The Sterling and Francine Clark Art Institute
Williamstown, MA

Presentation Outline

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: Building Information Modeling – Virtual Mockup
- Analysis 3: Precast Floor Planks
- Structural Breadth (Will Not Be Discussed)
- Analysis 4: Solar Photovoltaic (PV) Panels
- Electrical Breadth

- Summary
- Acknowledgements

Final Thesis Presentation
Mohamed S. Alali
Construction Management
Dr. Rob Leicht
April 10th, 2012
Project Background
**Project Background**

- **Location**
  - 225 South Street, Williamstown, MA 01267
  - Museum/Institutional

- **Building Parameters**
  - 78,200 SF
  - 68,150 SF Gross Building Area

- **Building Parameters**
  - Cost: $28 Million – GMP
  - Delivery Method: Design – Bid – Build
  - Schedule: Jan 2011 – Sep 2013
  - Architect: Tadao Ando

---

**PRESENTATION OUTLINE**

- Project Background
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  - Analysis 4: Solar PV Panels
  - Electrical Breadth
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Mohamed Alali, CM

**Location**

- 225 South Street, Williamstown, MA 01267
- Museum/Institutional

**Building Parameters**

- 78,200 SF
- 68,150 SF Gross Building Area

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CIP Structure
Glazed Aluminum Curtain Wall On The First Floor

Construction Phases:
• Plant
• VECC
Analysis 1
MEP Prefab
The Problem

- Embedded piping has to be within the middle third of the matslab (30”).
- Long runs with 1/8” of pitch exceeds 10’.
- Constructability issues, intense rebar.
- Project is behind schedule.

The Goal

- Increase accuracy and efficiency.
- Put the schedule back on track.
- Potential cost savings.
Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

Site Challenges

- Intensive amount of rebar.
- Pipe penetration through slab to connections
- Lay, Support, and achieve required Pitch.
- Know what is in the system.
- How the units will be divided.
- Understand Constraints & Complications
  - Max. size of a single unit due to transportation limitations.
- Understand Constraints & Complications
  - Max. size of a single unit due to transportation limitations.

Presentation Outline

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
  - Quantity Take-Off
  - Site Challenges
  - Coordination
- Analysis 2: BIM – Virtual Mockup
- Analysis 3: Precast Floor Planks
  - Electrical Breadth
- Summary
- Acknowledgements

Quantity Take-Off

- Utilizing 3D Model
  - Clash Detection
- In Slab System Location
- Where plumbing would penetrate slab
- Exact locations reduces conflicts between trades

Coordination with Other Trades

- Utilizing 3D Model
  - Clash Detection
- In Slab System Location
- Where plumbing would penetrate slab
- Exact locations reduces conflicts between trades

Mohamed Alali, CM
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Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

Final Results:
- Time savings of general conditions cost and critical path.
  - $14,611 of GC.
  - $35,840 of labor.
- Total: $57,771.

### Present Outline
- Project Background
- Analysis 1: Implementation of MEP Prefabrication
  - Cost & Schedule
- Analysis 2: BIM – Virtual Mockup
- Analysis 3: Precast Floor Panels
- Analysis 4: Solar PV Panels
  - Electrical Breadth
- Summary
- Acknowledgements

### Prefab Cost Savings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Current Cost</th>
<th>Prefab Cost</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td>$7,168</td>
<td>$35,840</td>
<td>50%</td>
</tr>
<tr>
<td>Area 2</td>
<td>$7,168</td>
<td>$35,840</td>
<td>50%</td>
</tr>
<tr>
<td>Area 3</td>
<td>$7,168</td>
<td>$35,840</td>
<td>50%</td>
</tr>
<tr>
<td>Area 4</td>
<td>$7,168</td>
<td>$35,840</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Tot: $28,464</td>
<td>Tot: $143,680</td>
<td></td>
</tr>
</tbody>
</table>

**Total Savings:**
- Current System: $28,464
- Prefab System: $143,680
- **Total Savings: $115,216**

### Prefab Schedule Savings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Current Duration</th>
<th>Prefab Duration</th>
<th>Percent Time Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 2</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 3</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 4</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28 Days</td>
<td>14 Days</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

**Total Savings:**
- Current System: 28 Days
- Prefab System: 14 Days
- **Total Savings: 14 Days (50%)**
Conclusion & Recommendation

- It is best to apply the analysis on the building to save time and money.

