Air-Water Systems

TROX USA

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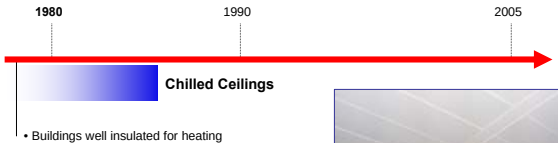
Chilled Ceilings and Beams

Early 1980's



- Buildings well insulated for heating
- Advent of personal computers
- Need to remove heat from space
- Limited space available

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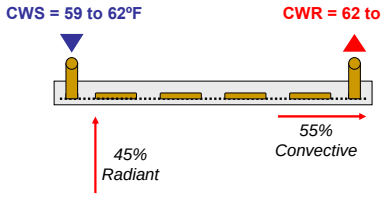
Principle of Operation

Chilled Ceiling Panels



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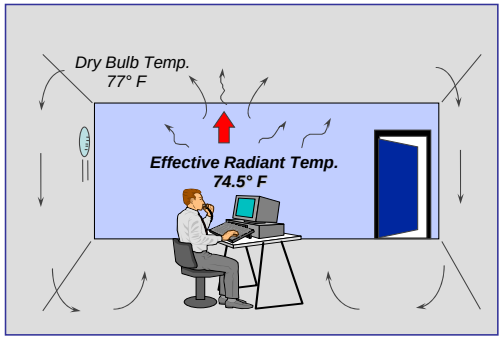
Radiant Effect on Occupants

Chilled Ceiling Panels



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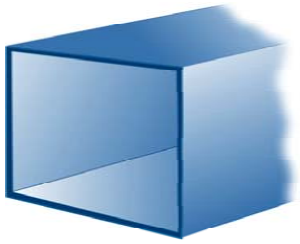
Cooling Capacity Comparison

Flow Cross Section Ratio

1 : 327

18" x 18"
Air Duct



1" diameter
Water Pipe

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Chilled Ceiling Systems

- Improved thermal comfort
- Minimal space requirements
- Low energy cooling solution
- Limited Cooling Capacity
  - 25 BTUH/FT^2 of active panel
  - 18 BTUH/FT^2 of floor area (based on 70% active ceiling)

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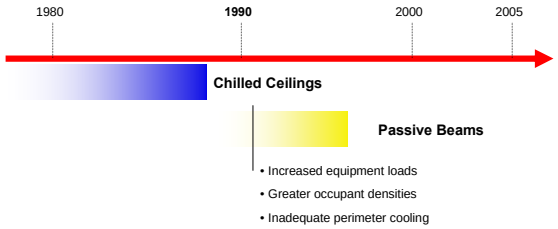
Chilled Ceilings and Beams

Early 1990's



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Passive Chilled Beams

- Ceiling manufacturers begin to sell high free area perforation panels competitively
- Convective coils replace ceiling panels

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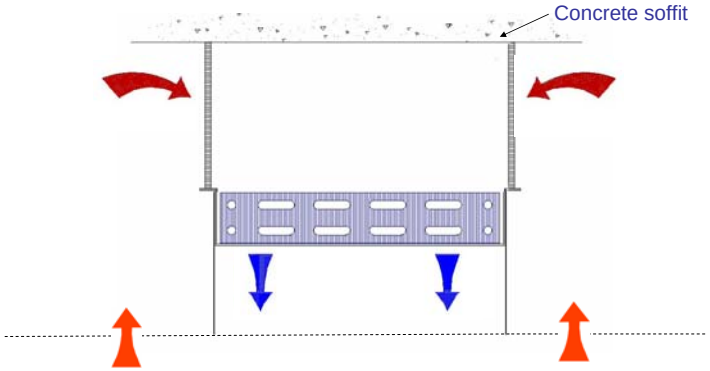
Passive Chilled Beams



