Thesis Proposal

Mechanical

Proposed Mechanical Revisions for Medical Office Building

Author: Kale Mullikin

Advisor: Donghyun Rim

December 9, 2014

Contents

Executive Summary

This is the proposal for a thesis topic to be completed in spring 2015. This proposal contains a summary of the building and the mechanical system it currently has as well as ideas taken under consideration for the proposal, a mechanical depth proposal, and two breadth proposals.

The mechanical depth proposes to replace the propane fueled heating source in the roof top units as well as the self-contained refrigeration system in the units and replace them with a geothermal system that will supply both the heating and the cooling for the roof top units. This system would be more energy efficient as well as reduce the monthly utility bills.

The breadth analyses will concentrate on the topics of structural and electrical. A brief look at future systems shows that there will be a need for more roof top units to satisfy the heating and cooling load of the building. The structural breadth will cover the potential need to redesign the roof system due to the added weight from the roof top units. The electrical depth will cover the need to potentially change the electrical panels and wire sizes to handle more roof top units.

Mechanical Systems Summary

The Medical Office Building is located in North-East United States and is to house many medical offices as well as some examination rooms and a physical therapy area. The building is two stories with a total square footage of 72,706.

The main heating and cooling for the Medical Office Building will be provided by two roof top units supplying VAV boxes with reheat coils. The roof top units are self-contained, meaning that there are no hot or cold water lines running to the units. The units utilize a closed loop refrigerant system for cooling and a gas furnace system fueled by propane for heating. The VAV system utilizes electric resistance for the reheat system.

A few additional electric baseboard heating systems are utilized at the entrances to the building. There are also five ductless split system units that supply control rooms for important medical equipment.

Mechanical System Design Requirements

Design Objectives

The Medical Office Building was designed to provide a building that will satisfy the needs for medical examination as well as physical therapy and imaging. The building is designed to be energy efficient and meet the design standards of ASHRAE.

Design Conditions

The Medical Office Building is located in the North-East United States. This area is in zone 5A according to ASHRAE 90.1 table B-1. This area is very humid in the summers and can be quite cold in the winters. Indoor and outdoor air conditions for the building were obtained from the ASHRAE Handbook of Fundamentals 2009.

The indoor design temperatures were designed to be 72°F for the winter and 75°F for the summer with a maintained relative humidity of 50%.

	Summer Design Cooling (0.4%)	Winter Design Heating (99.6%)
Outdoor Air Dry Bulb (°F)	92.4	9.4
Outdoor Air Wet Bulb (°F)	74.1	-
Indoor Air Design Temp (°F)	75	72

Table 1: Design temperatures

Ventilation

The Medical Office Building has two roof top units. These units provide the appropriate amount of ventilation necessary to be compliant with the ventilation rate procedure found in ASHRAE Standard 62.1. All areas requiring a direct exhaust to the outside have been equipped with their own separate exhaust ducts and fans. These areas only include the bathrooms and due to the low amount of air being exhausted from them, heat recovery systems were not included for these. A heat recovery system has been built into the roof top units for energy savings. The roof top units have been equipped with MERV 8 filters placed before the heating and cooling coils.

Minimum ventilation rates for people-based calculations and area-based calculations were all taken from ASHRAE Standard 62.1 and can be seen below in table 2.

Room Type	People-Based (CFM/Person)	Area-Based (CFM/S.F)
Conference	5	0.06
Corridor	0	0.06
Lobby	5	0.06
Office	5	0.06
Physical Therapy	20	0.06
Procedure Room	15	0.06
Reception	5	0.06
Storage	0	0.12

Table 2: Room ventilation requirements

Both of the roof top units were compliant with providing the appropriate amount of outside air. The units that were selected also provide more outdoor air than what was required as can be seen in table 3.

System	Calculated Outdoor Air (CFM)	Design Outdoor Air (CFM)
RTU-1	3767	4260
RTU-2	4272	4600

Table 3: Comparison of calculated and design outdoor air

Heating and Cooling Loads

A load simulation for the Medical Office Building was performed using the TRANE Trace program. The calculations for this program were performed using a block load procedure. Similar rooms in the building were grouped together in a "block" which simplified the calculation process. The blocks were then given a template which was specific to the type of space. The blocks were as follows:

- Conference
- Corridor
- Lobby
- Office
- Physical Therapy
- Procedure
- Reception
- Storage

The simulation was run for all times of the year. The results were used to create a graph that depicts the amount of heating and cooling for each month shown below.