Congestion reduction.
- Enhanced safety in the building footprint.
- "3.5" Critical path savings.
- Total of $57,771 of cost savings.
Analysis 2
BIM - Virtual Mockup
The Problem

- BIM utilized only in 3D clash detection.
- More BIM uses can be used.

The Goal

- Increase efficiency.
- Add value to the owner and to the building.
- Supporting the physical Mockup will be built.
Initial Use of BIM

- 3D Clash detection.
- To coordinate complex MEP’s embedded in the malslab.
- Started on August 2011.

How Can Virtual Mockup Help?

- Quantity take off.
- Resolving design issues (Architect).
- Aids any project’s system prefabrication (GC).
- Minimizes RFI’s and COR’s.
- Building the project twice (GC & Subs).
- Opportunity for the owner to walkthrough virtually.
Keep in Mind
- Start in the early stages of the project.
- Need to be developed throughout the project.
- Ability to manipulate.

The Process
- Modeling software (AutoCAD 2012).
- Rendering software (3ds Max Design 2012).
- Choose a section.
- Determining what is in the section.
Feedback

- Tagging and tracking.
- Future maintenance.
- Future renovations.

Cost Benefits

<table>
<thead>
<tr>
<th>Task</th>
<th>Time it took me to model (Hrs)</th>
<th>Professional Wage ($/Hr)</th>
<th>Professional to take 50% of the time (Hrs)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determining a section to model</td>
<td>1</td>
<td>$97</td>
<td>½</td>
<td>$48.5</td>
</tr>
<tr>
<td>Determining What is in the section</td>
<td>8</td>
<td>$97</td>
<td>3</td>
<td>$291</td>
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<tr>
<td>Section modeling</td>
<td>40</td>
<td>$97</td>
<td>15</td>
<td>$1,455</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>$97</td>
<td>18 ½</td>
<td>$1,795</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foreman Trade</th>
<th>Foreman Wage ($/Hr)</th>
<th>Interpretation Time Savings (2 Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>$55.20</td>
<td>$110.40</td>
</tr>
<tr>
<td>Iron</td>
<td>$83.08</td>
<td>$166.16</td>
</tr>
<tr>
<td>Plumbing</td>
<td>$75.72</td>
<td>$131.43</td>
</tr>
<tr>
<td>Glazing</td>
<td>$54.43</td>
<td>$108.86</td>
</tr>
<tr>
<td>Gypsum Boards</td>
<td>$66.18</td>
<td>$132.36</td>
</tr>
<tr>
<td>Gutter</td>
<td>$83.08</td>
<td>$166.16</td>
</tr>
<tr>
<td>Sheeting</td>
<td>$66.18</td>
<td>$132.35</td>
</tr>
<tr>
<td>Metal Panels</td>
<td>$83.08</td>
<td>$166.16</td>
</tr>
<tr>
<td>Roofer</td>
<td>$66.18</td>
<td>$132.35</td>
</tr>
<tr>
<td>Wood Flooring</td>
<td>$45.38</td>
<td>$90.76</td>
</tr>
<tr>
<td>Flooring</td>
<td>$66.18</td>
<td>$132.35</td>
</tr>
<tr>
<td>Sealants</td>
<td>$44.30</td>
<td>$88.60</td>
</tr>
<tr>
<td>Waterproofing</td>
<td>$54.43</td>
<td>$108.86</td>
</tr>
<tr>
<td>Total</td>
<td>$1,554.45</td>
<td></td>
</tr>
</tbody>
</table>
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Williamstown, MA

Analysis 2: BIM – Virtual Mockup

Conclusion & Recommendation

- Go with virtual mockup to fix issues in advance and better experience the building.
- Will benefit the owner in future restaurant.
- Very low cost, do both.

- Increased efficiency.
- Increased coordination.
- Less RFIs and COR's.
- Better for future renovations and maintenance.
- Costs $240.55
- Virtual Mockups has limitations.

PRESENTATION OUTLINE
- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: BIM – Virtual Mockup
  - Conclusion & Recommendation
- Analysis 3: Precast Floor Planks
- Analysis 4: Solar PV Panels
  - Electrical Breadth
- Summary
- Acknowledgements

Image courtesy of Google images.
Analysis 3
Precast Roof Planks
The Problem

- Complex geometry.
- Safety.
- Congestion.
- Constructability issues.

