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 Facilitate
  - 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

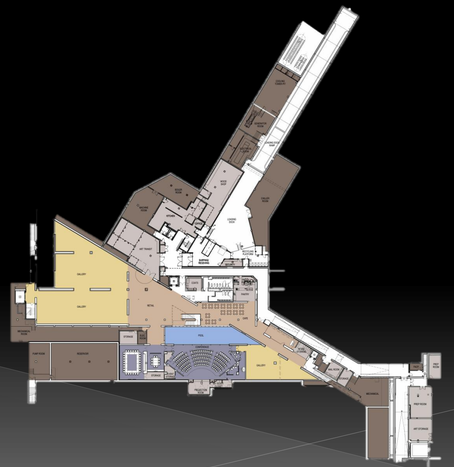
Mohamed Alali, CM

Project Background

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

- **Location**
  - 225 South Street, Williamstown, MA 01267
  - Museum/Institutional
- **Building Parameters**
  - 78,800 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



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Project Background

The Sterling and Francine Clark Art Institute
Williamstown, MA

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
- Summary
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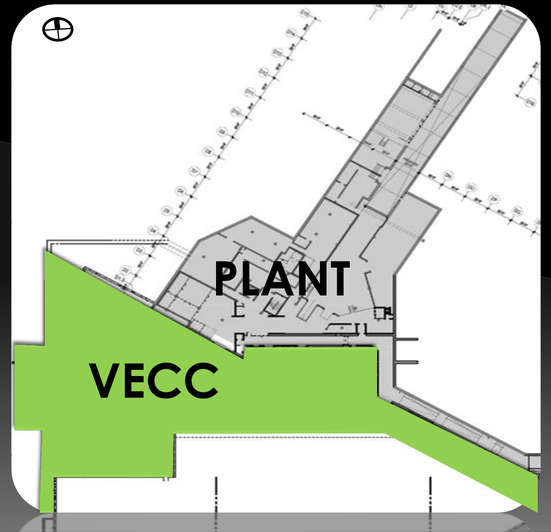
- **CIP Structure**
- **Glazed Aluminum Curtain Wall On The First Floor**

- **Construction Phases:**
  - **Plant**
  - **VECC**



Analysis 1
MEP Prefab

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Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

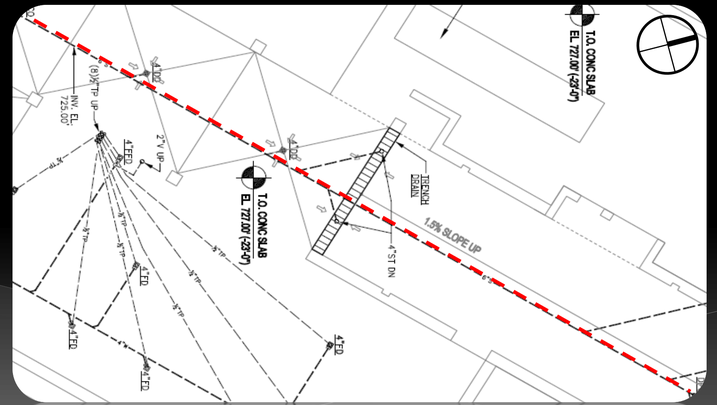
PRESENTATION OUTLINE

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.



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Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

Quantity Take-Off

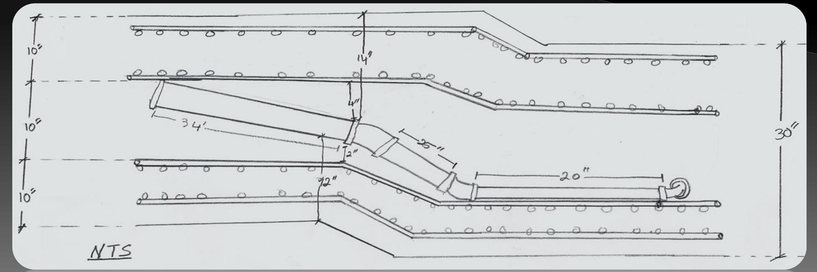
- Know what is in the system.
- How the units will be divided.
- Understand Constraints & Complications
  - Max. size of a single unit due to transportation limitations.

