Potomac Yard Land Bay E
Arlington, Virginia

Drew Heilman | Construction Management | April 12, 2010

Potomac Yard Land Bay E
Arlington, Virginia

Presentation Outline

- Project Overview
- Implementation of Solyndra PV System (Electrical Breadth)
- Implementation of Curtain Wall System (Mechanical Breadth)
- Implementation of Chilled Beams (Critical Industry Issue)
- Conclusions and Recommendations
- Acknowledgements and Questions

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Project Overview:

- Two Tower Office Building with Underground Parking
- 9-Story 370,000 S.F. Office Space
- 3 P-Levels – 235,000 S.F., 600 parking spaces
- Cost: $75 million Negotiated GMP
- Duration: 20 months, 1/2/08 - 9/30/09
- Design-Bid-Build
- LEED Gold
- White TPO Roof
- Two Building Facades
- Cast-In-Place Concrete Structure
- Forced air VAV mechanical system

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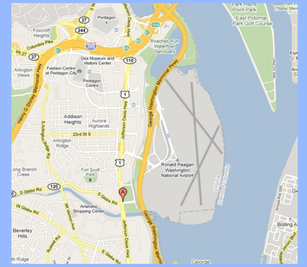
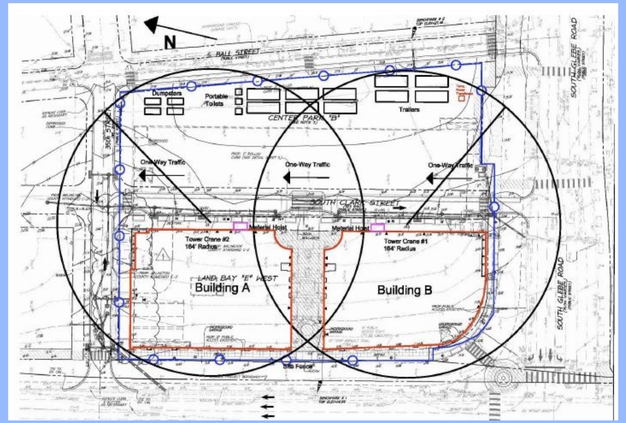
Location:

- Arlington, VA
- Regan National Airport
- US Rte. 1
- George Washington Memorial Parkway





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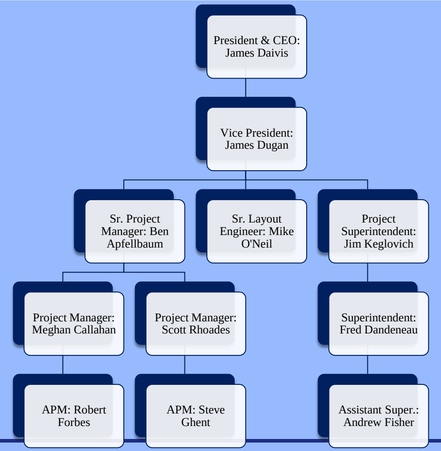
Owner: Meridian Group

General Contractor: James G. Davis Construction

Architect: Davis, Carter, Scott LTD.

MEP Engineer: Allen & Shariff Corporation

Glazing: TSI/ Exterior Wall Systems, Inc.



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Purpose for Analyses

- Energy conservation
  - Solyndra PV System
  - Chilled Beam Mechanical System
- Schedule Acceleration
  - Curtain Wall System

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Opportunity

- Need for energy conservation
  - Over 50% of US energy consumption in commercial buildings
- Unusable rooftop area
  - Implement a solar collection system
- Solyndra PV System
  - Great for application with existing white TPO roof

Goal

- Determine advantages
- Reduce building's energy consumption
- Determine savings and payback

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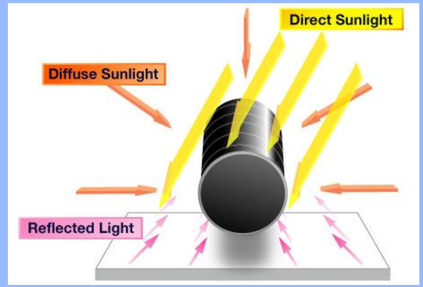
Solyndra System

- Founded in 2005 in Fremont, California
- State of the art highly automated production
- Reliable hermetic seal on ends of each module
- Great application on cool roofs
- Absorbs energy from 360 degrees
  - Direct
  - Diffuse
  - Reflected
- Can produce 99% of output regardless of orientation when used with highly reflective roof