The Goal

- Increase efficiency and productivity.
- Schedule reduction.
Initial Planning

- Existing: CIP
- Applied in the VECC 21,450 SQF.
- Can't be applied on the reservoir.
- Choosing a typical bay.

PRESENTATION OUTLINE

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: BIM – Virtual Mockup
- Analysis 3: Precast Floor Planks
  - Initial Planning & Process
- Analysis 4: Solar PV Panels
  - Electrical Breadth
- Summary
- Acknowledgements
Mohamed Alali, CM

Analysis 3: Precast Roof Planks

The Sterling and Francine Clark Art Institute
Williamstown, MA

Cost

• More expensive initially.
• Savings from GC offsets increased cost.
• Net savings: $47,662

Schedule

• 3 months lead time.
• 3600 SQF/Day.
• 18 days of critical path.

Presentaion Outline

• Project Background
• Analysis 1: Implementation of MEP Prefabrication
• Analysis 2: BIM – Virtual Mockup
• Analysis 3: Precast Floor Planks
  • Cost & Schedule
• Analysis 4: Solar PV Panels
  • Electrical Breadth
• Summary
• Acknowledgements

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Extra Cost</th>
<th>Cost Savings</th>
<th>%Extra Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast In Place</td>
<td>$165,509</td>
<td>$47,662</td>
<td>N/A</td>
<td>28.8%</td>
</tr>
<tr>
<td>Precast Planks</td>
<td>$117,908</td>
<td>N/A</td>
<td>$47,662</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Value Comparison

<table>
<thead>
<tr>
<th></th>
<th>Cast In Place</th>
<th>Precast</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>↓</td>
<td>↑ $47,662 Net Savings</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>↓</td>
<td>↑ 18 Days of Critical Path</td>
</tr>
<tr>
<td><strong>Lead Time</strong></td>
<td>↑ 0</td>
<td>↓ 3 Months</td>
</tr>
<tr>
<td><strong>Following Trades</strong></td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td><strong>LEED</strong></td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td><strong>Congestion</strong></td>
<td>↓ Congested</td>
<td>↑ Less Congestion</td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>GOOD</td>
<td>BEST</td>
</tr>
</tbody>
</table>

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The Sterling and Francine Clark Art Institute
Williamstown, MA
Disadvantages

- Lead time.
- Traffic authority.
- Interior Finishing.
- Future renovations.
Conclusion & Recommendation

- It is not recommended to apply the analysis.
- That is due to:
  - Architectural implications.
  - Future renovations.
  - Traffic issues.

Area: 21,450 SQF using 4’x20’

- Saves:
  - 18 days of critical path
  - Net savings: $47,60.
Analysis 4
Solar PV Panels
The Problem

- High lighting energy consumption.
- May not achieve LEED Silver.

The Goal

- Energy cost reduction.
- Aid in achieving LEED goal.
Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

Building Location & Solar Info

- Site
  - No major shadow issues from surroundings.
  - Will be placed at the Manton!
  - 24,600 SQF of usable flat roof.

Building Location

- N 42' 42' 28.5156" W 73' 12' 54.9806"
- Elevation of Roof: 32 Feet
- Average Sunlight: 4.2 Sunlight Hours/day
- System Orientation: Facing South
- System Tilt Angle: 42.7°
- Summer/Winter Tilt Angle Adj.: ± 15°
- Spring Equinox (Year 2012): March 20
- Summer Solstice (Year 2012): June 20
- Fall Equinox (Year 2012): September 22
- Winter Solstice (Year 2012): December 21

Site Image courtesy of Bing Maps
Analysis 4: Solar Photovoltaic Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

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  - Structural Breadth (Will Not Be Discussed)
- Analysis 4: Solar Photovoltaic Panels
  - Shadow Analysis
- Summary
- Acknowledgements

SHADOW ANALYSIS

MOHAMED ALALI, CM
Realistic Energy Reduction

- Lighting system consumes 1360 kWh/day.
- Based on space:
  - 49 arrays/strings.
  - Enough to power 280.17 kWh/day.
- Good for lighting in:
  - Café.
  - Two retail spaces.
  - Lobby.
  - Family room.
  - Vestibule.
### Summary of Calculations

