

Michael Baker Corporation Headquarters



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Senior Thesis
Mechanical Option
2004-2005

Building Overview

- The building is currently part of proposed 6 building business park.
- The site currently includes one other building and a parking garage.
- Façade is composed of tilt-up concrete panels, glass curtain wall, a metal roof cornice and punched window openings.
- Designed office furniture and placement of office furniture for maximum flexibility and daylight.



- 120,000 square foot area with approximately 100,000 square feet in open office space.
- Indirect lighting system to reduce eye strain and increase productivity
- Hand-drawn mural in 2 story lobby
- Electrical and Telecommunication systems are ran under a 2" raised floor.

The 3 P's

- **Perspective**

- Corporation Headquarters
- Location: next door to the Pittsburgh International Airport
- Flagship of the Airside Business Park Development

- **Productivity**

- Traditional Overhead VAV system
- In open office space, 2" raised floor system and movable partitions for easy renovation and remodeling.
- 525 tenants in about 100,000 square feet of office space.
- Flexibility is key.

- **Problems**

- 1.5 cfm/sf is used to supply the building throughout the day.
- Excess energy costs

Current Design

- The building is serviced by 6 gas-fired packaged air-handling units. They have gas heat for A.M. warm-up with 50% 4" pleated filters.
- The air-handling units supply a range of 3,150 to 20,000 cfm at 55 F. The supply air leaves the air-handlers and experiences no more than 5.25" of loss.
- Each air-handling unit is at 50% throw away.
- The building is comprised of interior and perimeter zones.
 - The interior zones have cooling-only VAV boxes at about 1/1500 sq. ft.
 - The perimeter zones have fan powered VAV boxes and electric reheat at about 1/1000 sq. ft.
 - There are around 34 zones per floor.
- Outside design conditions for the summer and winter are 86 F/71 F and 5 F respectively.
- The air is maintained at 72 F in the summer and 75 F in the winter.
- All flow rates meet ASHRAE standards for the prescribed amount of cfm/person, cfm/area or air changes (whichever is the most demanding)
- All supplied areas are considered fully-mixed.

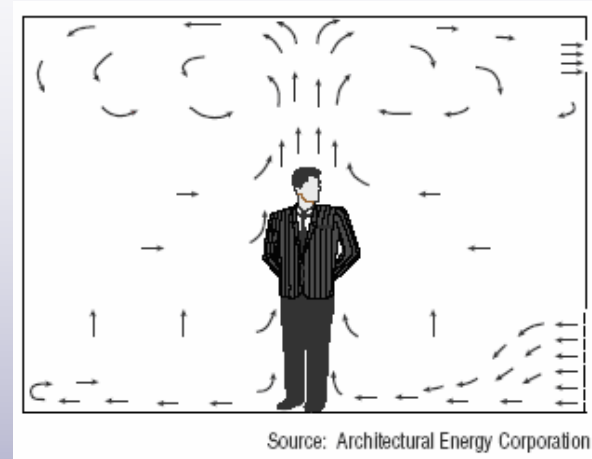
Redesign Considerations

- Underfloor Air Distribution Systems (UADS)

- Displacement Ventilation Systems (DVS)
- Hybrid Ventilation Systems (HVS)
- Non-Pressurized vs. Pressurized Plenums

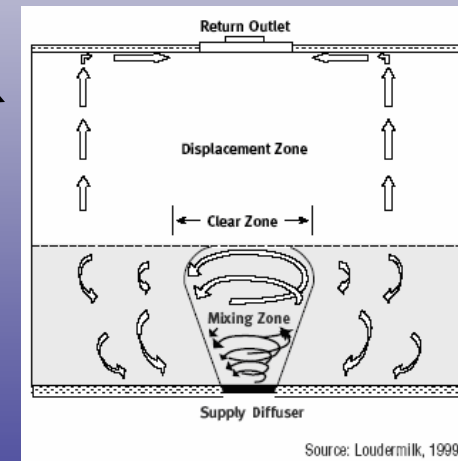
- Displacement Ventilation Systems

- Lower air velocities (50 fpm), creates 2 zones within a space due to stratification
- Higher Indoor Air quality and lack of a draft
- Potential issues with mold and bacteria growth