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Solyndra Advantages

- Flat installation, higher panel placement
- Lightweight design, 3lb/ft^2
- No roof penetrations, self ballasted
- 25-year power warranty
- Superior wind performance, tested and certified for 130 mph
- 3x faster installation
- 50% reduction in installation cost
- 30% Investment Tax Credit (ITC) when applied on a cool roof
  - Installation labor
  - Reflective roof material
  - Fasteners and adhesive agents
  - Insulation
  - Supporting Materials

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Application

- Allow for two feet maintenance walkways around panels
- Mechanical installation
  - Connect mounting hardware to panel
  - Transport panels to location
  - Plug in DC connectors and grounding cable
  - Install lateral clips to connect panels
  - Place ballasting material on mounting hardware
  - Five qualified workers two 8-hour days
- Electrical installation
  - Run wiring from panels to inverter
  - Install inverter
  - Two electricians 5-10 days to complete

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Energy Consumption (Electrical Breadth)

- Mechanical Equipment
  - 745.7 watts = 1HP
  - 261 work-days in 2010
  - 16 hour/day operation
  - Average energy cost Balt./Wash. 2009: $.137/kWh
- Lighting Load
  - Lighting Power Density, ASHRAE 90.1
  - LPD is an estimate of W/ft^2
  - 261 work-days in 2010
  - 10 hour/day operation
  - Average energy cost Balt./Wash. 2009: $.137/kWh

Mechanical Equipment Power Cost					
	Total KW	Use (Hr/Yr)	KWH/Yr	Cost (KWH)	Total Cost
Building A	2251.36	2610.00	5876049.60	$0.14	$805,018.80
Building B	2215.27	2610.00	5781854.70	$0.14	$792,114.09
P-Levels	135.36	2610.00	353289.60	$0.14	$48,400.68
		Consumption:	12011193.90	Total Cost:	$1,645,533.56

Lighting Cost					
	Total KW	Use (Hr/Yr)	KWH/Yr	Cost (KWH)	Total Cost
Building A	188.10	2610	490941	$0.14	$67,258.92
Building B	181.98	2610	474967.8	$0.14	$65,070.59
P-Levels	74.65	2610	194836.50	$0.14	$26,692.60
					$159,022.11

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Energy Consumption (Electrical Breadth)

- Receptacle Load
  - 1VA = 1Watt
  - NEC 2008 Table 20.44 Article 220: Branch Circuit-Feeder
    - 1st 10kVA = 100%
    - After 10kVA = 50%
  - 261 work-days in 2010
  - 10 hour/day operation
  - Average energy cost Balt./Wash. 2009: $.137/kWh

Receptacle Cost					
	Total KW	Use (Hr/Yr)	KWH/Yr	Cost (KWH)	Total Cost
1st 10 KVA	10	2610	26100	$0.14	$3,575.70
After 10KVA	33.43	2610	87252.3	$0.14	$11,953.57
		Total:	113352.3	Total:	$15,529.27

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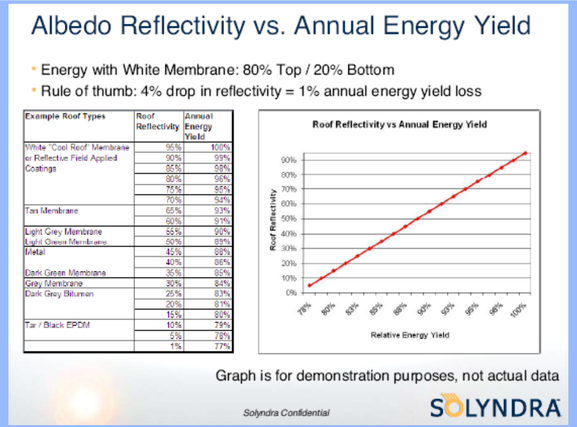
Energy Production (Electrical Breadth)

- Solyndra Panels (1030)
- GAISMA Insolation

Month	Days/Month	Insolation (kWh/m^2/day)	Sun Hours/Day	Max Power Rating/Panel (Wp)	Output/Panel kWH/Panel)
January	31	1.87	1.87	200	11.594
February	28	2.61	2.61	200	14.616
March	31	3.58	3.58	200	22.196
April	30	4.61	4.61	200	27.66
May	31	5.27	5.27	200	32.674
June	30	5.75	5.75	200	34.5
July	31	5.65	5.65	200	35.03
August	31	5.08	5.08	200	31.496
September	30	4.11	4.11	200	24.66
October	31	3.14	3.14	200	19.468
November	30	2.1	2.1	200	12.6
December	31	1.64	1.64	200	10.168
		Power Output/Panel/Year (KWH/panel/year)			276.662
		Total Power Output 100%:			284961.86
		Total Power Output On White TPO Roof 99%:			282112.24