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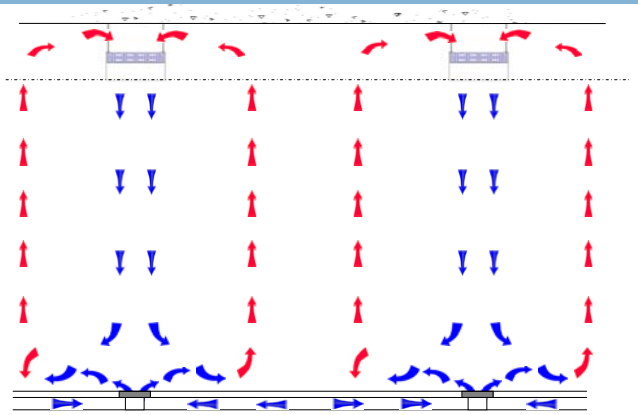
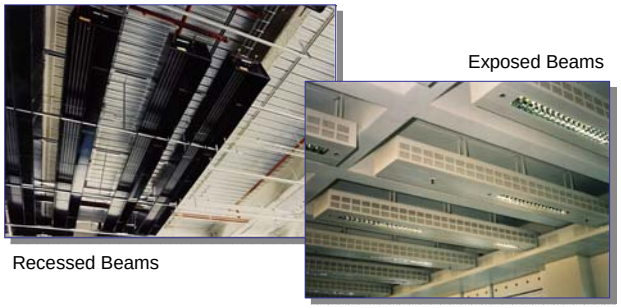
Passive Chilled Beam

Air Distribution Pattern



Passive Chilled Beams



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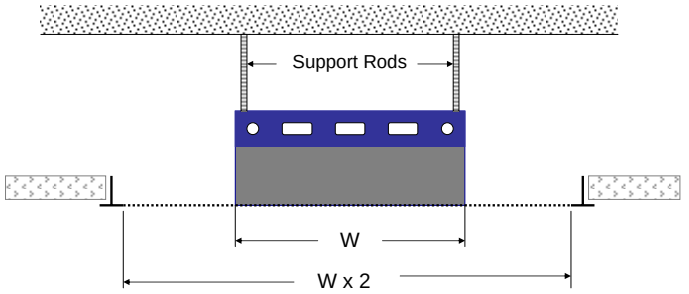
Recessed Passive Beams



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Passive Beam Installations

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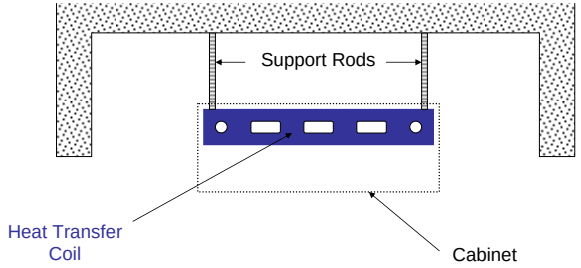
Exposed Passive Beam



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Passive Beam Installations

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Chilled Ceilings and Beams

Mid 1990's

- Continually increasing sensible loads
- Greater occupant densities
- Gypsum board tiles become common
- Combine cooling and ventilation

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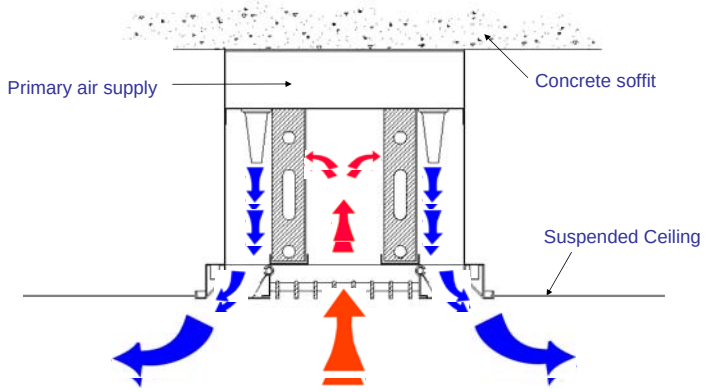
Active Chilled Beams