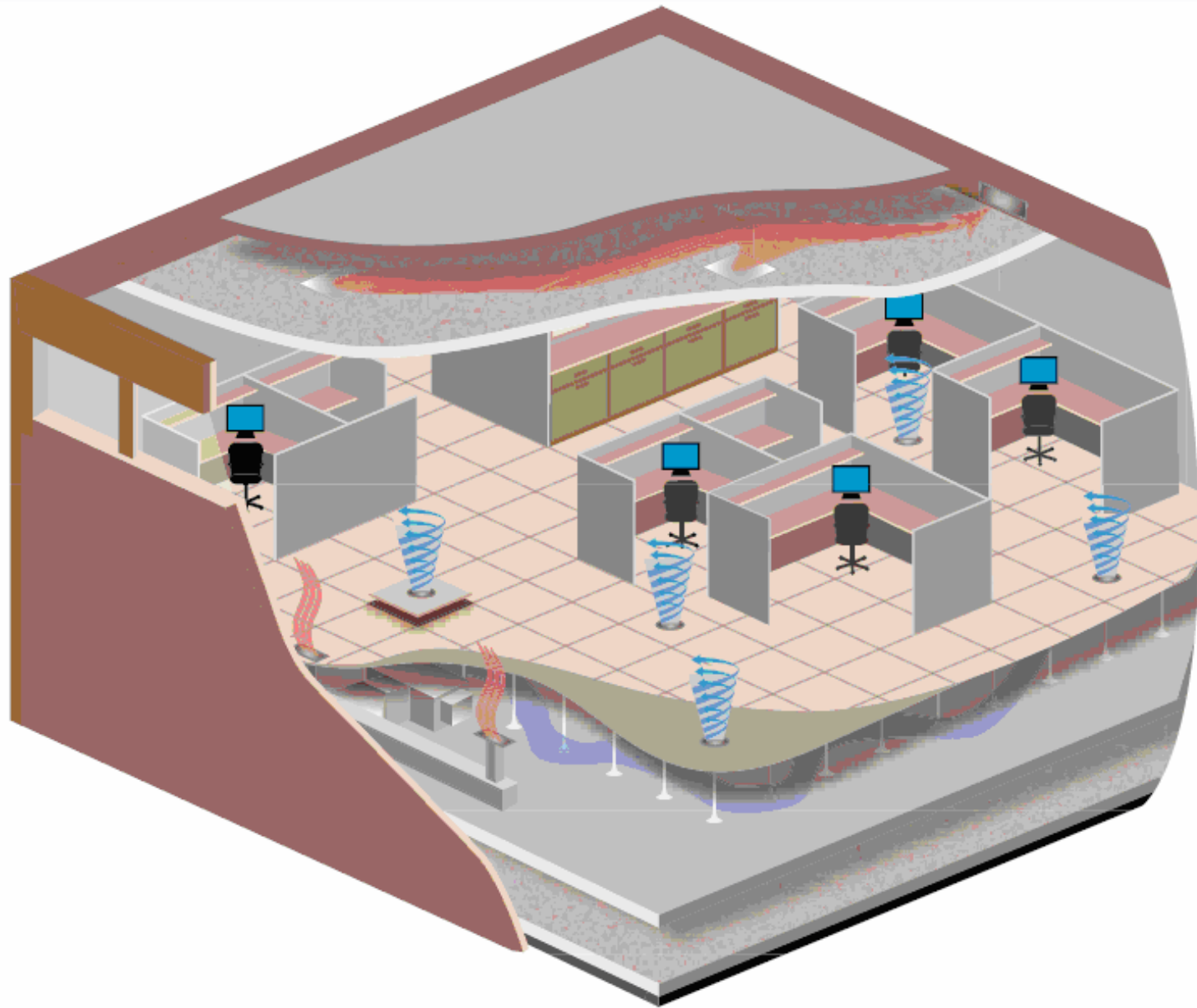
- Hybrid Ventilation Systems

- Higher air velocities (200-400 fpm), creates a more mixed space
- Little stratification and lower chances of mold and bacteria growth
- Potential issues with draft and "clear zones"



