THESIS PROPOSAL:
MECHANICAL REDESIGN

TRY STREET TERMINAL BUILDING
620 SECOND AVENUE
PITTSBURGH, PA

PREPARED FOR:
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MECHANICAL OPTION
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EXECUTIVE SUMMARY

For the spring semester thesis work, several alternatives for the mechanical redesign were considered. It is important to note that these alternatives considered were for educational purposes only. Neither the alternatives discussed, nor the redesign chosen imply that there were any problems with the original design or that another design should have been pursued.

Therefore, after careful consideration I have proposed to design a geothermal heat pump system for the Try Street Terminal Building. More specifically, a groundwater heat pump system will be designed to replace the existing conventional heat pump system. With the GWHP system, I will evaluate the energy savings associated with this environmentally friendly system by performing an energy analysis with Carrier's Hourly Analysis Program. A first cost and life cycle cost comparison will also be completed.

In addition, a computational fluid dynamic (CFD) analysis and air quality study will be performed for the breadth analyses. For the CFD model, I plan to look at the effect of air distribution on the temperature in the two story lobby and exercise room. In terms of air quality, I am looking to use a special air cleaning system in which the apartments will be freed of all contaminants.

Overall, I am hoping to look into many issues some of which include: energy consumption, thermal comfort, air quality, operating cost, construction cost and maintainability.

Regardless of the outcome and final recommendation based on my spring semester study, I expect that this educational experience will prove to be a valuable one.

BUILDING BACKGROUND INFORMATION

The Try Street Terminal Building project involves renovations to the 10 story, 230,000 square foot building originally constructed in 1910. Although the main function is to provide apartments for the Art Institute of Pittsburgh, other features include: an atrium, exercise room, first-floor retail space and possibly a convenience store and casual dining restaurant.

Because the project does include renovations to an industrial building that was constructed in 1910, special considerations were taken in order to preserve the appearance of the building's façade. In fact, according to a news article found on The Art Institute's website, the building is in the process of being designated a historic landmark. Other design objectives included minimizing costs, while maximizing occupant comfort and control. A lightwell in the core of the building was also added in order to satisfy a natural lighting requirement for the interior apartments set forth by the IBC 2003.

The Try Street Terminal Building is still currently under construction and is expected to be complete April 2007.

MECHANICAL SYSTEM OVERVIEW

Four rooftop make-up air units (MAUs) supply the required ventilation to the apartments and corridors on floors 1-9. The first floor lobby is also served by these spaces. The MAUs have design supply airflow rates ranging from 4820 to 7550 cfm and total 23,825 cfm.

Water source heat pumps serve the exercise room and each individual apartment. These units vary in size from 0.5 nominal ton to 10 tons. The advantage of these units is their ability to simultaneously heat and cool. A fluid cooler on the roof provides the necessary condenser water to the heat pumps when addition cooling is required. On the other hand, two boilers provide the necessary hot water when additional heating is required.

The apartments are also equipped with exhaust fans that remove air from the bathroom and kitchen areas. To minimize the transfer of odors into other apartments or public spaces, the amount exhausted is greater than the code requirement.

Four self contained, air cooled vertical package units supply constant volume cooling to the basement and first floor unassigned spaces. These air handling units range in size from 7.5 to 15 nominal tons. They supply a combined 20,000 nominal cubic feet per minute (cfm). Approximately, 30% of the supply is fresh outdoor air. Each of these units is also equipped with an electric open coil duct heater.

ALTERNATIVES CONSIDERED

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Ground Source Heap Pump System

Initially, a closed loop ground source heat pump system (GSHP) was considered. With the closed loop earth coupled system, a vertical or horizontal design may be chosen. With the vertical arrangement, a series of vertical pipes that circulate water are buried deep within the ground. With the horizontal GSHP, a network of pipes is distributed horizontally at a more shallow depth. An advantage of this geothermal system is that the need for a cooling tower and boiler is eliminated. This is possible because in the summer, heat from the building is rejected to the ground. While in the winter, the ground source heat pump would utilize the heat stored in the ground. These particular configurations were not pursued though because the building's property line does not provide ample room for the bore fields required for this system.

DOAS paralleled with WSHP System

Another alternative considered was to modify the existing system into a Dedicated Outdoor Air System (DOAS) paralleled with the existing water source heat pumps. In order to accomplish this, the make-up air units would need to be replaced with DOAS units. In addition the exhaust would need to be redirected in order to utilize the energy recovery wheels associated with the DOAS units. However, the additional cost associated with the DOAS units and the ductwork for redirecting the exhaust may not be justifiable in terms of first cost.

THESIS DEPTH TOPIC

Groundwater Heat Pumps

Although several options for the mechanical redesign were considered, the final system chosen was based on research completed for the Cooling Production and Distribution Systems class (AE 557). Therefore, the system chosen for the mechanical redesign was a groundwater heat pump (GWHP) system.

As mentioned earlier, the closed loop earth coupled heat pump system was not selected due to size constraints on the site. However, after speaking with the mechanical project manager, I was notified of the underground river that flows beneath many of the buildings located in downtown Pittsburgh. This underground river is actually the source of water for the fountain at Point State Park. The underground water is a fresh, 55 degree source with no bacteriological count. Therefore, it actually provides drinking water for some of downtown Pittsburgh.

