ENVIROCENTER PHASE II

JESSUP, MD

PENN STATE AE SENIOR THESIS PROJECT

CHRIS LORENZ | MECHANICAL | DR. BAHNFLETH ADVISOR

ENVIROCENTER PHASE II

JESSUP, MD

- **INTRODUCTION**
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

PENN STATE AE SENIOR THESIS PROJECT
CHRIS LORENZ | MECHANICAL | DR. BAHNFLETH ADVISOR

PRESENTATION OUTLINE

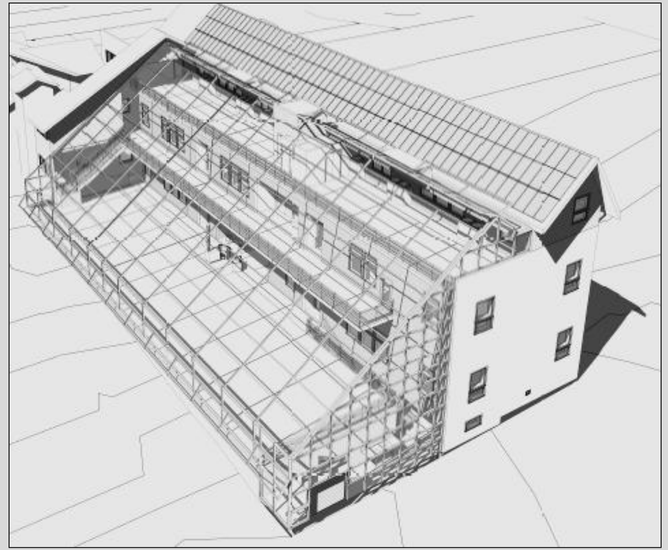
SLIDE 3

- **INTRODUCTION**
  - **BUILDING INFORMATION**
  - MECHANICAL SYSTEM
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

BUILDING INFORMATION

SIZE: 24,000 SF
OCCUPANCY: Office Space

TEAM
ARCHITECT – ASG, Inc.
MEP ENGINEERING – JDB Engineering
STRUCTURAL ENGINEERING – JDB Engineering
CONTRACTOR – Forrester Construction



PRESENTATION OUTLINE

SLIDE 4

- **INTRODUCTION**
  - **BUILDING INFORMATION**
  - MECHANICAL SYSTEM
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

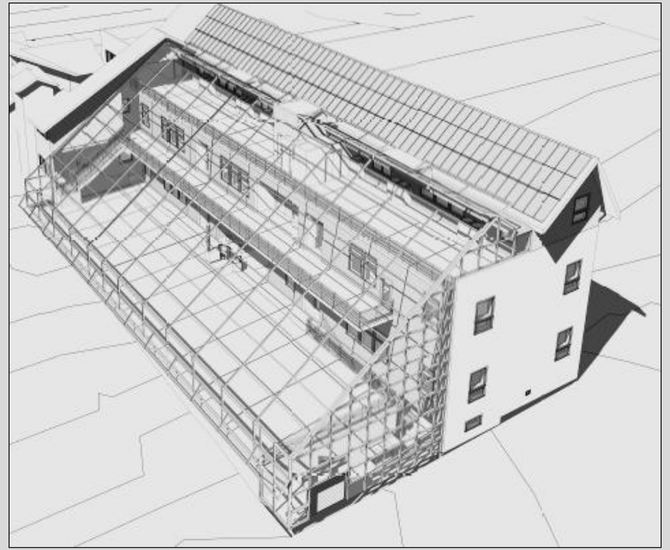
BUILDING INFORMATION

ENVIRONMENTAL GOALS

Environmentally conscious tenants

Numerous sustainability features

LEED Platinum certification



PRESENTATION OUTLINE

SLIDE 5

- **INTRODUCTION**
  - BUILDING INFORMATION
  - **MECHANICAL SYSTEM**
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

MECHANICAL SYSTEM

WATERSIDE

- Two Reversible Water-to-Water Heat Pumps
- One Main Cooling Coil
- Hot water to terminal units
- Hot water to radiant slabs and mass wall