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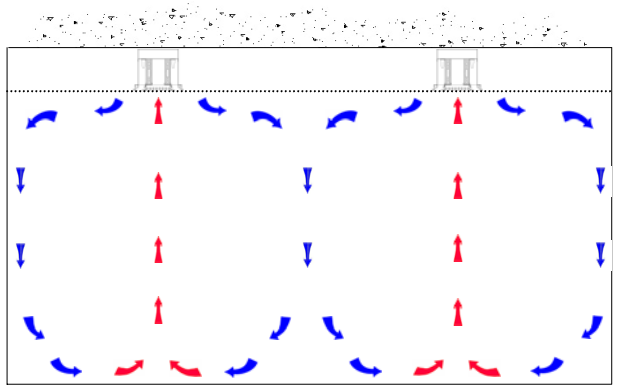
TROX® TECHNIK

Active Chilled Beam

Air Distribution Pattern



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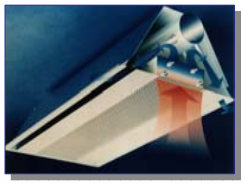
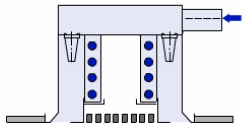
Active Chilled Beams

- Sensible loads up to 100 BTUH/FT^2
- Primary air delivered at conventional (50 to 55ºF) temperatures at or near minimum ventilation flow rate
- Can be used with fiberglass ceiling tiles or without any ceiling





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Active Beam Installation

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Typical Output

Device Capacity		Cooling Effect (BTUH/FT²)
25 BTUH/FT²	Chilled Ceiling 	18 BTUH/FT²
400 BTUH/LF	Passive Beam 	40 BTUH/FT²
800 BTUH/LF	Active Beam 	100 BTUH/FT²

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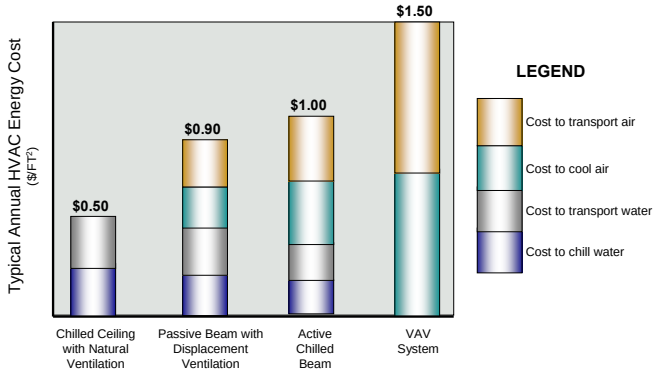
Comparative Energy Costs



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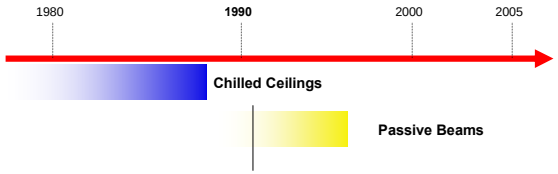
Passive Chilled Beams

For UFAD Applications



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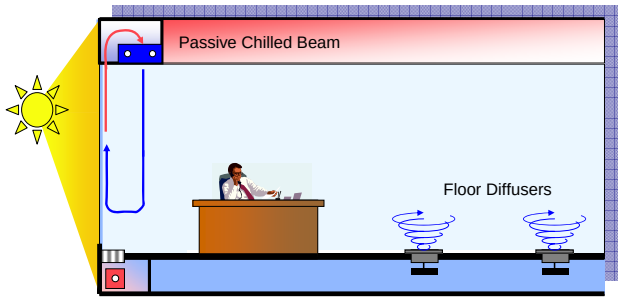
UFAD Perimeter Treatment

Decoupled Sensible Cooling System



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Supply Airflow Requirements

Fan Terminals vs. Chilled Beams

For a floor plate that is 60% interior space

Fan Powered Perimeter Solution:

Interior:	0.6 CFM/ft^2
Perimeter (design):	3.0 CFM/ft^2
Perimeter Diversity:	70%
Overall :	1.2 CFM/ft^2

Chilled Beam Perimeter Solution:

Interior:	0.6 CFM/ft^2
Perimeter:	0.6 CFM/ft^2
Overall :	0.6 CFM/ft^2

50% reduction in supply airflow

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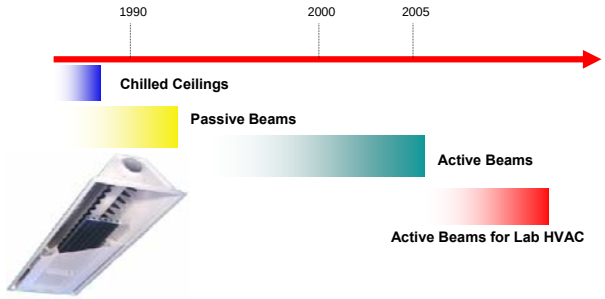
Active Chilled Beams

For Laboratory HVAC Applications



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Laboratory Design Issues

- Space sensible heat gains of 60 to 75 BTUH/FT^2
- Ventilation requirements of 6 to 8 ACH^{-1}
- Laboratories where chemicals and gases are present require 100% OA
- All air systems require 16 to 20 ACH^{-1} to satisfy sensible load
- Active beams remove over 60% of sensible heat via chilled water circuit
- Require only 40% the primary airflow rate (6-8 ACH^{-1}) of all-air system

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Case Study

Laboratory Design for Pharmaceutical Company

- Location: St. Louis, MO
- Outdoor Design Conditions: 94DB/75WB
- Laboratory Space: 54,000 FT^2
- Minimum Ventilation Rate: 8 ACH^{-1}
- Space Sensible Heat Gain: 72 BTUH/FT^2

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Equipment Requirements

Equipment	Conventional VAV	Active Chilled Beam
Air Handling Units	180,000 CFM	72,000 CFM
Cooling	1,477 Tons	587 Tons
Heating	21,617 lbs/hr	8,588 lbs/hr
Duct Distribution	285,493 lbs.	214,120 lbs.
Control Points	800	800
Chilled Beams		1,056
Piping Distribution		4,200 LF
Sensible Cooling Chiller System		200 Tons

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Energy Comparisons

Case Study, 94/75F Outdoor Design

Active Chilled Beam (Parallel Sensible Cooling)

- Reduced fan power – 32 % from Base VAV
- Reduced cooling energy – 46 % from Base VAV
- Reduced ductwork sizes – 18-20 ACPH to 6-8 ACH^{-1}
- Higher Pumping energy – 15% - Offset by other savings
- Higher cooling system efficiencies

Overall 35% Reduction in Energy Costs

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Equipment Requirements

Equipment	Conventional VAV	Active Chilled Beams
Air Handling Units	$2,264,335	$899,610
Cooling	$1,627,799	$646,717
Heating	$244,267	$97,046
Duct Distribution	$1,481,709	$1,111,282
Control Points	$1,200,000	$1,140,000
Chilled Beams		$1,652,984
Piping Distribution		$266,444
Sensible Cooling Chiller System		$265,373
Totals	$6,818,109	$6,079,456

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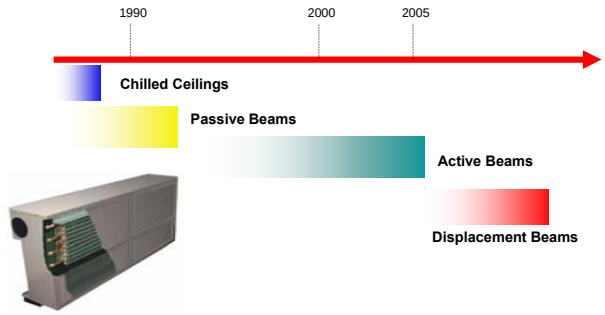
Displacement Beams