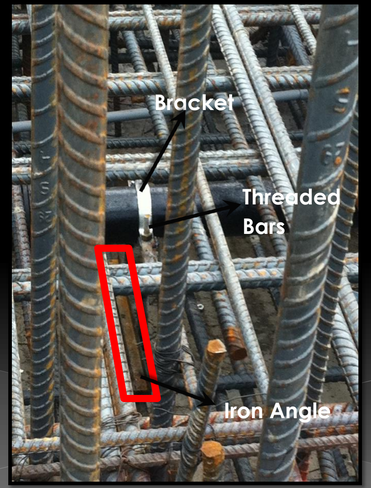
Site Challenges

- Intensive amount of rebar.
- Pipe penetration through slab to connections
- Lay, Support, and achieve required Pitch.

Coordination with Other Trades

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





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Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

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

Prefab Cost Savings

	Current	Prefab
Total	Tot: $71,680	Tot: $35,840
Total Savings	N/A	50%

Prefab Schedule Savings

Activity	Current System Duration	Prefab Duration	Percent Time Savings
Area 1	7	3.5 Days	50%
Area 2	7	3.5 Days	50%
Area 3	7	3.5 Days	50%
Area 4	7	3.5 Days	50%
Total	28 Days	14 Days	50%
Total Savings	N/A	3.5 Days	12.5%

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

PRESENTATION OUTLINE

- Congestion reduction.
- Enhanced safety in the building footprint.
- "3.5" Critical path savings.
- Total of $57,771 of cost savings.

Conclusion & Recommendation

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

Analysis 2
BIM - Virtual Mockup

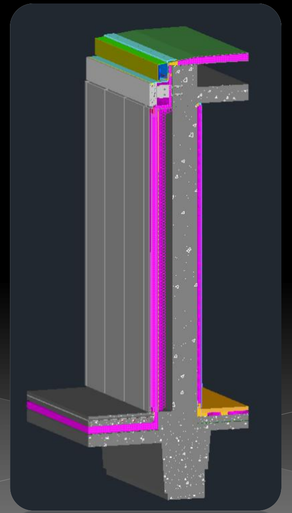
PRESENTATION OUTLINE

The Problem

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

The Goal

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



PRESENTATION OUTLINE

Initial Use of BIM

- 3D Clash detection.
- To coordinate complex MEP's embedded in the matslab.
- 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.

Image courtesy of Google images.

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Analysis 2: BIM – Virtual Mockup

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

Keep in Mind

- Start in the early stages of the project.
- Need to be developed though out 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.

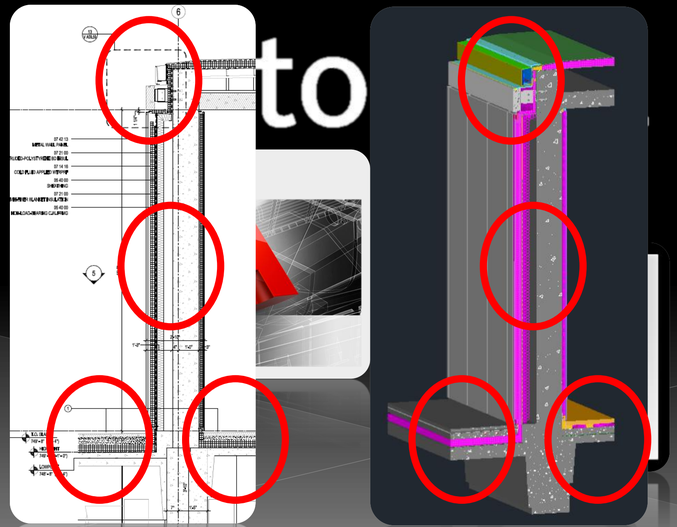


Image courtesy of Google images

PRESENTATION OUTLINE

Feedback

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

Cost Benefits

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

Foreman Trade	Foreman Wage ($/Hr)	Interpretation Time Savings (2 Hrs)
Concrete	$55.20	$110.40
Iron	$83.08	$166.16
Plumbing	$75.72	$151.43
Glazing	$54.43	$108.86
Gypsum Boards	$66.18	$132.36
Gutter	$83.08	$166.16
Sheeting	$66.18	$132.35
Metal Panels	$83.08	$166.16
Roofer	$66.18	$132.35
Wood Flooring	$45.38	$90.76
Sealants	$44.30	$88.60
WaterProofing	$54.43	$108.86
Total		**$1,554.45**

PRESENTATION OUTLINE

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

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.