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System Cost

- $1,400 per panel
- 1,030 panels implemented
- $1,442,00 total system cost

Energy and Cost Savings

- 276.7 kWh/panel
- 282,112 kWh total
- 1.38 % energy savings per year
- $38,649.38 energy cost savings during first year

Annual Building Consumption & Energy Cost		
	Consumption per Year (KWH)	Cost ($)
Mechanical	19,217,910.24	$2,632,853.70
Lighting	1,160,731.21	$159,020.18
Receptacles	113,352.30	$15,529.27
Totals:	20,491,993.75	$2,807,403.15

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System Payback

- Initial energy cost = $.137
- 5% energy increase per year
- 22-year payback
- $402,622.63 energy cost savings by 25-year warranty
- After 40-year period:
  - Projected energy cost = $.92/kWh
  - $3,226,836 savings for owner

Solyndra Payback Period					
Year	Cost Increase/y	Energy Cost	Energy Produc	Cost Savings	Savings To-date
1		$0.14	282112.24	$38,649.38	$38,649.38
2	1.05	$0.14	564224.48	$40,581.85	$79,231.22
3	1.05	$0.15	846336.72	$42,610.94	$121,842.16
4	1.05	$0.16	1128448.96	$44,741.48	$166,583.65
5	1.05	$0.17	1410561.20	$46,978.56	$213,562.20
6	1.05	$0.17	1692673.44	$49,327.49	$262,889.69
7	1.05	$0.18	1974785.68	$51,793.86	$314,683.55
8	1.05	$0.19	2256897.92	$54,383.55	$369,067.11
9	1.05	$0.20	2539010.16	$57,102.73	$426,169.84
10	1.05	$0.21	2821122.40	$59,957.87	$486,127.71
11	1.05	$0.22	3103234.64	$62,955.76	$549,083.47
12	1.05	$0.23	3385346.88	$66,103.55	$615,187.02
13	1.05	$0.25	3667459.12	$69,408.73	$684,595.75
14	1.05	$0.26	3949571.36	$72,879.16	$757,474.91
15	1.05	$0.27	4231683.60	$76,523.12	$833,998.04
16	1.05	$0.28	4513795.84	$80,349.28	$914,347.32
17	1.05	$0.30	4795908.08	$84,366.74	$998,714.06
18	1.05	$0.31	5078020.32	$88,585.08	$1,087,299.14
19	1.05	$0.33	5360132.56	$93,014.33	$1,180,313.47
20	1.05	$0.35	5642244.80	$97,665.05	$1,277,978.52
21	1.05	$0.36	5924357.04	$102,548.30	$1,380,526.83
22	1.05	$0.38	6206469.28	$107,675.72	$1,488,202.54
23	1.05	$0.40	6488581.52	$113,059.50	$1,601,262.05
24	1.05	$0.42	6770693.76	$118,712.48	$1,719,974.53
25	1.05	$0.44	7052806.00	$124,648.10	$1,844,622.63
				Initial Cost:	$1,442,000.00
				Yr. 25 Savings:	**$402,622.63**

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Conclusions

- Excellent for use on cool roof
- No roof penetrations
- 30% Investment Tax Credit
- Marketability, Green Technology
- First year savings of $38,650
- 22-year payback
- Best suited for low-rise buildings
- Would be acceptable for this project

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Opportunity

- Two building envelope systems
  - Architectural precast and punched windows
  - Curtain wall system
- Standardize materials, all one curtain wall system
- Prefabricated units assembled in controlled environment
- Reduce site congestion
- Limit crane usage

Goal

- Shorten project schedule
- Reduce construction costs
- Determine increased solar gain