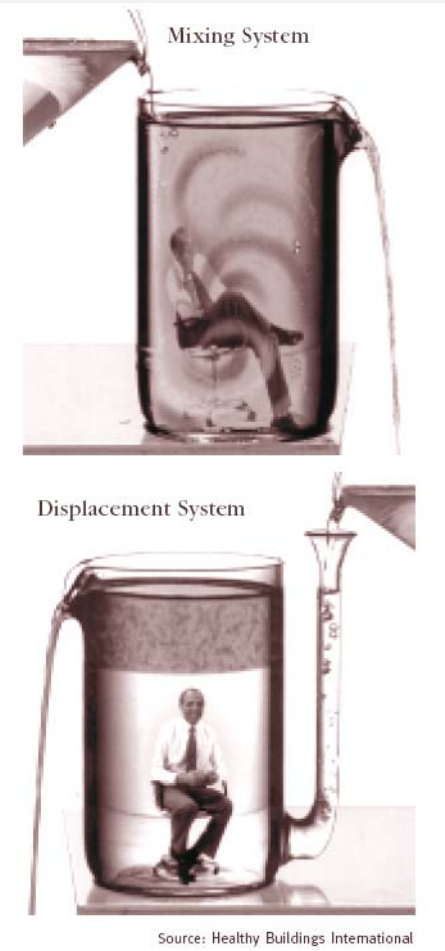
- Non-Pressurized vs. Pressurized Plenums

<u>Pressurized</u>		<u>Non-pressurized</u>	
Advantages	Disadvantages	Advantages	Disadvantages
♦ Additional fans are not needed to deliver air to the space	♦ Air leakage from the plenum becomes an issue	♦ Occupants have more control over air distributed to their space	♦ Additional fan is needed to deliver air to the space
♦ System allows for complete "plug and play"	♦ Removing a floor tile disrupts system operation	♦ Removing a floor tile does not disrupt system operation	♦ Increased initial cost due extra equipment
♦ Lower initial cost		♦ Low plenum leakage	