Image courtesy of Google images.

Analysis 3
Precast Roof Planks

Mohamed Alali, CM

Analysis 3: Precast Roof Planks

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

The Problem

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

The Goal

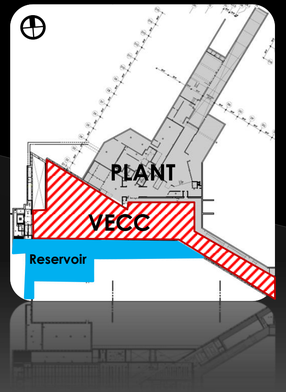
- Increase efficiency and productivity.
- Schedule reduction.

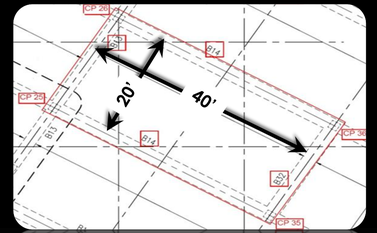
Image courtesy of Google images.

PRESENTATION OUTLINE

Initial Planning

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





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PRESENTATION OUTLINE

Schedule

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

Cost

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

System	Cost	Extra Cost	Cost Savings	%Extra Cost
Cast In Place	$165,509	$47,662	N/A	28.8%
Precast Planks	$117,908	N/A	$47,662	N/A

PRESENTATION OUTLINE

Value Comparison

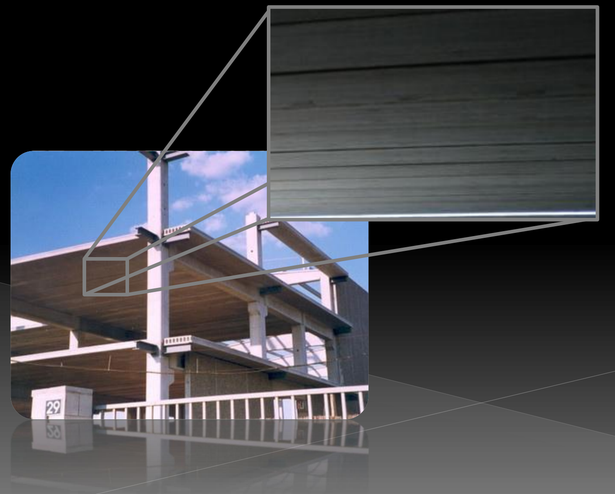
	Cast In Place	Precast
Cost	↓	↑ $47,662 Net Savings
Schedule	↓	↑18 Days of Critical Path
Lead Time	↑ 0	↓ 3 Months
Following Trades	↓	↑
LEED	↓	↑
Congestion	↓ Congested	↑ Less Congestion
Value	GOOD	**BEST**

PRESENTATION OUTLINE

- Interior Finishing.
- Future renovations.

Disadvantages

- Lead time.
- Traffic authority.



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PRESENTATION OUTLINE

- Area: 21,450 SQF using 4'x20'
- Saves:
  - 18 days of critical path
  - Net savings: $47,60.

Conclusion & Recommendation

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

Analysis 4
Solar PV Panels

PRESENTATION OUTLINE

The Problem

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

The Goal

- Energy cost reduction.
- Aid in achieving LEED goal.

Image courtesy of Alternate Power & Construction, Inc.