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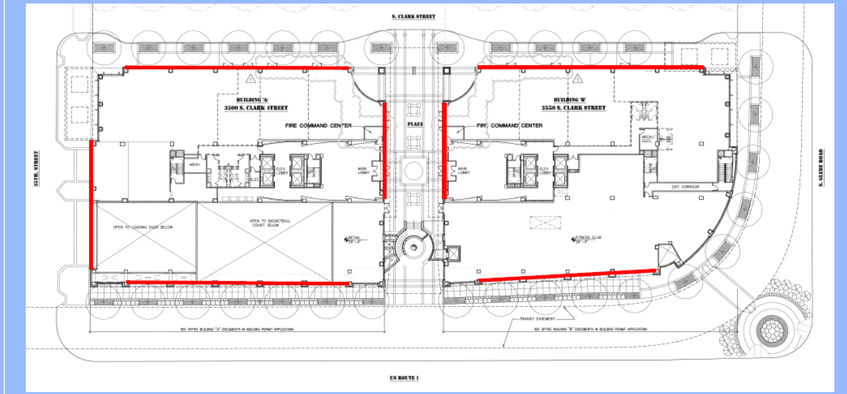
Curtain Wall System

- Keep outdoor elements out of interior
- Lightweight design
- Extruded aluminum framing
- Predominantly glass
- No structural support
- Connected on columns or floor systems

Advantages

- Speedy installation
- Span multiple floors
- Architects have various coatings to make building facades pleasing
- Units assembled in controlled environment
- Doesn't require external access for installation



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Installation Methods

- Tower Crane
  - Used to finish topping out the building
- Mobile Crane
  - Site congestion
  - Staging
  - Permits
- Monorail System
  - Reinforce roof structure for cantilever mounting
  - Multiple elevation usage
  - Easily maneuverable
- Floor Crane
  - Accessible anywhere

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Heat Gain- the rate at which heat enters or is generated in a space over a given period of time

- **Sensible-** energy added to a space by conduction, convection or radiation
  - Through floors, ceilings and walls
  - Occupant's body heat
  - Solar heat gain through glazing
  - Appliances
- **Latent-** energy added to a space by moisture
  - Infiltration and ventilation
  - Occupant respiration
  - Moisture from equipment

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Cooling Load- the rate at which energy must be removed from a space to maintain a constant air temperature

- External and internal loads
- Differs from heat gain due to delayed effect

CLTD/SCL/CLF Method (Mechanical Breadth)

- Used to compensate for the delay in thermal storage
- CLTD factors used to adjust for conductive heat gains on envelope
- CLF factors used to adjust for transmission heat gains through glazing
- Total heat gain = Conductive heat gains + Solar heat gains
- Conductive: Q = U*A*CLTD
- Solar: Q = A*SC*SCL

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Cooling Load (Mechanical Breadth)

Conductive:
Q = U A *CLTD

U-value: .26, from Viracon data table
Area of exposed glass: Architectural plans
CLTD at noon = 9 Table 34 Ch. 28
CLTD correction = [CLTD + (78-TR) + (TM-85)]

TR= Indoor room temp
TM= Mean outdoor air temp

Arlington Virginia

- Elevation: 720 feet
- Latitude: 37º 38N
- Longitude: 078º 56W
- Indoor Room Temperature: 70º assumed
- Maximum outdoor temperature: 87º in July
- Mean daily range: 20º

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Cooling Load (Mechanical Breadth)

Solar:

Q = A* (SC) * (SCL)

Area of exposed glass: Architectural plans

SC: .44 from Viracon data table

Zone Type: A, from ASHRAE 1997 Ch. 28, Table 35B

SCL: 67 at Noon, from ASHRAE 1997 Ch. 28, Table 36

Conductive Q		
	Punched Windows (BTU)	Curtain Wall (BTU)
	994,922.50	2,011,262.50
Solar Q		
Elevation	Punched Windows (BTU)	Curtain Wall (BTU)
North	914,353.44	2,120,210.40
East	6,325,277.20	12,571,004.00
South	681,801.84	1,580,979.40
West	5,693,007.80	11,314,214.00
Total:	**14,609,362.78**	**29,597,670.30**
% Increase:		**202.59%**

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Cost Comparison

- TSI/ Exterior Wall Systems, Glazing Contractor
  - Material: $54.30 s.f.
  - Installation: $20.28 s.f.
- Arban & Carosi, Precast Contractor
  - Material and Installation: $20.00 s.f.
- Cost of existing system: $3,533,950.00
- Cost of proposed curtain wall: $4,615,362.00
- Cost increase of 31%

