros**

- VRF Heat & Cool: Lowest First Cost, Zero Onsite Emissions
- UFAD + Radiant Heat: Best Efficiency, Best Air Quality, Best User Control
- VRF + Radiant Heat: Low Energy Cost, Best Thermal Comfort

**Cons**

- VRF Heat & Cool: Highest Energy Cost
- UFAD + Radiant Heat: Highest First Cost, Highest Maintenance
- VRF + Radiant Heat: Average Annual Cost

**HVAC Decision Matrix**
No Building Steel - VRF Heat & Cool
VRF Heat & Cool System Diagram
VRF Heat & Cool Floor Sandwich & Plan
No Building Timber - UFAD + Radiant Heat
UFAD Ventilation
UFAD Thermal Comfort
UFAD Floor Sandwich

- 2” Architectural Floor
- 12” Floor UFAD Plenum
- 4” CLT Slab
- 33” Glulam
- 8” Exhaust Duct
- 12” Space

5’11” Sandwich

Floor
S.M.A.R.T. - Steel - VRF Heat & Cool
VRF Heat & Cool

Level 1
-1.7 m
-3 m

Level 2
2 m

Level 3
5.7 m

Sub Level

Roof
9 m

Auditorium
VRF Heat & Cool

Floor

12' 2"

7' 8"

12" Space

12" Duct

24" Girder

6" Slab

4' 6" Sandwich

20" x 12"
S.M.A.R.T. - Timber - VRF + Radiant Heat
VRF + Radiant Heat
VRF + Radiant Heat
Comparing Energy Use of Design Alternatives
Global Warming Potential

Life-Cycle Target: 5.9 million kg CO2e

S.M.A.R.T

No Building

Sustainable Target Value Progression
‘No Building’

S.M.A.R.T

Construction Managers
Map of Possible Suppliers with Distance to Site

1. G&R  
   Crane, Transport

2. Thyssen  
   Steel, Cement, Systems

3. Loxan  
   Rental Equipment

4. Thomas-Gruppe  
   Concrete

5. Stahlwerk Thüringen  
   Steel

6. RSP  
   Excavation Equipment

7. FG  
   Concrete
Road Access to Site
Site Logistics

- Tracking Pad
- Site Office
- Staging Area
- Protected Area
- Uninterrupted Pedestrian Traffic Flow
- Emergency Exit
- Site fence / Silt fence
- Trench + Berm
- Sedimentation Basin
- Parking
- Waste
- Crane
Protected Area

Uninterrupted Pedestrian Traffic Flow

Site Office

Tracking Pad

Parking

Staging Area

Waste

Crane

Sedimentation Basin

Site fence / Silt fence

Trench + Berm

Emergency Exit

Site Logistics
Supplier: Potain Cranes in Edersleben, Germany (65 km from site)

Price: $1,250 /week vs. $3,900 /week (Mobile Crane) vs. $925 /week (Tower Crane)

Critical Pick: 1.1 t load at tip (20 ft long W24x55)

Selected Self-Erecting Crane
Critical Steps of Construction Process
Critical Steps of Construction Process

- Excavation
- Dewatering
- Modules
- Lab Finished
Steel/Concrete

- 40% smaller floorplans

Cast Concrete

Lab delivery May 1st

June 16nd 2020

Timber

- 40% smaller floorplans

Dewatering

Modules

May 1st 2020

Lab delivery May 1st

June 22nd 2020

Both alternatives

- Dewatering

Construction Schedules - Start September 1st
<table>
<thead>
<tr>
<th>City of Weimar</th>
<th>Population</th>
<th>University</th>
<th>Density (per km²)</th>
<th>Construction Costs</th>
<th>Minimum wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>65,000</td>
<td>Bauhaus</td>
<td>750</td>
<td>Average of $185/sq.ft for Building between 15k and 30k sq.ft (Local General Contractor)</td>
<td>$9.35 (€8.50)</td>
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<tr>
<td>88,000</td>
<td>UC Santa Barbara</td>
<td>410</td>
<td>Average of $200/sq.ft for Building between 15k and 30k sq.ft (RS Means)</td>
<td>$10.00</td>
<td></td>
</tr>
</tbody>
</table>

RS Means - Comparable US City to Weimar, Germany
Assumptions:
- Construction Fees 25%
- Insurance Fee 3%
- Performance Bond 1%
- Architectural Fees 9%
- Contingency 10%
- LEED registration $3,500

‘No Building’ & S.M.A.R.T - TVD Comparison
‘No Building’

S.M.A.R.T

Life Cycle Financial Manager
Risk Brainstorming

- Inflation risks
- Delay in the time schedule
- Fire
- Financial risks
- Health risks because of bad material
- Risks of poor construction quality
- Rise of water table
- Governmental budgeting risk - Loss of funding
- Supplier risk
- Replacement risks because of cheap quality materials
- Flooding
- Exchange risks
- Change in use
- Corrosion of steel and rotting of timber
- Higher O+M costs based on wrong assumptions
- Vandalism and Sabotage
- Social uprising against unisex bathrooms
1. Flood risk
2. Vandalism and sabotage risk
3. High replacement costs because of cheap quality materials

Risk Matrix
Risk Management & Strategies
Operation & Maintenance Costs

<table>
<thead>
<tr>
<th>Category</th>
<th>Green Walls</th>
<th>Grey Walls</th>
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<tbody>
<tr>
<td>O+M (p.a.)</td>
<td>12,000$</td>
<td>1,100$</td>
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<tr>
<td>CO² - Reduction</td>
<td>🌿</td>
<td>😞</td>
</tr>
<tr>
<td>Improvement in Air Quality</td>
<td>🌿</td>
<td>😞</td>
</tr>
<tr>
<td>Habitat creation</td>
<td>🌿</td>
<td>😞</td>
</tr>
<tr>
<td>Aesthetic</td>
<td>🌿</td>
<td>😞</td>
</tr>
</tbody>
</table>