PRESENTATION OUTLINE

Site

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

Building Location & Solar Info

Building Location	**N 42° 42' 28.5156" W 73° 12' 54.9806"**
Elevation of Roof	32 Feet
Average Sunlight Hrs/Day	4.2
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

Image courtesy of Bing Maps

Mohamed Alali, CM

Analysis 4: Solar Photovoltaic Panels

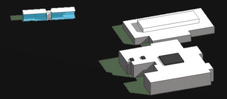
The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: Building Information Modeling – Virtual Mock-Up
- Analysis 3: Precast Floor Planks
  - Structural Breadth (Will Not Be Discussed)
- **Analysis 4: Solar Photovoltaic Panels**
  - **Shadow Analysis**
- Summary
- Acknowledgements

SHADOW ANALYSIS

SPRING/FALL EQUINOX



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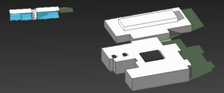

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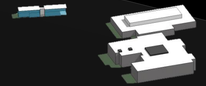
SUMMER SOLSTICE



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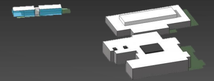

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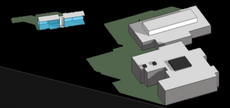
WINTER SOLSTICE



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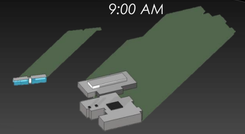

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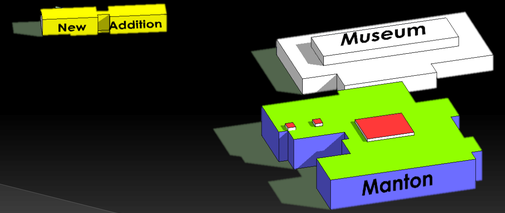
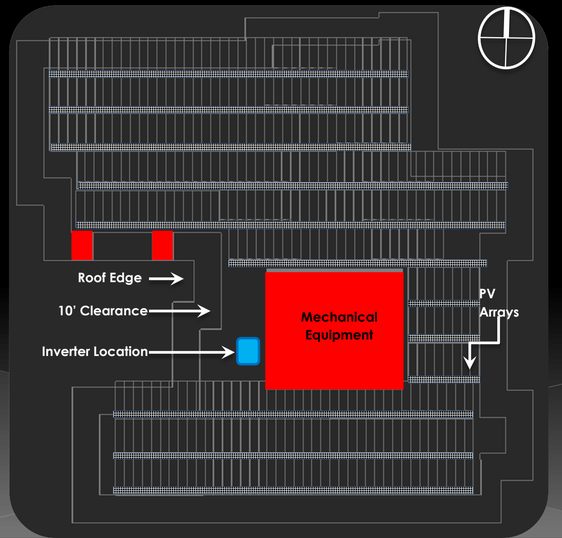


PHOTOVOLTAICS ON THE GREEN SHADED ROOF

PRESENTATION OUTLINE

Realistic Energy Reduction

- Lighting system consumes 1560 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.



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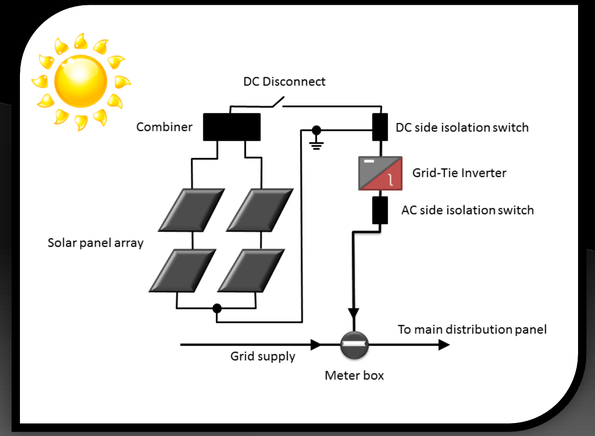
Analysis 4: Solar Photovoltaic Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
1	2.93	6852	856.77
2	3.69	7891	986.69
3	4.59	10387	1298.79
4	4.78	10100	1262.90
5	5.08	10620	1327.92
6	5.01	9765	1221.02
7	5.33	10550	1319.17
8	5.11	10326	1291.16
9	4.80	9661	1208.01
10	3.87	8282	1035.58
11	2.62	5536	692.22
12	2.37	5414	676.97
Year	4.19	105,383	13,177.1