Curtain Wall				
	Elevation	Type	Area (ft^2)	Cost ($)
Building A	West	Glazing	12168.00	$907,515.00
	East	Glazing	12168.00	$907,515.00
	North	Glazing	5215.00	$388,935.00
	South	Glazing	5215.00	$388,935.00
Building B	West	Glazing	9735.00	$726,012.00
	East	Glazing	12168.00	$907,515.00
	North	Glazing	5215.00	$388,935.00
	South	Glazing	none	none
			Total:	**$4,615,362.00**

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Schedule Comparison

- Duration based off of 50 units a day
- Preparation, 4 man crew
  - 3 men installing slab edge anchors and ball anchors
    - 1 man shooting elevation
    - 2 installing material
  - 1 man installing silicon boot on slab and anchor bedding
- Installation, 8 man crew
  - 2 men operating floor crane two floors above
  - 3 men distributing units in crates from truck
  - 3 men set units into place and secure connections
- 23 days reduction in project schedule

ID	Task Name	Duration	Start	Finish
1	**Punched and Precast System**	**116 days**	**Mon 2/9/09**	**Mon 7/20/09**
2	**Building B**	**86 days**	**Mon 2/9/09**	**Fri 6/19/09**
3	Install Architectural Precast B	55 days	Mon 2/9/09	Mon 4/27/09
4	Install Punch Windows B	21 days	Thu 4/9/09	Thu 5/7/09
5	Precast Caulking B	30 days	Mon 5/11/09	Fri 6/19/09
6	Window Caulking B	40 days	Mon 4/27/09	Fri 6/19/09
7	**Building A**	**112 days**	**Fri 2/13/09**	**Mon 7/20/09**
8	Install Architectural Precast A	76 days	Fri 2/13/09	Thu 5/28/09
9	Install Punch Windows A	36 days	Tue 5/5/09	Tue 6/23/09
10	Precast Caulking A	15 days	Tue 6/2/09	Mon 6/22/09
11	Window Caulking A	26 days	Mon 6/15/09	Mon 7/20/09
12				
13	**Curtain Wall System**	**95 days**	**Mon 2/9/09**	**Wed 6/17/09**
14	**Building B**	**77 days**	**Mon 2/9/09**	**Tue 5/26/09**
15	Installation of Slab Edge and Ball Anchors	53 days	Mon 2/9/09	Wed 4/22/09
16	Installation of Silicon Boot	22 days	Wed 3/18/09	Thu 4/16/09
17	Install Curtain Wall System B	21 days	Fri 3/27/09	Fri 4/24/09
18	Install Sealants on East	10 days	Mon 4/20/09	Fri 5/1/09
19	Install Sealants on West	10 days	Mon 5/4/09	Fri 5/15/09
20	Install Sealants on North	7 days	Mon 5/18/09	Tue 5/26/09
21	**Building A**	**89 days**	**Fri 2/13/09**	**Wed 6/17/09**
22	Installation of Slab Edge and Ball Anchors	41 days	Fri 2/13/09	Fri 4/10/09
23	Installation of Silicon Boot	17 days	Mon 3/23/09	Tue 4/14/09
24	Install Curtain Wall System A	28 days	Wed 4/1/09	Fri 5/8/09
25	Install Sealants on East	10 days	Fri 5/1/09	Thu 5/14/09
26	Install Sealants on West	10 days	Fri 5/15/09	Thu 5/28/09
27	Install Sealants on North	7 days	Fri 5/29/09	Mon 6/8/09
28	Install Sealants on South	7 days	Tue 6/9/09	Wed 6/17/09

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General Conditions Reduction

- Original: $6,110,382.88
- Reduced: $6,003,681.58
- Savings: $106,701.30
- Reduction: 1.75%
- Categories Reduced:
  - General Contractor Staff
  - Dumpsters

General Contractor Staff					
Description	Time on Job	Quantity	Unit	Unit Price	Total
Project Executive	20%	81.5	week	$1,144.00	$93,236.00
Senior Project Manager	80%	81.5	week	$2,653.00	$172,877.60
Project Managers (2)	100%	81.5	week	$2,083.00	$339,529.00
Assistant Project Managers (2)	100%	81.5	week	$1,555.00	$253,465.00
Superintendents (2)	100%	81.5	week	$3,345.00	$545,235.00
Assistant Superintendents (1)	100%	81.5	week	$2,465.00	$200,897.50
Safety	10%	81.5	week	$161.00	$13,123.50
Layout Engineer	60%	81.5	week	$1,373.00	$111,899.50
				Total Cost	$1,730,359.10