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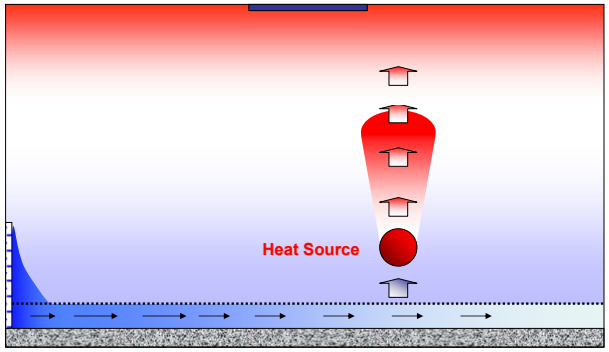
Displacement Conditioning



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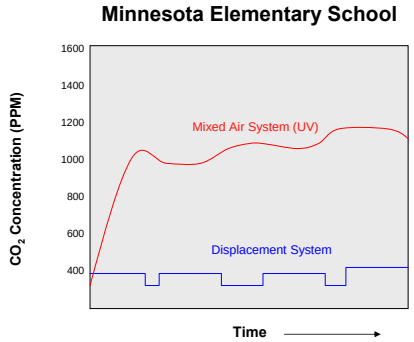
Displacement Conditioning Advantages



- Identical classrooms
- Tests conducted over two week period
- CO_2 concentration at six foot level monitored
  - Mixed system: 1200 PPM
  - DV System: 400 PPM

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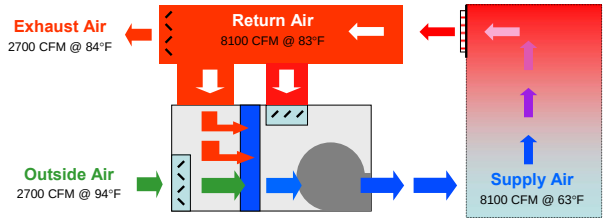
Displacement System Air Handling Unit Design



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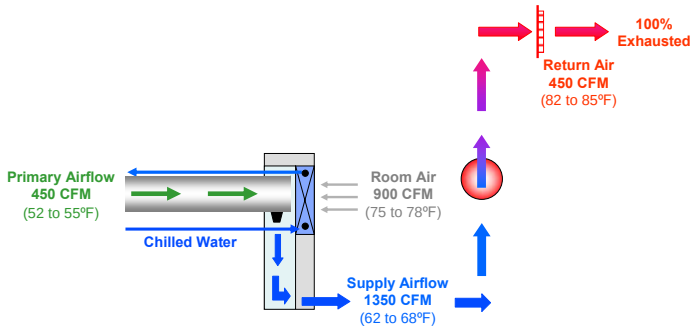
Displacement with Induction

Cooling mode operation



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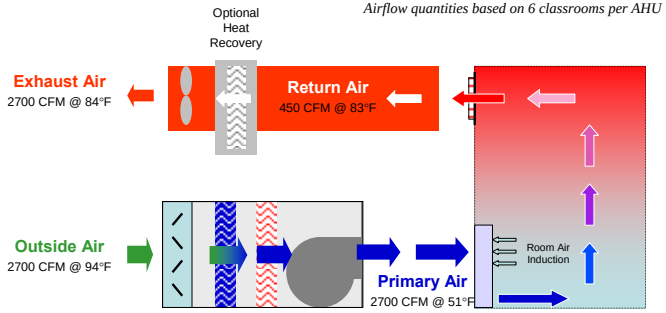
Displacement with Induction Air Handling Unit Design