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 $13177.1 Annually on Electric Bill
- **Covers 17.85% of Total Electric Demand**

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Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

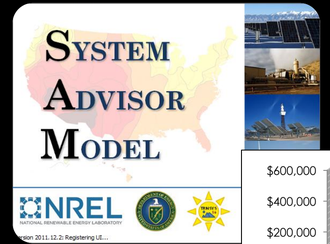
- Project Background
- Analysis 1: Implementation of MEP Prefabrication
- Analysis 2: BIM – Virtual Mockup
- Analysis 3: Precast Floor Planks
- **Analysis 4: Solar PV Panels**
  - Electrical Breadth
  - **Cost**
- Summary
- Acknowledgements

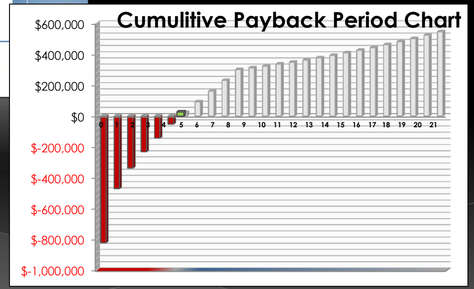
Initial Cost

- **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



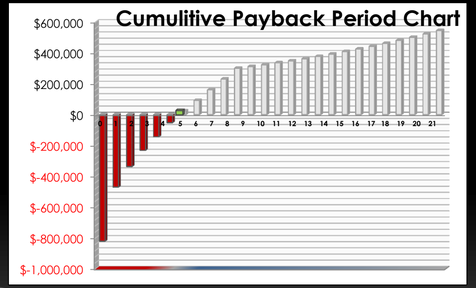


PRESENTATION OUTLINE

- 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 pales producing 105,383 kWh/year.
- Net system cost $227,646.
- Payback period is in 6 years.
- Savings over 25 years: $544,520.

Conclusion & Recommendation

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



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Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

Summary

- **Analysis 1: MEP Prefabrication**
  - Increased efficiency and safety.
  - Less congestion.
  - Utilizing 3D BIM model aids coordination.
  - Saves time and money.
- **Analysis 2: BIM – Virtual Mockup**
  - Increased coordination and efficiency.
  - Less routine.
  - Beneficial for all project parties.
- **Analysis 3: Precast Roof Planks**
  - Disadvantages impeded the analysis.
    - Architectural implications.
    - Town size.
- **Analysis 4: PV Panels**
  - Feasibility was possible due to the governmental monetary supports.
  - Payback period of 6 years.

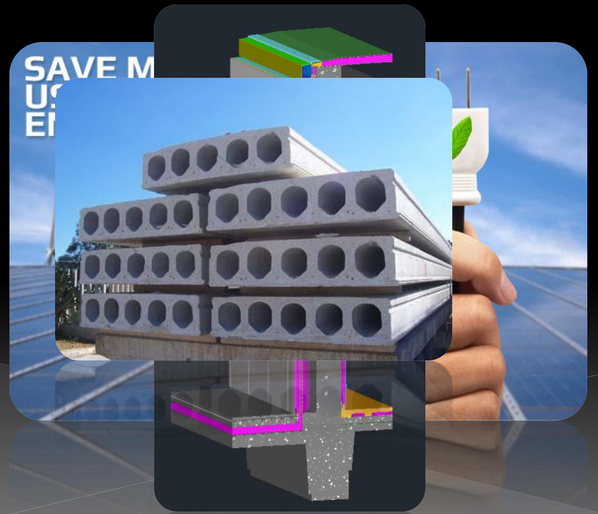


Image courtesy of Alternate Power & Construction, Inc.