Temporary Utilities					
Description	Quantity	Unit	Duration	Unit Price	Total
Heat	1	CSF/week	20	$12.50	$154,750.00
Lighting	1	CSF		$29.42	$18,210.98
Power	1	CSF		$51.79	$32,002.30
Toilets	8	Month	20	$162.00	$25,920.00
				Total Cost	$230,883.28

Construction Facilities and Equipment					
Description	Quantity	Unit	Duration	Unit Price	Total
Trailers	4	EA/month	10	$410.00	$16,400.00
Storage Boxes	3	EA/month	10	$79.00	$2,370.00
Field Office Equipment Rental	4	Month	10	$171.00	$6,840.00
Office Supplies	4	Month	10	$93.50	$3,740.00
Field Office Lights & HVAC	4	Month	10	$165.00	$6,600.00
Scaffolding	30	CSF		$124.00	$3,720.00
Fencing	800	LF		$11.15	$9,000.20
Signage	100	SF		$25.00	$2,500.00
Dumpsters	4	Week	81.5	$620.00	$202,120.00
Tower Crane Material Hoist (Trades)					$0.00
Testing and Inspections (Owner)					$0.00
				Total Cost	$253,290.20

Permits, Insurance and Fee				
Description	Quantity	Unit	Unit Price	Total
Permits	1	LS	$383,000.00	$383,000.00
Building Permit and others (Owner)				$0.00
Payment and Performance Bond	1	LS	$459,600.00	$459,600.00
General Liability Insurance	1	LS	$183,840.00	$183,840.00
Builder's Risk Insurance (Owner)				$0.00
Contractors Fee	1	LS	$2,762,700.00	$2,762,700.00
			Total Cost	$3,789,140.00

Total General Conditions	$6,003,681.58
% Total Contract Value	7.84
Cost per Month	$100,184.08
Cost per Week	$69,810.35

Potomac Yard Land Bay E
Arlington, Virginia

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- Project Overview
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- **Implementation of Curtain Wall System (Mechanical Breadth)**
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- Conclusions and Recommendations
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Conclusions

- Reduces schedule 23 days
- 1.75% reduction in general conditions
- Able to begin installation before building is topped out
- Doubles glazing
  - More natural daylight for occupants
  - More than doubles the cooling load
- Increased initial cost of 31%
- Existing system is better suited
  - Lower initial cost
  - More energy efficient, less solar heat gain

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Opportunity

- Implement a more efficient mechanical system
- Reduce the amount of large ductwork
- Reduce floor-to-floor height

Goal

- Learn about the types of chilled beams and their advantages
- Determine conditioned air space savings
- Determine CIP savings
- Compare system cost
- Compare installation duration

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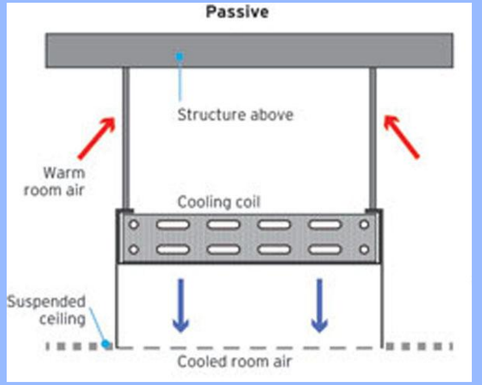
Passive Chilled Beams

- Simplest type, cooling capacity of 50 Btuh/sf
- Relies on natural convection to condition space
- Water supplies unit
- Heat exchanger made of aluminum or copper coils
- Additional ventilation required
- Not suited for placement above:
  - Work stations
  - Heat generators
- Good placement by windows to enhance convection
- Ground water may be used to supply units



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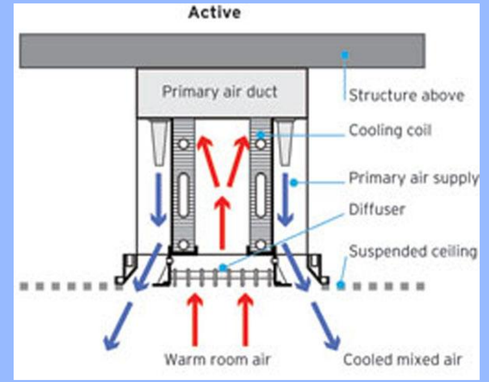
Active Chilled Beams