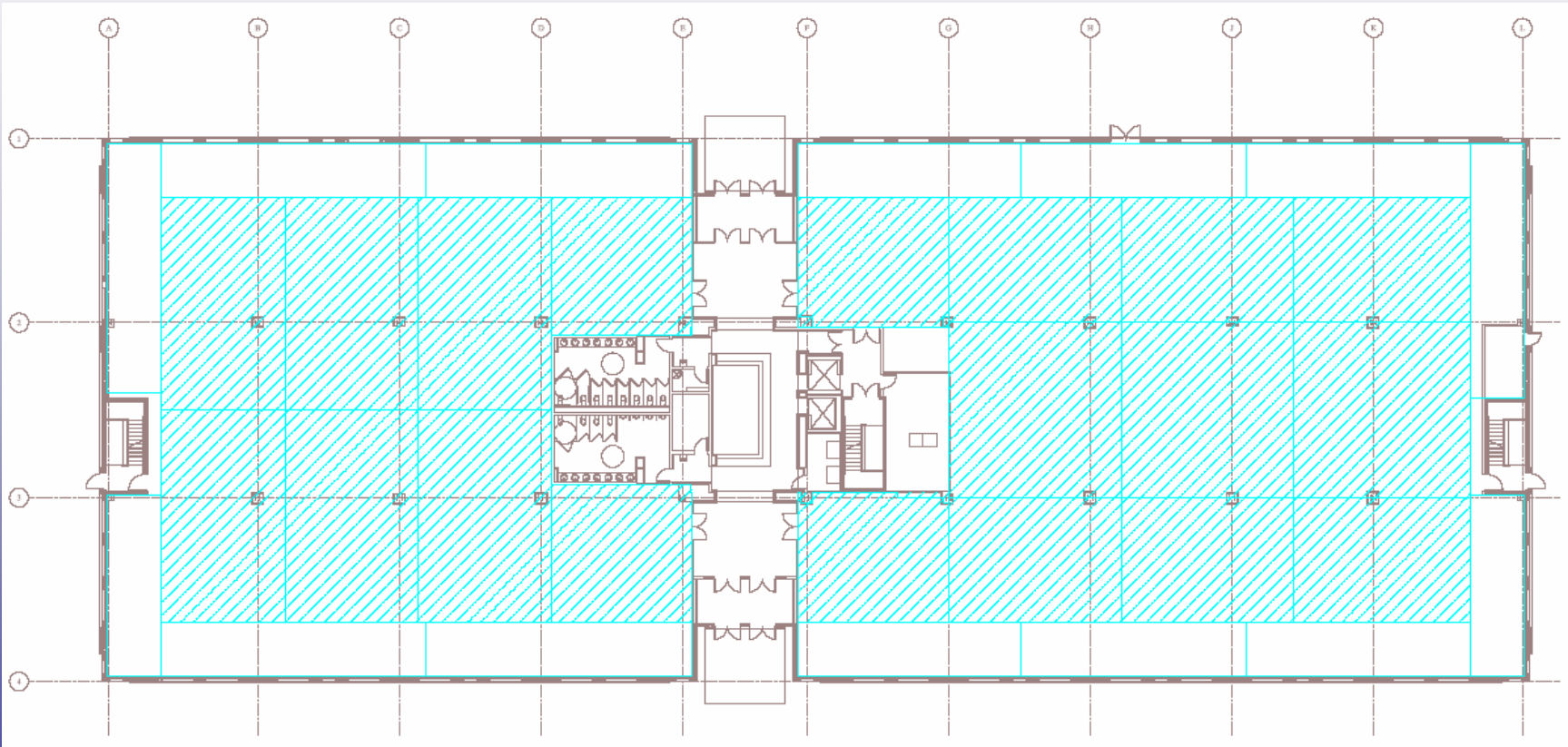


Redesign

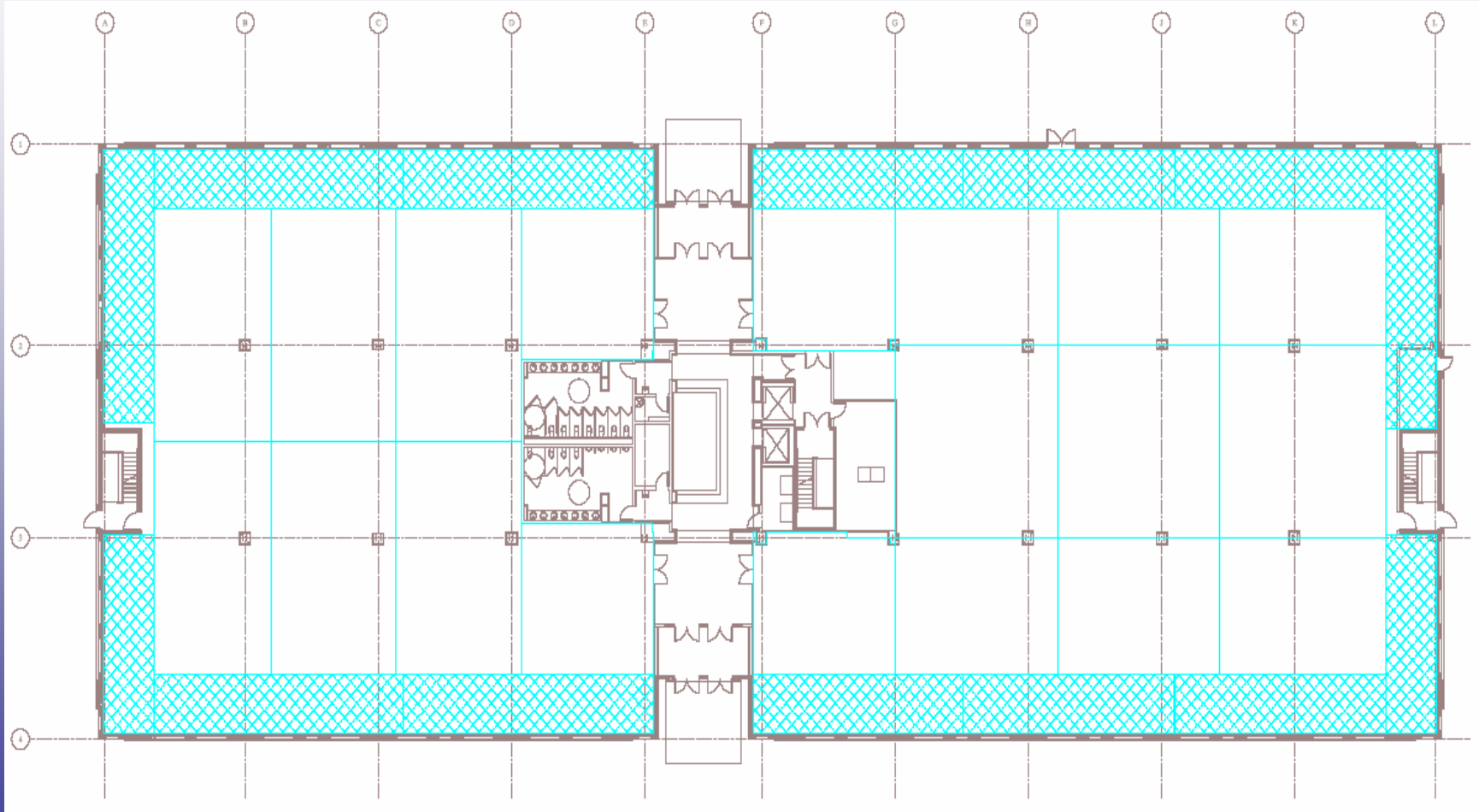
- The current system which incorporates a traditional VAV overhead system so operated under the assumption of fully mixed air conditions. →
- This system requires more air to ventilate the air properly of contaminants. The Michael Baker Corporation Headquarters currently uses as much as 1.8 cfm/sf to ventilate the air.
- Using a DVS with a non-pressurized plenum, the underfloor system can deliver a more conformable, higher quality air supply.
- Using this system, the Michael Baker Corporation Headquarters will use about 1.0 cfm/sf.
- There is also a reduction in cooling necessary to supply the air using a UADS.
- Typically, overhead systems uses 55 F supply air to the spaces. With a UADS, you can use a range from 62 F to 68 F. This redesign will be at 62 F.