Adequate AC Energy for family room, lobby, café, two retail spaces, and a vestibule

- **105,383 kWh** Produced by 392 panels (240 Wdc)
- **100,861.2 kWh/year** Needed.
- **Savings** of **$13,177.1 Annually on Electric Bill**
- Covers **17.85%** of Total Electric Demand
Analysis 4: Solar PV Panels

**Initial Cost**
- Gross System cost: $781,850
- System cost: $261,910
- Installation cost: $517,440
- Transportation cost: $2,500

**Cost After Incentives and Rebates**
- New net cost: $227,646
  - MA Solar Renewable Energy Credits: $316,149
  - Federal tax credit: $234,555
  - MA Renewable Energy Income Tax Credit: $1,000
  - TOT: $551,704

**PRESENTATION OUTLINE**
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- Analysis 3: Precast Floor Planks
- Analysis 4: Solar PV Panels
  - Electrical Breadth
  - Cost
- Summary
- Acknowledgements
Conclusion & Recommendation

- It is best to apply the analysis on the building to save energy, energy costs, and environment.

- PV’s will be installed on the Manton’s roof.
- Usable flat roof area: 24,600 SQF.
- 49 arrays, 8 panels/array, 240 Wdc/panel.
- 392 panels producing 105,383 kWh/year.
- Net system cost $227,646.
- Payback period is in 6 years.
- Savings over 25 years: $544,520.
Summary

- Analysis 4: Solar PV Panels
  - Feasibility was possible due to the governmental monetary supports.
  - Payback period of 6 years.

- Analysis 3: Precast Roof Planks
  - Disadvantages impeded the analysis.
  - Architectural implications.
  - Town size.

- Analysis 2: BIM – Virtual Mockup
  - Increased coordination and efficiency.
  - Less routine.
  - Beneficial for all project parties.

- Analysis 1: MEP Prefabrication
  - Increased efficiency and safety.
  - Less congestion.
  - Utilizing 3D BIM model aids coordination.
  - Saves time and money.

PRESENTATION OUTLINE

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- Analysis 4: MEP PV Panels
- Electrical Breadth
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Acknowledgements

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- Prof. Robert Holland

- Dr. David Riley
- Prof. Paul Bowers

- Family
- Friends
- AE Classmates
Appendices
The Sterling and Francine Clark Art Institute
Williamstown, MA

Analysis 1: Implementation of MEP Prefabrication

Prefab Schedule Savings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Current System Duration</th>
<th>Prefab Duration</th>
<th>Percent Time Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 2</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 3</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Area 4</td>
<td>7</td>
<td>3.5 Days</td>
<td>50%</td>
</tr>
<tr>
<td>Total</td>
<td>28 Days</td>
<td>14 Days</td>
<td>50%</td>
</tr>
</tbody>
</table>

Total Savings: 50%

Final Results:
- 15% less time to build.
- 50% less time to install.
- 3 days of crew cost and time savings (time to build it)
- 14 days total float (building and installing)
- “3.5” days general conditions cost and critical path savings.
  - $14,611 of GC.
  - $35,840 of labor.
  - Total: $57,771.
Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

Mohamed Alali, CM

PRESENTATION OUTLINE

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Cost & Schedule
- Analyst 2: BIM – Virtual Mockup
- Analyst 3: Precast Floor Planks
- Analyst 4: Solar PV Panels
- Electrical Breadth
- Summary
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Table 5-2: Prefabrication Onsite Vs. Offsite Time Savings