- Cooling capacity of 80 Btuh/sf
- Integrate use of ventilated air supply to unit
- Natural convection assistance
- Ventilated air introduced at high velocity
- Conditioned air and ventilated air mixed thoroughly inside the unit
- Induction and exhaust located on the bottom of unit
- 50-75% less forced air than an all air system
- Placement is key for optimum performance
  - Depends on ceiling height
  - Doesn't matter if placed above workstation or heat generator
- May produce heat



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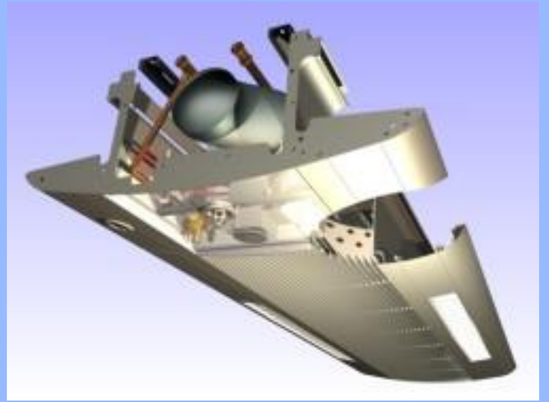
Multiservice Chilled Beams

- May be either active or passive
- Much larger, prefabricated units
- Speed up schedule
- Incorporate many building features:
  - Mechanical system
  - Lighting
  - Sprinklers
  - Public address system
  - Building automated systems
  - Wire ways



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Advantages

- Water is more dense than air, which allows it to transfer cooling energy more efficiently
- More energy efficient than all air systems
  - Constitution Center in Washington DC will consume 23% less energy with a chilled beam system compared to an all air system compliant with ASHRAE 90.1 standard
- Lower discharge velocity, more comfortable for occupants
- Ventilated and conditioned air mixed more thorough
- Reduce large metal ductwork
- Reduction of air handlers and fans
- Quiet operation, no moving parts
- Low maintenance

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Disadvantages

- Initial cost and installation
  - Units come from overseas
  - Unfamiliarity of contractors
  - Piping
  - Insulation
  - Pumps
- Not suited for high ceilings or rooms with high humidity
- Building may not have operable windows
- Building air must be dehumidified

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Reduction of Conditioned Air Volume

- VAV ceiling plenum: 18”
- Chilled beam ceiling plenum: 10”
- Ceiling plenum and floor-to-floor height savings: 8”
- Conditioned air savings 268,123 CF or 5.22%
- Allows for a higher percentage of ventilated air into the occupied space
  - Healthier work environment

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Cast-in-place Concrete Savings

- Structural columns on office floors
- 5.19% CIP concrete reduction from columns
- 52.7 CY reduction
- Approximately 6 truck deliveries
- $67,390.13 savings

Concrete Savings				
Strenght (PSI)	Original (CY)	Proposed (CY)	Savings (CY)	Savings (%)
5000	215.49	203.98	11.51	5.34%
6000	800.43	759.24	41.19	5.15%
		Total Savings:	52.70	5.19%

Cost Savings $1375/CY			
Strenght (PSI)	Original ($)	Proposed ($)	Savings ($)
5000	$296,298.75	$280,472.50	$15,826.25
6000	$1,100,591.25	$1,043,955.00	$56,636.25
		Total Savings:	$72,462.50
		Adjusted (.93):	$67,390.13

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Cost Comparison

- Chilled beam system- **$3,049,248**
  - Union labor rate $54
  - 1” pipe $600/100’ including fittings
  - 1 hour for beam installation
  - 30hours/100’ of pipe
  - 25”x5” trunk duct
  - $1800/100’ duct
  - 25 hours to fabricate and install duct
  - $30 flex duct supplying individual unit
  - Chilled beam cost $800
  - 18 beams for 2700s.f.