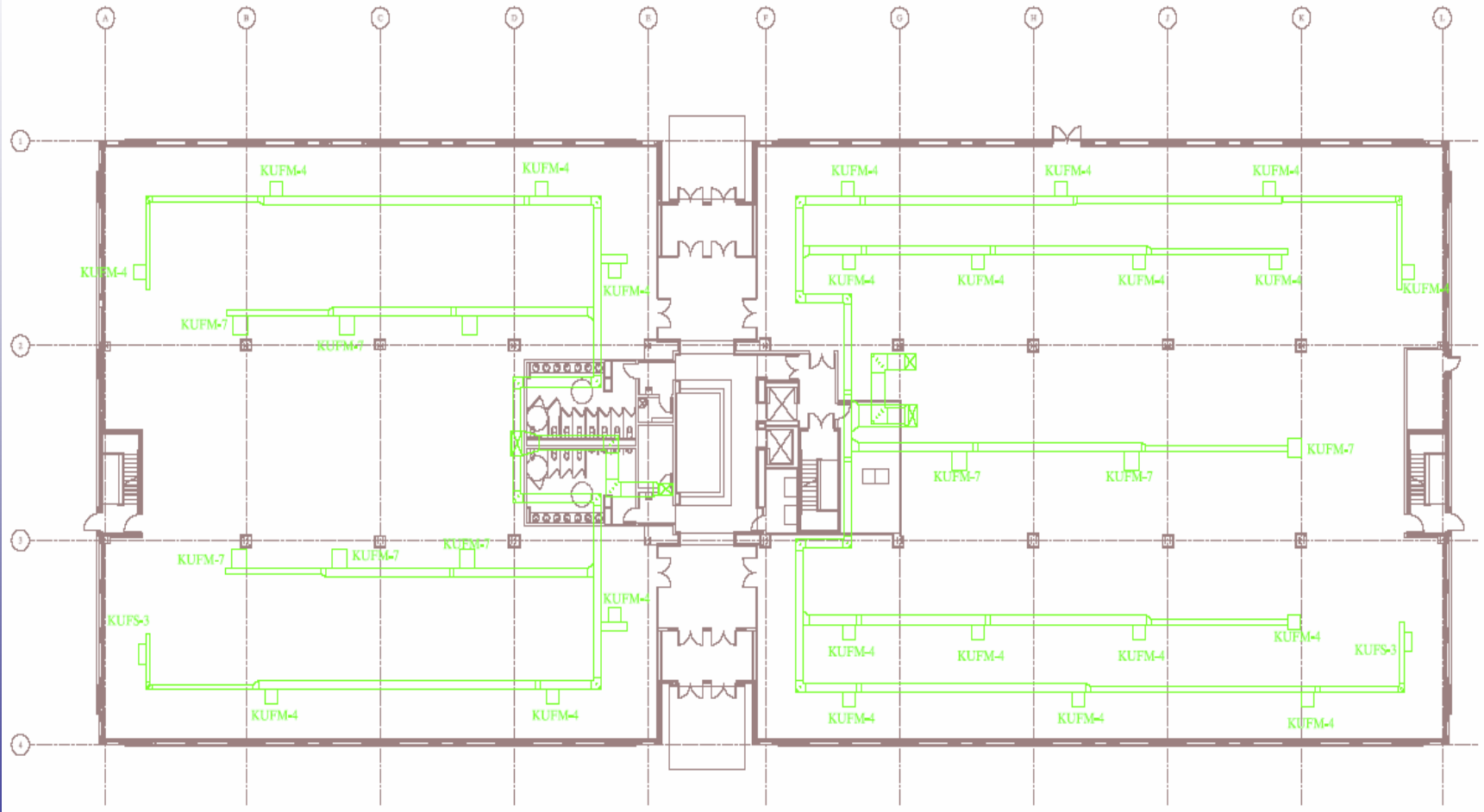
Floorplans



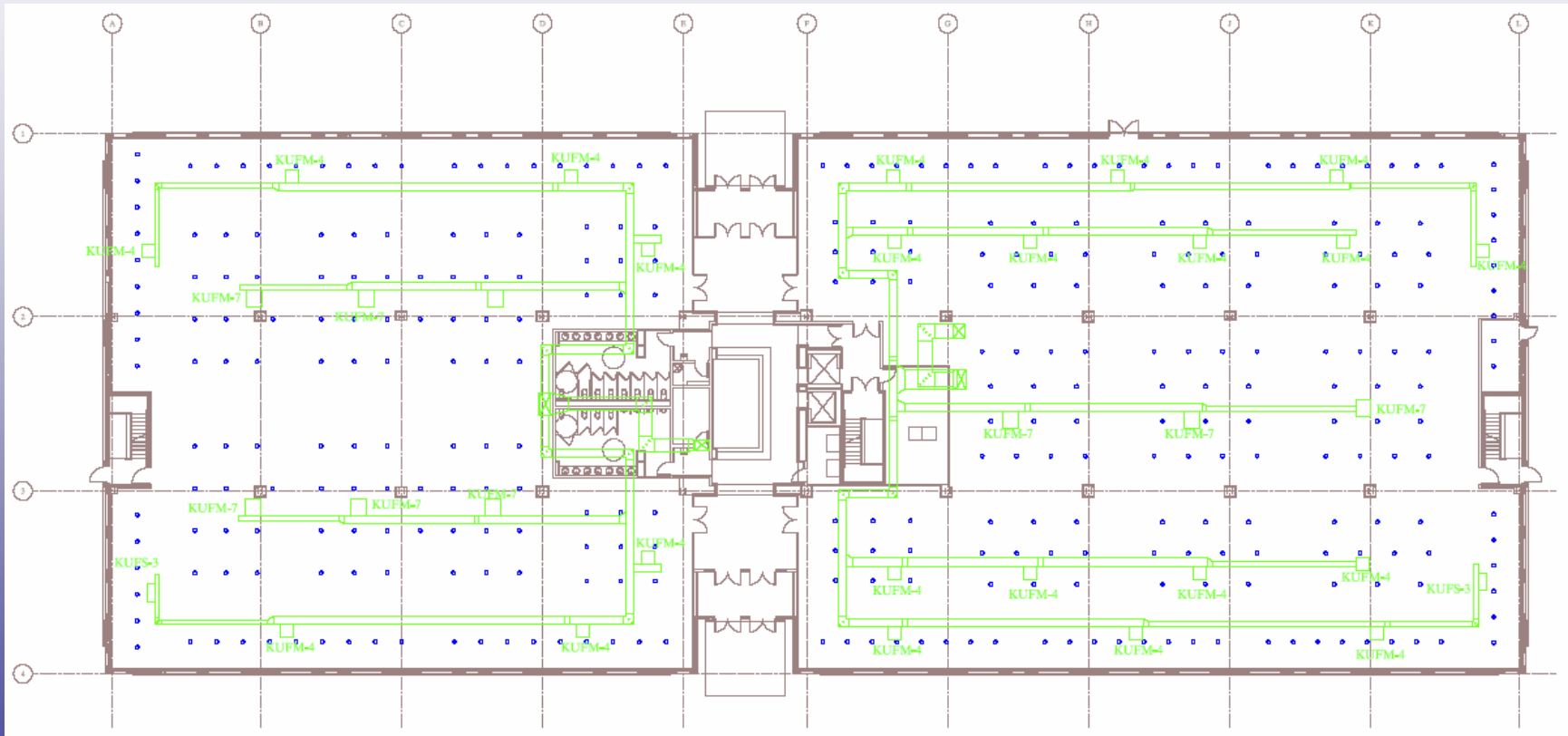
Floorplans



Floorplans



Floorplans



Cost Comparison

- Using Carrier's Hourly Analysis Program (HAP), the current building and the redesigned building were analyzed.
 - The current building costs an estimated \$930,000 to operate annually.
 - Using the redesign building the cost drop to an estimated \$800,000 to operate annually.
 - Therefore, net savings annually for the redesigned area equal about \$130,000 annually or 1.3 \$ per square foot
- Construction costs also will change.
 - There is currently a 2" raised floor system in place at the Michael Baker Corporation Headquarters. By raising that floor 16" more, a UADS can be installed.
 - However, will a UADS system about 1/3 of the ductwork is necessary.
 - Estimated costs then are \$2.15 million for the current building's raised floor system and ductwork and \$1.7 million for the redesign similarly.
 - Also there is a need for new mechanical equipment including terminal units. The estimated cost for the current building is \$114 thousand and \$110 thousand for the redesign.