AIRSIDE

- 13,500 CFM VAV with terminal reheat
- Earth Tubes for free pretreating

PRESENTATION OUTLINE

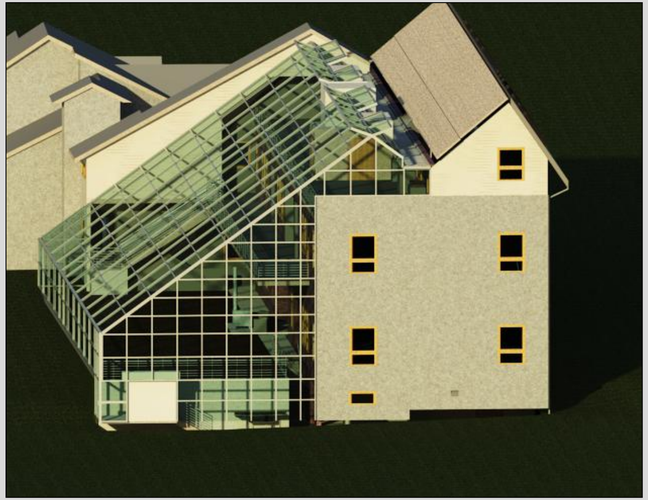
SLIDE 6

- INTRODUCTION
- **GOALS**
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

GOALS

SYSTEM REDESIGNS

- Replace airside cooling with radiant cooling
- Replace mixing ventilation with displacement ventilation
- Evaluate changes based on changing loads



PRESENTATION OUTLINE

SLIDE 7

- INTRODUCTION
- GOALS
- **DISPLACEMENT VENTILATION**
  - **INTRO**
  - IMPACT
  - HUMIDITY CONTROL
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

DISPLACEMENT VENTILATION

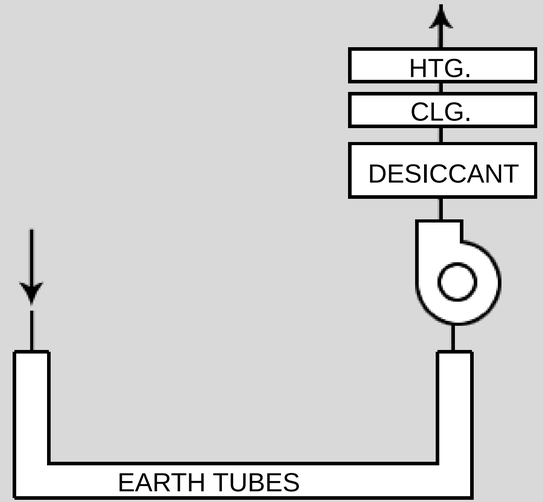
Earth tubes pretreat air

- Design OA @ 97 ° F cooled to 67 ° F
- Design OA @ 11 ° F warmed to 37 ° F

Desiccant dehumidifies warm, humid air

Cooling coil cools AIR TO 65 ° F

Heating coil heats air to 70 ° F



PRESENTATION OUTLINE

SLIDE 8

- INTRODUCTION
- GOALS
- **DISPLACEMENT VENTILATION**
  - INTRO
  - **IMPACT**
  - HUMIDITY CONTROL
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

DISPLACEMENT VENTILATION

- Provides 100% Outside Air at minimum ventilation levels

- 75% reduction in supplied Air,
- Over 90% reduction in fan power

- Supplied closer to room temperature reducing coil load
  - 70° F vs. 75° F
  - 65 ° F vs. 55° F

COIL LOAD (BTU/HR-CFM)			
	VAV	DV	%RED.
HEATING	41	30	**26**
COOLING	13	2	**84**

PRESENTATION OUTLINE

SLIDE 9

- INTRODUCTION
- GOALS
- **DISPLACEMENT VENTILATION**
  - INTRO
  - IMPACT
  - **HUMIDITY CONTROL**
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

HUMIDITY CONTROL

LOW FLOW DESICCANT DEHUMIDIFICATION

- Experimental Technology (DOE, NREL)

- Air flows over thin film of liquid desiccant (44% LiBr)
- Desiccant is recharged by hot air flowing over regenerator

- Return water usable for conditioning
- Small electric water heater for regen, 5kW

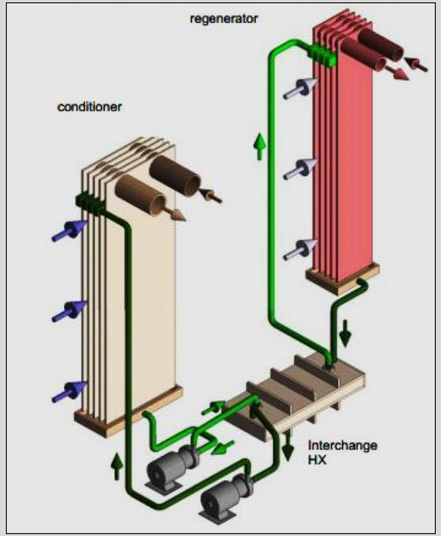


IMAGE COURTESY OF NREL

PRESENTATION OUTLINE

SLIDE 10

- INTRODUCTION
- GOALS
- **DISPLACEMENT VENTILATION**
  - INTRO
  - IMPACT
  - **HUMIDITY CONTROL**
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