PRESENTATION OUTLINE

Acknowledgements

SCO مكتب البعثات الدراسية Scholarships Office

- H. H. Sheikh Zayed Bin Sultan Al Nahyan
- H. H. Sheikh Khalifa Bin Zayed Al Nahyan
- The Scholarships Office

PENNSTATE Department of Architectural Engineering ae

- Prof. Moses Ling
- Dr. Kevin Parfitt
- Dr. Robert Leicht
- Prof. Robert Holland
- Dr. David Riley
- Prof. Paul Bowers

Turner Construction Company

THE CLARK

Family

Friends

AE Classmates

Appendices

Mohamed Alali, CM

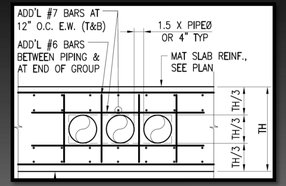
Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

Prefab Cost Savings

	Current	Prefab
Total	Tot: $71,680	Tot: $35,840
Total Savings	N/A	50%



Prefab Schedule Savings

Activity	Current System Duration	Prefab Duration	Percent Time Savings
Area 1	7	3.5 Days	50%
Area 2	7	3.5 Days	50%
Area 3	7	3.5 Days	50%
Area 4	7	3.5 Days	50%
Total	28 Days	14 Days	50%
Total Savings	N/A	3.5 Days	12.5%

- **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.**

Mohamed Alali, CM

Analysis 1: Implementation of MEP Prefabrication

The Sterling and Francine Clark Art Institute
Williamstown, MA

PRESENTATION OUTLINE

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

Table 5-3: Prefabrication Schedule Savings

Activity	Original Schedule			Installation Time Savings	Percent Time Savings	Original Cost	Prefab. Cost
	Duration (Days)	Start	Finish				
Install In-Slab Plumbing Area 1	7	18-Nov-11	30-Nov-11	3.5 Days	50%	$17,920	$8,960
Install In-Slab Plumbing Area 2	7	20-Dec-11	29-Dec-11	3.5 Days	50%	$17,920	$8,960
Install In-Slab Plumbing Area 3	7	06-Dec-11	14-Dec-11	3.5 Days	50%	$17,920	$8,960
Install In-Slab Plumbing Area 4	7	05-Apr-12	13-Apr-12	3.5 Days	50%	$17,920	$8,960
Total	28 Days	18-Nov-11	13-Apr-12	14 Days	50%	Tot: $71,680	Tot: $35,840
Total Savings	N/A			3.5 Days	12.5%	N/A	50%

Table 5-2: Prefabrication Onsite Vs. Offsite Time Savings

Size	Length	Time To Build on Site	Time To Prefab in Shop	Time Savings	Percent Time Saving
4"	863.72 LF	15.7 Days	13.3 Days	2.4 Days	15%
6"	194.57 LF	2.7 Days	2.3 Days	0.4 Days	15%
8"	106.47 LF	1.8 Days	1.5 Days	0.3 Days	15%
Tot.	1164.76 LF	20.2 Days	17.1 Days	3 Days	15%