The concept of heating and cooling is similar to the earth coupled system except that groundwater is the source. With the open loop GWHP system the fluid is not confined to a loop of pipes. Rather a pumping well is used to move the water through the heat pump. For a project such as the Try Street Terminal, the use of a two well system would most likely be expected. One well would be used for supply and the other return. Another disposal method would be surface disposal in which the return water is diverted to a surface body of water, such as a river. However, with this disposal type a National Pollutant Discharge Elimination System (NPDES) permit may be required for the discharged water.

The main goal of the proposed design is to analyze the potential energy savings of the groundwater heat pump system compared to the current conventional system design. Throughout the redesign process many factors will need to be considered and analyzed. Some areas of installation requiring further research include: local water quality, distance from existing wells, volume of discharge water, and local and state construction codes.

With the GWHP system, the use of a cooling tower and boiler used in a conventional system is eliminated. However, the installation cost associated with the ground water heat pumps can be far greater due to the site development and boring of wells. Therefore, the intention is to compare the current conventional system to the proposed GWHP system in terms of energy savings, first cost and life cycle cost.

GWHP Tools and Methods

To carry out the work associated with the groundwater heat pump proposed design, additional research will need to be conducted in order to obtain valuable information such as: water quality, geology of the site, and any local or state codes. I plan to obtain this information by contacting resources such as the Pennsylvania Department of Energy.

A Carrier Hour Analysis Program (HAP) energy analysis will also be completed for the GWHP system. The results of this analysis will then be compared to the results of the energy model performed for the existing system during the Fall semester. Once this simulation is complete, GWHP can be selected and additional calculations can be performed. Sizing the well is an example of the type of calculations that are expected to be performed.

In order, to conduct a first cost and life cycle cost analysis, manufacturer's date and RS Means data will be used to evaluate the two systems.

THESIS BREADTH TOPICS

CFD Analysis

As mentioned in the building background information, a lightwell was added in the core of the building in order to meet the natural lighting requirement for the apartments in the core of the building. This lightwell extends from the second floor through the ninth. On the second floor, the roof area covers part of the two story atrium and exercise room. In each space two overhead skylights allow natural light into these areas as well. Therefore, I'd like to do a computational fluid dynamic (CFD) analysis of these two spaces in order to see the effect of the air distribution on the temperature of these spaces. With the atrium design I'd also like to look at the displacement of the ventilation in order to verify that placement of diffusers is effective.

CFD Tools and Methods

In order to accomplish this study, a program such as Fluent will be used.

Air Quality Study

Another aspect I would like to look into is the possibility of making a portion of the apartments contaminant free zones. This concept will require the integration of filters into the individual apartment heat pumps, as well as the corresponding make-up air unit. For a college apartment complex this idea could be appealing to many students with health related issues such as allergies or asthma.

Air Quality Tools and Methods

Additional research about this filter integration will be required. Manufacturer's data will be carefully analyzed to see if current filters may be upgraded, if filters can be added to the equipment already selected, or if different equipment is required altogether.

PRELIMINARY RESEARCH AND RESOURCES

Below is a list of the sources that were used to conduct preliminary research. These in addition to others will be used throughout the spring semester during various stages of the redesign process.

ASHRAE Handbook, Fundamentals. American Society of Heating Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA 2005.

ASHRAE Handbook, HVAC Applications. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2003.

ASHRAE Handbook, HVAC Systems and Equipment. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2004.

"Ground Source Heat Pump Manual." Department of Environmental Protection. 2000. 14 Dec. 2006 <www.dep.state.pa.us>

Flaherty, Robert. "Geothermal Heat Pump Systems." SEi Companies 14 Dec. 2006 <http://www.seicompanies.com/vision/White%20Papers/Geothermal%20Heat%20Pump%20Systems_.pdf>

"The Point: The Underground River." Carnegie Library of Pittsburgh. 2006. Carnegie Library of Pittsburgh. 14 Dec. 2006 <http://www.clpgh.org/exhibit/neighborhoods/point/point_n77.html>

"The Fourth River." Four Rivers Software Systems 14 Dec.n 2006 <http://www.frsoft.com/Pages/InfoPage.aspx?PageID=7>

REFERENCES

Mapquest, Map of 620 Second Avenue and 420 Blvd. of the Allies, Pittsburgh, PA

McKamish, Documents for the Try Street Terminal Building.

TKA Architects, Documents and rendering for the Try Street Terminal Building.

The Pennsylvania State University Department of Architectural Engineering Faculty Advisors

Past Penn State AE Thesis Technical Reports

SPRING SEMESTER PROPOSED SCHEDULE

Below is a plan to accomplish the proposed spring semester work that was discussed throughout this document. Please note that this schedule is tentative and is subject to change at any time.

SPRING SEMESTER THESIS SCHEDULE

TASK	JANUARY		FEBRUARY				MARCH					APRIL				MAY	
	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15	WEEK 16	WEEK 17
	15-19	22-26	29-2	5-9	12-16	19-23	26-2	5-9	12-16	19-23	26-30	2-6	9-13	16-20	23-27	30-4	7-11
Reorganize for the semester									SPRING BREAK								FINALS
Faculty Consultations																	
Final touches on existing HAP																	
GWHP Research																	
CFD Research																	
Air Quality Research																	
GWHP HAP Energy Analysis																	
Choose GWHPs																	
GWHP calculations (ie size well)																	
CFD Breadth Analysis																	
Obtain first cost information																	
Life Cycle Cost Analysis																	
Air Quality Breadth																	
Compile Final Report																	
Finalize Final Report																	
Final Report Due																	
Prepare Presentation																	
Presentation																	
CPEP Maintenance																	