HUMIDITY CONTROL

LOW FLOW DESICCANT DEHUMIDIFICATION

- Capable of high levels of dehumidification per input energy
  - Input: 6000 CFM 95°F DB, 76°F WB (1)
  - Output: 92°F DB, 66°F WB, dewpoint = 49°F (2)
  - 196 MBH latent cooling

- Latent Load = 25 MBH

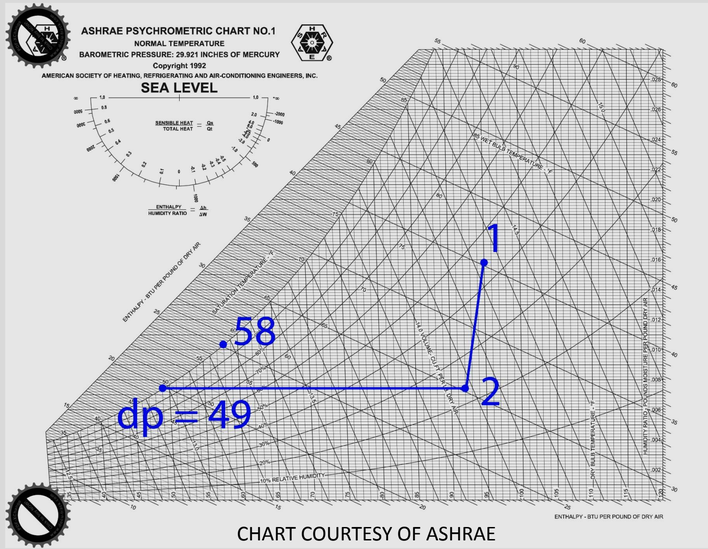


CHART COURTESY OF ASHRAE

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- **RADIANT COOLING**
  - **INTRO**
  - IMPACT
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

- Sensible Loads only
- Energy Efficient
- Architecturally Pleasing

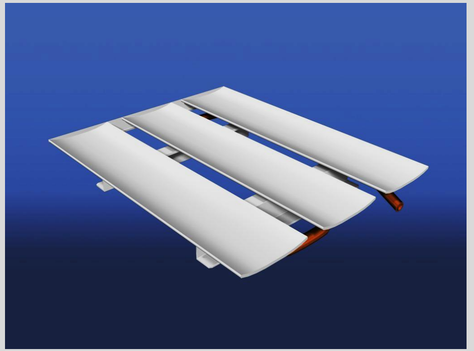


IMAGE COURTESY OF PRICE INDUSTRIES

PRESENTATION OUTLINE

SLIDE 12

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- **RADIANT COOLING**
  - **INTRO**
  - IMPACT
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

RADIANT COOLING

METHOD

- Account for DV sensible cooling
- Select Square Footage of CSA required for each zone

ZONE	ROOM SENSIBLE LOAD (BTUH)	DV RATE (CFM)	VENT COOLING (BTUH)	CSA LOAD (BTUH)
110	3291	310	1252.4	**2038.6**
120	2551	250	1010	**1541**
121	2041	220	888.8	**1152.2**
130	5091	570	2302.8	**2788.2**
210	3875	360	1454.4	**2420.6**
220	3061	420	1696.8	**1364.2**
221	3571	390	1575.6	**1995.4**
230	2041	240	969.6	**1071.4**
231	2551	280	1131.2	**1419.8**
310	4600	360	1454.4	**3145.6**
320	6632	220	888.8	**5743.2**

PRESENTATION OUTLINE

SLIDE 13

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- **RADIANT COOLING**
  - INTRO
  - **IMPACT**
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

RADIANT COOLING

- Fewer GPM required.
  Less Head Loss than VAV system (Heating)