PRESENTATION OUTLINE

Schedule

Table 6-1: Detailed Schedule of New And Existing Systems

Task Name	Cast In Place			Precast			Time Savings	Percent Time Savings
	Duration	Start	Finish	Duration	Start	Finish		
Area# 1	97 days	Sat 11/19/11	Mon 4/2/12	73 days	Sat 11/19/11	Tue 2/28/12	24 Days	24.74%
FRP Superstructure	61 days	Sat 11/19/11	Fri 2/10/12	61 days	Sat 11/19/11	Fri 2/10/12	0 Days	0%
Deck FRP/Erection	26 days	Mon 2/13/12	Mon 3/19/12	2 days	Mon 2/13/12	Tue 2/14/12	24 Days	92.3 %
Waterproofing	10 days	Tue 3/20/12	Mon 4/2/12	10 days	Wed 2/15/12	Tue 2/28/12	0 Days	0%
Area# 2	135 days	Wed 11/2/11	Tue 5/8/12	112 days	Wed 11/2/11	Tue 4/5/12	23 Days	23.71%
FRP Superstructure	99 days	Wed 11/2/11	Mon 3/19/12	99 days	Wed 11/2/11	Mon 3/19/12	0 Days	0%
Deck FRP/Erection	26 days	Tue 3/20/12	Tue 4/24/12	3 days	Tue 3/20/12	Thu 3/22/12	23 Days	88.46%
Waterproofing	10 days	Wed 4/25/12	Tue 5/8/12	10 days	Fri 3/23/12	Thu 4/5/12	0 Days	0%
Area# 3	98 days	Wed 10/26/11	Fri 3/9/12	85 days	Wed 10/26/11	Tue 2/21/12	13 Days	13.40%
FRP Superstructure	74 days	Wed 10/26/11	Mon 2/6/12	74 days	Wed 10/26/11	Mon 2/6/12	0 Days	0%
Deck FRP/Erection	14 days	Tue 2/7/12	Fri 2/24/12	1 day	Tue 2/7/12	Tue 2/7/12	13 Days	92.86%
Waterproofing	10 days	Mon 2/27/12	Fri 3/9/12	10 days	Wed 2/8/12	Tue 2/21/12	0 Days	0%
Area# 4	93 days	Wed 2/29/12	Fri 7/6/12	70 days	Wed 2/29/12	Tue 6/5/12	23 Days	23.71%
FRP Superstructure	58 days	Wed 2/29/12	Fri 5/18/12	58 days	Wed 2/29/12	Fri 5/18/12	0 Days	0%
Deck FRP/Erection	26 days	Mon 5/21/12	Mon 6/25/12	2 days	Mon 5/21/12	Tue 5/22/12	23 Days	88.46%
Waterproofing	10 days	Mon 6/25/12	Fri 7/6/12	10 days	Wed 5/23/12	Tue 6/5/12	0 Days	0%

System	Cost	Extra Cost	Cost Savings	%Extra Cost
Cast In Place	$165,509	$47,662	N/A	28.8%
Precast Planks	$117,908	N/A	$47,662	N/A

Mohamed Alali, CM

Analysis 4: Solar PV Panels

The Sterling and Francine Clark Art Institute
Williamstown, MA

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

Initial Cost

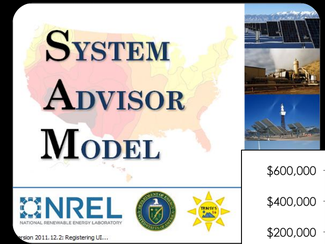
- **Gross System cost: $781,850**
  - System cost: $261,910
  - Installation cost: $517,440
  - Transportation cost: $2,500

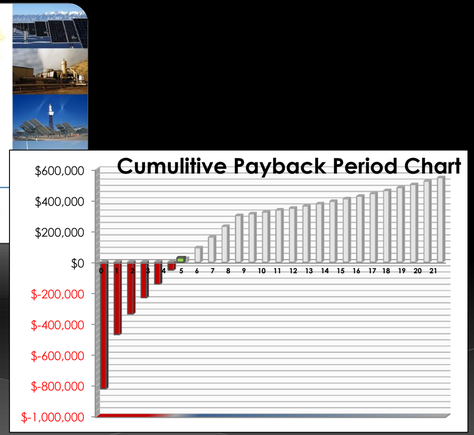
Cost After Incentives and Rebates

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

Year	Cumulative payback
0	-$820,658.00
1	-$469,370.00
2	-$336,054.00
3	-$230,924.00
4	-$142,153.00
5	-$52,010.80
6	$23,754.70
7	$92,673.40
8	$160,551.00
9	$229,917.00
10	$300,804.00
11	$311,700.00
12	$323,265.00
13	$335,519.00
14	$348,483.00
15	$362,179.00
16	$376,628.00
17	$391,852.00
18	$407,876.00
19	$424,723.00
20	$442,417.00
21	$460,985.00
22	$480,452.00
23	$500,845.00
24	$522,191.00
25	$544,520.00





Analysis 4: Solar PV Panels

PRESENTATION OUTLINE

1. DC wires 2. DC switch, disconnect 3. Combiner 4. Grid-tie inverter	1. AC wires 2. AC switch 3. Meter box (grid and PV supplies connects here)