Cost Comparison

- VAV System- **$2,108,768**
  - Union labor $54
  - Assuming average duct size 2’x3’
  - Material $240/12’
  - 3 hours fabrication for 12’
  - 10 hours installation for 12’
  - VAV $2500 including local controls
  - 4 hours for VAV installation

- Chilled Beam system is 45% higher than VAV system
- Cost savings for AHU’s, fans and controls not accounted for

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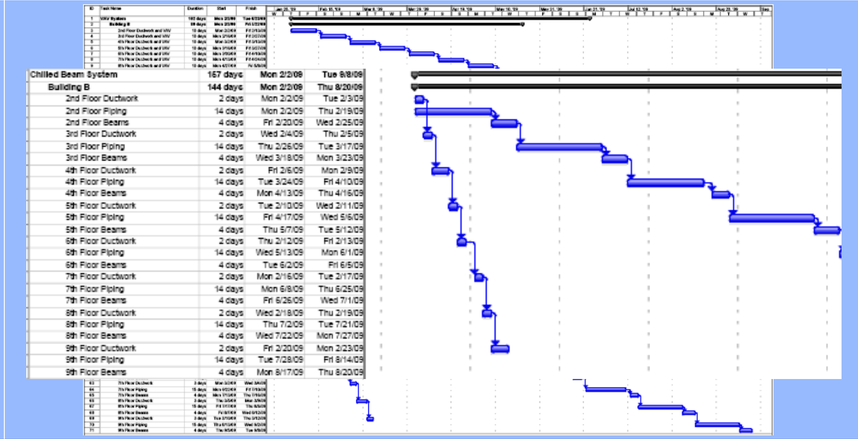
Schedule Comparison

- VAV system duration: 102 days
- Chilled beam system duration: 157 days
- Chilled beam system takes 54% longer to install
- Assumptions for chilled beam system:
  - 5 men crew
  - Ductwork: 19hr/100’
  - Piping: 30hr/100’
  - Beams: 1hr/beam



	Task Name	Duration	Start	Finish
1	Chilled Beam System	157 days	Mon 2/2/09	Tue 9/8/09
2	Building B	144 days	Mon 2/2/09	Thu 8/20/09
3	2nd Floor Ductwork	2 days	Mon 2/2/09	Tue 2/3/09
4	2nd Floor Piping	14 days	Mon 2/2/09	Thu 2/19/09
5	2nd Floor Beams	4 days	Fri 2/20/09	Wed 2/25/09
6	3rd Floor Ductwork	2 days	Wed 2/4/09	Thu 2/5/09
7	3rd Floor Piping	14 days	Thu 2/26/09	Tue 3/17/09
8	3rd Floor Beams	4 days	Wed 3/18/09	Mon 3/23/09
9	4th Floor Ductwork	2 days	Fri 2/6/09	Mon 2/9/09
10	4th Floor Piping	14 days	Tue 3/24/09	Fri 4/10/09
11	4th Floor Beams	4 days	Mon 4/13/09	Thu 4/16/09
12	5th Floor Ductwork	2 days	Tue 2/10/09	Wed 2/11/09
13	5th Floor Piping	14 days	Fri 4/17/09	Wed 5/6/09
14	5th Floor Beams	4 days	Thu 5/7/09	Tue 5/12/09
15	6th Floor Ductwork	2 days	Thu 2/12/09	Fri 2/13/09
16	6th Floor Piping	14 days	Wed 5/13/09	Mon 6/1/09
17	6th Floor Beams	4 days	Tue 6/2/09	Fri 6/5/09
18	7th Floor Ductwork	2 days	Mon 2/16/09	Tue 2/17/09
19	7th Floor Piping	14 days	Mon 6/8/09	Thu 6/25/09
20	7th Floor Beams	4 days	Fri 6/26/09	Wed 7/1/09
21	8th Floor Ductwork	2 days	Wed 2/18/09	Thu 2/19/09
22	8th Floor Piping	14 days	Thu 7/2/09	Tue 7/21/09
23	8th Floor Beams	4 days	Wed 7/22/09	Mon 7/27/09
24	9th Floor Ductwork	2 days	Fri 2/20/09	Mon 2/23/09
25	9th Floor Piping	14 days	Tue 7/28/09	Fri 8/14/09
26	9th Floor Beams	4 days	Mon 8/17/09	Thu 8/20/09

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Conclusions

- Chilled beam system takes longer to install
- Higher initial cost
- Increased energy savings
- Lower floor-to-floor height
  - Concrete savings
  - Conditioned air savings
  - Higher percentage of outside air
  - Allows for more floors in height restricted areas
- Good investment with deregulation of energy and prices increasing

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Conclusions and Recommendations

- Solyndra PV System
  - Large savings in upcoming years
  - Payback 22 years
- Curtain Wall System
  - High initial cost
  - Increased cooling load
  - Speedy installation
- Chilled Beam System
  - Substantial savings in concrete and conditioned air
  - Increased energy savings
  - Higher initial cost

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