Airflow quantities based on 6 classrooms per AHU



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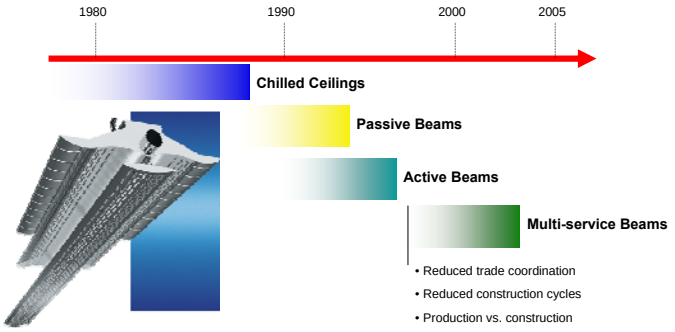
Chilled Ceilings and Beams

Early 2000's



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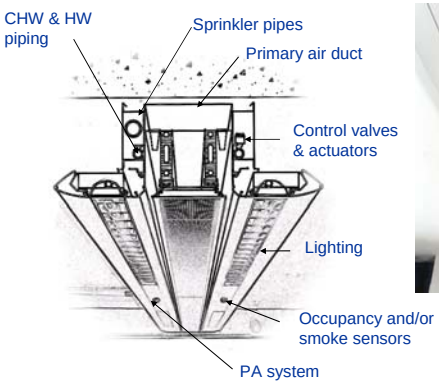
The Future



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Multi Service Beams

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Indirect Lighting

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Passive Multi-Service Beam

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Production vs Construction

- Reduce on site fixed costs
- Reduce trade coordination
- Improved quality control
- Reduce design coordination
- Reduce construction schedule
- Deliver building earlier

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MSCB Economics

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Cost Calculations

- Class A Office Building
- Location: Chicago, Illinois
- 250,000 NSF, 200,000 RSF
- 10 Floors, 25,000 ft² per floor
- Construction Cost: $150 per ft²
- Fixed Site Costs: 12%
- Construction Time: 24 months
- Net Lease Rate: $25 per ft²

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Capital Costs

- Building Construction Cost: 250,000 ft² x $150/ft² = $37,500,000

• Fixed Site Costs:	12% of $37,500.000 =	$4,500,000	$43,000 per week
• Construction Loan Interest:	5% of 18,750,000 =	$938,000*	$18,000 per week
• Accelerated Revenue:	200,000 ft² x $25/ft² =	$5,000,000	$96,000 per week
			$157,000 per week

** Annual interest cost*

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First Cost Comparison

Conventional VAV System

• HVAC Run out Costs:	250,000 ft² x $8/ft²	= $2,000,000	
• Air Handling Units:	300,000 CFM x $2.25/CFM	= $675,000	
		$2,675,000	$10.70/ft²

Multi-service Beams

• MSCB's:	7600 lf x $550/lf	= $4,180,000	
• Air Handling Units	120,000 CFM x $2.25/CFM	= $270,000	
• Air Cooled Chillers	240 Tons x $1000/Ton	= $240,000	
		$4,690,000	$18.76/ft²
Less: Lighting Installation Costs ($1 per ft²):		$250,000	
Less: Suspended Ceiling ($4 per ft²):		$1,000,000	
		$3,440,000	$13.76/ft²
Premium for MSCB over VAV:		**$765,000**	$3.06/ft²

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Capital Costs

Actual Scenario (worst case):

- *Owner is able to rent 25% of space immediately*
- *MSCB reduce construction time by 10% (10 weeks)*

• Building Construction Cost:	250,000 ft^2 x \$150/ft^2 = \$37,500,000		
• Fixed Site Costs:	12% of \$37,500.000 =	\$4,500,000	\$43,000 per week
• Construction Loan Interest:	5% of 18,750,000 =	\$938,000*	\$18,000 per week
• Accelerated Revenue:	25% x 200,000 ft^2 x \$25/ft^2 =	\$1,250,000	\$24,000 per week
			\$85,000 per week
			x 10 weeks
	Net cash result		\$850,000

** Annual interest cost*

Payback Analysis

Worst Case Scenario

- Initial Cost Premium: = \$765,000*
- Early Delivery Worst Case Cash Flow Effect: = \$850,000

HVAC Energy Savings (\$0.50/ft^2) ≈ \$125,000 annually