<table>
<thead>
<tr>
<th>Size</th>
<th>Length</th>
<th>Time to Build on Site</th>
<th>Time to Prefab in Shop</th>
<th>Time Savings</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>863.72 LF</td>
<td>15.7 Days</td>
<td>13.3 Days</td>
<td>2.4 Days</td>
<td>15%</td>
</tr>
<tr>
<td>6&quot;</td>
<td>194.57 LF</td>
<td>2.7 Days</td>
<td>2.3 Days</td>
<td>0.4 Days</td>
<td>15%</td>
</tr>
<tr>
<td>8&quot;</td>
<td>106.47 LF</td>
<td>1.8 Days</td>
<td>1.5 Days</td>
<td>0.3 Days</td>
<td>15%</td>
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<tr>
<td>Tot.</td>
<td>1164.76 LF</td>
<td>20.2 Days</td>
<td>17.1 Days</td>
<td>3 Days</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 5-3: Prefabrication Schedule Savings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Original Schedule</th>
<th>Prefabrication Schedule Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install In-Slab Plumbing Area 1</td>
<td>7-18 Nov -11</td>
<td>3.5 Days 50% $17,920 $8,960</td>
</tr>
<tr>
<td>Install In-Slab Plumbing Area 2</td>
<td>7-20 Dec 11</td>
<td>3.5 Days 50% $17,920 $8,960</td>
</tr>
<tr>
<td>Install In-Slab Plumbing Area 3</td>
<td>7-14 Dec 11</td>
<td>3.5 Days 50% $17,920 $8,960</td>
</tr>
<tr>
<td>Install In-Slab Plumbing Area 4</td>
<td>7-13 Apr 12</td>
<td>3.5 Days 50% $17,920 $8,960</td>
</tr>
<tr>
<td>Total</td>
<td>28 Days 18 Nov 11-13 Apr 12</td>
<td>14 Days 50% $71,680 $35,840</td>
</tr>
</tbody>
</table>

Total Savings N/A

3.5 Days 12.5%

N/A 50%
Mohamed Alali, CM

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Table 6.1: Detailed Schedule of New And Existing Systems

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Cast In Place</th>
<th>Precast</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Savings</th>
<th>%Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRP Superstructure</td>
<td>79 days</td>
<td>91 days</td>
<td>12 days</td>
<td>Wed 3/22/12</td>
<td>Thu 3/29/12</td>
<td>0 Days</td>
<td>0%</td>
</tr>
<tr>
<td>Deck FRP/Erection</td>
<td>20 days</td>
<td>20 days</td>
<td>0 Days</td>
<td>Wed 3/22/12</td>
<td>Thu 3/22/12</td>
<td>0 Days</td>
<td>0%</td>
</tr>
<tr>
<td>Waterproofing</td>
<td>10 days</td>
<td>10 days</td>
<td>0 Days</td>
<td>Wed 3/22/12</td>
<td>Thu 3/22/12</td>
<td>0 Days</td>
<td>0%</td>
</tr>
</tbody>
</table>

System Cost: $165,509
Extra Cost: $47,662
Cost Savings: N/A
% Extra Cost: 28.8%

Precast Planks Cost: $117,908
Extra Cost: $47,662
Cost Savings: N/A
% Extra Cost: N/A
Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

Mohamed Alali, CM

Initial Cost

- Gross System cost: $781,850
- System cost: $261,910
- Installation cost: $517,440
- Transportation cost: $2,500

Cost After Incentives and Rebates

New net cost: $227,646
- MA Solar Renewable Energy Credits: $316,149
- Federal tax credit: $234,555
- MA Renewable Energy Income Tax Credit: $1,000
- TOT: $551,704

Cumulative Payback Period Chart

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: BIM - Virtual Mockup
- Analysis 3: Precast Floor Planks
- Analysis 4: Solar PV Panels
- Electrical Breadth
- Cost
- Summary
- Acknowledgements
PRESENTATION OUTLINE

• Project Background
• Analysis 1: Implementation of MEP Prefabrication
• Analysis 2: BIM – Virtual Mockup
• Analysis 3: Precast Floor Planks
• Analysis 4: Solar PV Panels
  • Electrical Breadth
  • Cost
• Summary
• Acknowledgements

Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

Mohamed Alali, CM

<table>
<thead>
<tr>
<th>DC wires</th>
<th>AC wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DC wires</td>
<td></td>
</tr>
<tr>
<td>2. DC switch, disconnect</td>
<td></td>
</tr>
<tr>
<td>3. Combiner</td>
<td></td>
</tr>
<tr>
<td>4. Grid-tie inverter</td>
<td></td>
</tr>
<tr>
<td>1. AC wires</td>
<td></td>
</tr>
<tr>
<td>2. AC switch</td>
<td></td>
</tr>
<tr>
<td>3. Meter box (grid and PV supplies connects here)</td>
<td></td>
</tr>
</tbody>
</table>

DC Disconnect
DC side isolation switch
Grid-Tie Inverter
To main distribution panel

Solar panel arrays

Grid supply
Meter box