 - There is also a change in the amount of diffusers and grilles used in the building. The estimated costs for the current building is \$28 thousand and the redesign is \$15 thousand.
 - Height reduction of the building from the reduction of overhead plenum space (3') reduces the overall costs about \$53 thousand.

Cost Comparison Cont.

- The estimated average savings in construction cost workouts out to be about \$520,000.
- I got the majority of my quotes from Means.
- This equals about 5.2 \$ per square foot.
- However, it should be noted that UADS are still relatively new to most construction managers and they will likely bid higher to account for mistakes in construction.

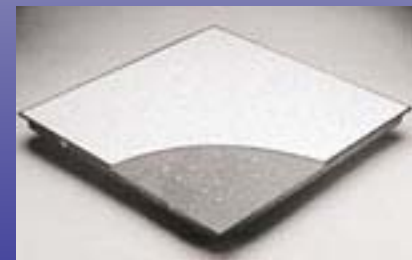
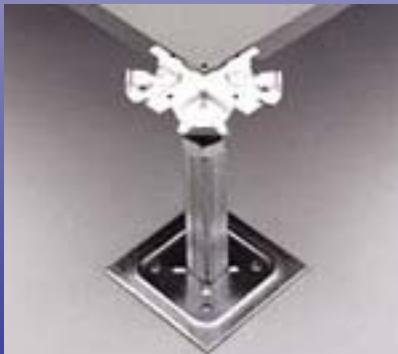
Items		Costs
New Ductwork and Raised Floor		1700000
Old Ductwork and Raised Floor		-2150000
New Diffusers and Grilles		14910
Old Diffusers and Grilles		-28228
New Terminal Units		109901
Old Terminal Units		-113876
Reduction of Building Height		-53225
Initial Savings		520518
HVAC Operation		
Current Overhead System		930000
New Underfloor System		-800000
Annual Savings		130000