- Electricity
- Gas
- Water, sewage
- Janitor
- Insurances
- Waste, disposal
- Security
- Administration
- Cleaning
- Cleaning windows
- Cloudservice
- Green roof & walls
- Maintenance of construction
Life Cycle Cost Overview
S.M.A.R.T. Steel / Concrete

‘No Building’ Steel / Concrete

No Building Timber

S.M.A.R.T. Timber
## Concept summary

<table>
<thead>
<tr>
<th>% Building</th>
<th>SMART</th>
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<tr>
<td>CONCEPT</td>
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<tr>
<td>Arch</td>
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<tr>
<td>STRATE</td>
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<tr>
<td>LOP</td>
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</tbody>
</table>

## Criteria catalog with definitions

### Environmental Quality
- **Criteria**: Environmental impact by carbon, Environmental impact by CO2, Environmental impact by LCA
- **Definition**: How much of the product is made from materials and processes that have a lower environmental impact?

### Economic Quality
- **Criteria**: Life Cycle Cost - Rent, Flexibility and adaptability of the building
- **Definition**: How much will we change the occupants to use the space?

### Socio-cultural and Functional Quality
- **Criteria**: Indoor air quality, Quality of outdoor spaces, User comfort, Design and Urban Quality
- **Definition**: How well do the occupants use the indoor spaces?

### Technical Quality
- **Criteria**: Reliability, Adaptability of technical systems, Maintenance
- **Definition**: How easy is it to maintain the building?

## Decision Matrix

<table>
<thead>
<tr>
<th>Main Criteria</th>
<th>Sub Criteria</th>
<th>Sara</th>
<th>Laxi</th>
<th>Lyli</th>
<th>Jordan</th>
<th>Elina</th>
<th>Arnaud</th>
<th>Carl</th>
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<td>Environmental impact by carbon</td>
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<td>4</td>
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<td>Environment impact by CO2</td>
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<td>5</td>
<td>3</td>
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<td>Primary energy consumption</td>
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<td>6</td>
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<table>
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## Weighting

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## Owner & member assessment

<table>
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<tr>
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<td>Land space efficiency</td>
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<td>3</td>
<td>2</td>
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<td>4</td>
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### Decision Matrix Results

<table>
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</thead>
<tbody>
<tr>
<td><strong>Team</strong></td>
<td>50%</td>
<td>377.36</td>
<td>421.29</td>
<td>328.64</td>
<td>365.43</td>
</tr>
<tr>
<td><strong>Owner</strong></td>
<td>50%</td>
<td>348.20</td>
<td>389.40</td>
<td>328.60</td>
<td>344.40</td>
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<tr>
<td><strong>Total</strong></td>
<td>1</td>
<td>362.78</td>
<td>405.34</td>
<td>328.62</td>
<td>354.91</td>
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</tbody>
</table>

**Notes:**
- **No Building**: No Building - Steel + Concrete - VRF Heat & Cool
- **S.M.A.R.T.**: S.M.A.R.T. - Steel + Concrete - VRF Heat & Cool
- **S.M.A.R.T.**: S.M.A.R.T. - Timber + Concrete - VRF + Radiant Heat
Responds to Air Quality

- **Arch:** Smaller footprint → Fewer Emissions
- **SE:** Timber → Low embodied emissions
- **MEP:** UFAD → Low life-cycle emissions
  - High indoor air quality and thermal comfort + user control
- **CM:** Shorter construction period → Fewer emissions
- **LCFM:** Green walls → Low life-cycle emissions

‘No Building’
Communication with Team & Owners.
Owner updates & surveys.
Team & Owner Meetings
Meeting agendas, notes and presentations.
Coordination of meetings.
Project web for documentation handling.
Modelling and Storing of models.
Automatic update of quantities.

Team Process Tools
To improve

- Update → **Communication**
- Transparency → **Collaboration**
- Folder structure → **Coordination**
- Consistency
- Dependency

Team Process & Progress
THANK YOU!
Questions?
APPENDIX

‘No Building’

S.M.A.R.T
1st floor

2nd floor

‘No Building’

Faculty Space

Service

Student and learning space

30 ft
1st floor

2nd floor

3rd floor

S.M.A.R.T
<table>
<thead>
<tr>
<th></th>
<th>VRF Heat &amp; Cool</th>
<th>UFAD + Radiant Heat</th>
<th>VRF + Radiant Heat</th>
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</thead>
<tbody>
<tr>
<td>Floor Sandwich Impact</td>
<td>20&quot; x 12&quot; AVERAGE</td>
<td>14&quot; x 8&quot; WORST</td>
<td>BEST</td>
</tr>
<tr>
<td>First Cost</td>
<td>Lowest</td>
<td>Highest</td>
<td>Average</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>Highest</td>
<td>Lowest</td>
<td>Average</td>
</tr>
<tr>
<td>Indoor Air Quality</td>
<td>Good</td>
<td>Best</td>
<td>Good</td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td>Best</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

**HVAC Equipment**

- **20" x 12"**
- **14" x 8"**
- **2" Pipe**
- **12" Floor Plenum**
Construction period: September 1st 2019 to June 18th 2020.

Construction Schedule - Steel/Concrete

Construction Schedule - Timber
Construction period: September 1st 2019 to June 22nd 2020.

Construction Schedule - Both Alternatives