- Less Energy Spent Chilling Water

- Less Coil Load
  Chilled Sail = Zone Level Cooling Coil

	GPM	HEAD LOSS (FT)
VAV	46	28.4
CSA	30	24.8
% RED.	**34.8%**	**12.7%**

COOLING CAPACITY				
	T1 (°F)	T2 (°F)	Q (GPM)	q (MBH)
VAV	90	45	26	583
CSA	90	55	30	522
% RED.				**10.4%**

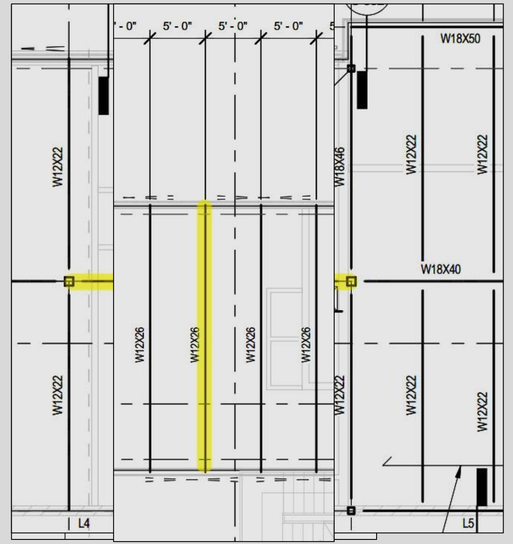
PRESENTATION OUTLINE

SLIDE 14

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- **STRUCTURAL BREADTH**
  - **INTRO**
  - RESULTS
- CONCLUSION
- QUESTIONS

STRUCTURAL BREADTH

- Check Structure For Added Load
- 2 Beams, and 1 Girder
- Chosen as Worst Case Beams
- Check Maximum Moment, Shear, & Deflection



PLANS COURTESY OF JDB ENGINEERING

PRESENTATION OUTLINE

SLIDE 15

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- **STRUCTURAL BREADTH**
  - INTRO
  - **RESULTS**
- CONCLUSION
- QUESTIONS

STRUCTURAL BREADTH

- After Adding Load, All Members Still Met Moment, Shear And Live Load Deflection Requirements
- Beam 2 Deflected Too Much Under Total Load
  - Required Moment of Inertia of $I \geq 226\ in^4$
  - Upsized Beam 2 to W14x26, $I = 245\ in^4$
  - Extra Depth Still Keeps Enough Ceiling Space

	Beam 1 W12x22	Beam 2 W12x26	Girder 1 W18x46
ϕMp (ft-kip)	110	140	294
Mu (ft-kip)	73	78	215
ϕVn (kip)	95.9	84	169
Vu (kip)	15.7	13.2	44.5
Max Allowable Δ (LL)	0.6166	0.7833	0.7583
Max Δ (LL)	0.3129	0.406	0.7338
Max Allowable Δ (TL)	0.925	1.175	1.1375
Max Δ (TL)	0.7189	1.2992	0.9144

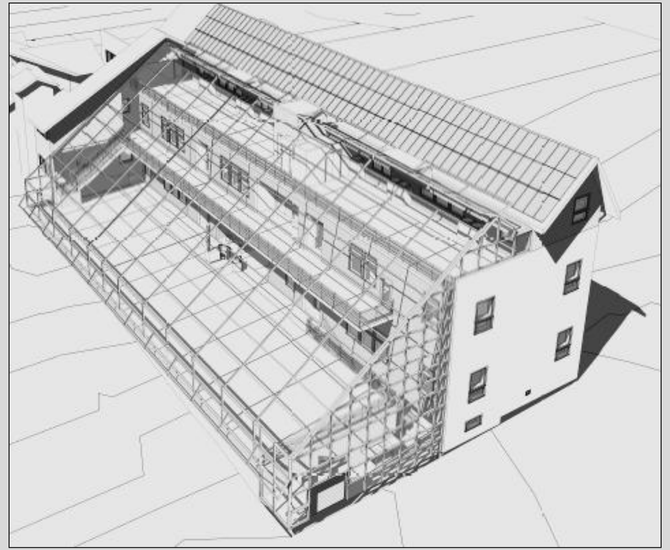
PRESENTATION OUTLINE

SLIDE 16

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- **CONCLUSION**
- QUESTIONS

CONCLUSION

- 10% Reduction in Cooling Energy
- 25% Reduction in Heating Coil Load
- 75% Reduction in Air Flow
- Dehumidification technique may not be feasible
- Implementation would require an upgraded structure



PRESENTATION OUTLINE

SLIDE 17

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- QUESTIONS

ACKNOWLEDGEMENTS

- Dr. William Bahnfleth
- Dr. James Freihaut
- Dr. Stephen Treado
- Dr. Moses Ling
- Tim Warren : JDB Engineering
- Stan Sersen : Owner / ASG, Inc.
- Family & Friends

PRESENTATION OUTLINE

SLIDE 18

- INTRODUCTION
- GOALS
- DISPLACEMENT VENTILATION
- RADIANT COOLING
- STRUCTURAL BREADTH
- CONCLUSION
- **QUESTIONS**

THANK YOU

ANY QUESTIONS?