Mechanical Conclusions

- The Michael Baker Corporation Headquarters does already achieve the necessary requirements to serve its occupants effectively.
- An Underfloor Air Distribution System will effectively serve the tenants while lower construction and operating costs and improving indoor air quality.
- Also the flexibility of the building is maintained if not improved.
 - The tenants can change the location of the diffusers to suit the building's office furniture.
 - The tenants can also change the rate of air flow leaving the diffusers.
- Therefore, I would suggest the implementation of a UADS in the Michael Baker Corporation Headquarters.

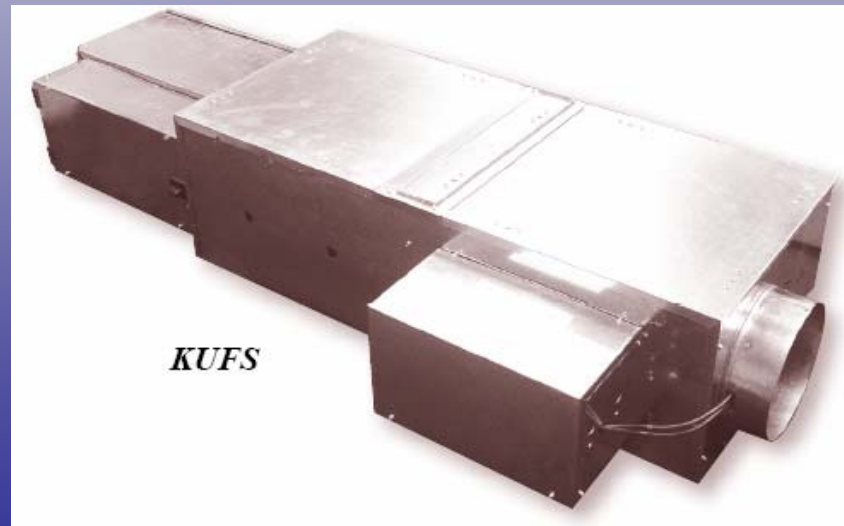
Structural Implications

- The Michael Baker Corporation Headquarters already has integrated a 2" raised floor system for there electrical and telecommunication cabling and connections.
- In order to provide enough room for terminal units, ductwork and the cabling the raised floor has to have 18" of clearance.
- With all of this equipment, ductwork and new struts will the beams need to be resized?
 - **NO!!!**
 - The struts themselves shouldn't add enough weight per square foot to affect the load and since all now there will be only 1/3 to 1/2 the ductwork and about the same terminal units.
 - Therefore, the weight will actually decrease if anything. However, this weight loss is negligible.
 - The beams and girders shouldn't need to be resized.



Electrical Implications

- The terminal boxes in the Michael Baker Corporation Headquarters currently are all connected to 480Y/277 Volt 3-phase panels. 2 per floor. 1 at 4 Watts, 200 amps the other at 4 Watts, 100 amps.
- Currently there are 96 terminal units in use.
- In the redesign there are 100 terminal units in use.
- However, they are smaller in size and most required only 208Y/120 Volt 3-phase connections.
- Therefore, there are still 2 panels per floor. The first at 480Y/277 Volts 3-phase, 4 Watts, 200 amps and the other at 208Y/120 Volts 3-phase, 4 Watts, 150 amps.



Acknowledgments

- It is my privileged and honor to thank the people who helped me over the last eight months working on this project:
 - **Lou Mittelman** at Baker & Associates for all opportunity to use the Michael Baker Corporation Headquarters as my thesis and for all the mechanical information I needed.
 - **Keith Williams** at Baker & Associates for all of the architectural information he gave including the costs of the building.
 - The Penn State Architectural Engineering faculty for all of there help and guidance through my time here.
 - My parents and little sister Robin.

Hi Mom!!!!

- My friends from here and from home who have helped me keep my sanity.
- And of course, my colleagues and friends within the major whom are more than I can mention...you all made this special for me one way or another. Best of luck.

Thank You All!!!!

Questions????