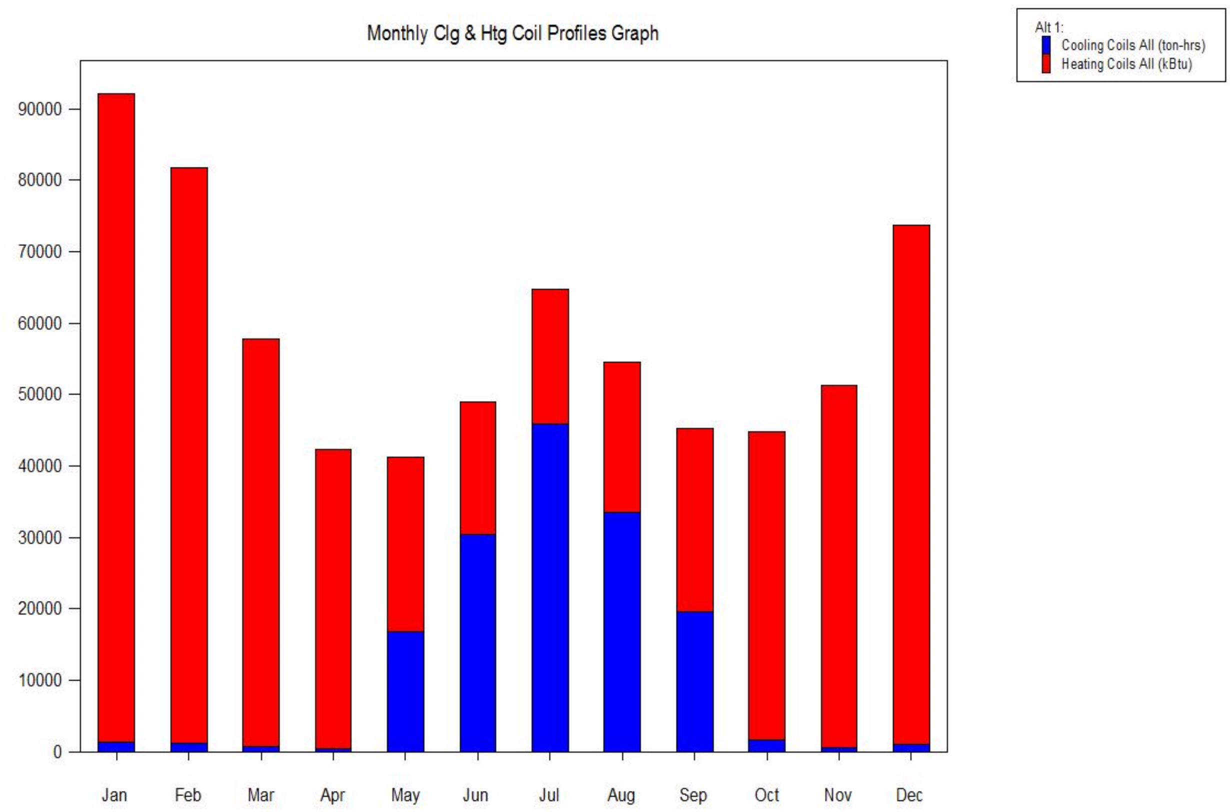


Figure 1: Monthly heating and cooling profiles

As the figure shows, there is a majority of heating in the colder months and cooling in the warmer months. Since the system is equipped with VAV reheat boxes, there will be some heating in the summer to bring the supply air temperature up to the desired level.

Alternative Designs

There are many different designs that were considered to improve the Medical Office Building's system. The following is a proposed revision to the system that could effectively reduce the monthly utilities cost of the building and also make the building more energy efficient.

Solar Energy

By using solar energy to provide heating for the roof top units, the units would not need to use propane gas as the fuel. A solar array could be placed on the roof and used to heat water that would be used to heat the building. A solar array on the building would also be able to provide power to the building and therefore reducing the amount of power needed from the grid. This design, however, would not be very effective in the area the building is located because of the large amount of cloud cover that is present in the northeast United States in the winter.

Mechanical Proposal

Geothermal System

The solution that will most likely provide the most energy savings for the Medical Office Building is the installation of a geothermal system on the site. Geothermal systems are desirable because of the constant and steady temperature of the earth. The earth provides a constant temperature of around 50 °F below 10 feet which provides a heat sink for heating and cooling. Heat is extracted from the earth in the winter and dumped into the earth in the summer. The Medical Office Building is located on a rather large site which would allow for plenty of space to locate a geothermal well field as can be seen in figure 1 where green represents the building location and red represents the potential well locations. The geothermal system would use either water or a modified refrigerant to circulate in the loop. Using a geothermal system would allow the building to no longer use propane gas as a fuel source in the roof top units and therefore save money.

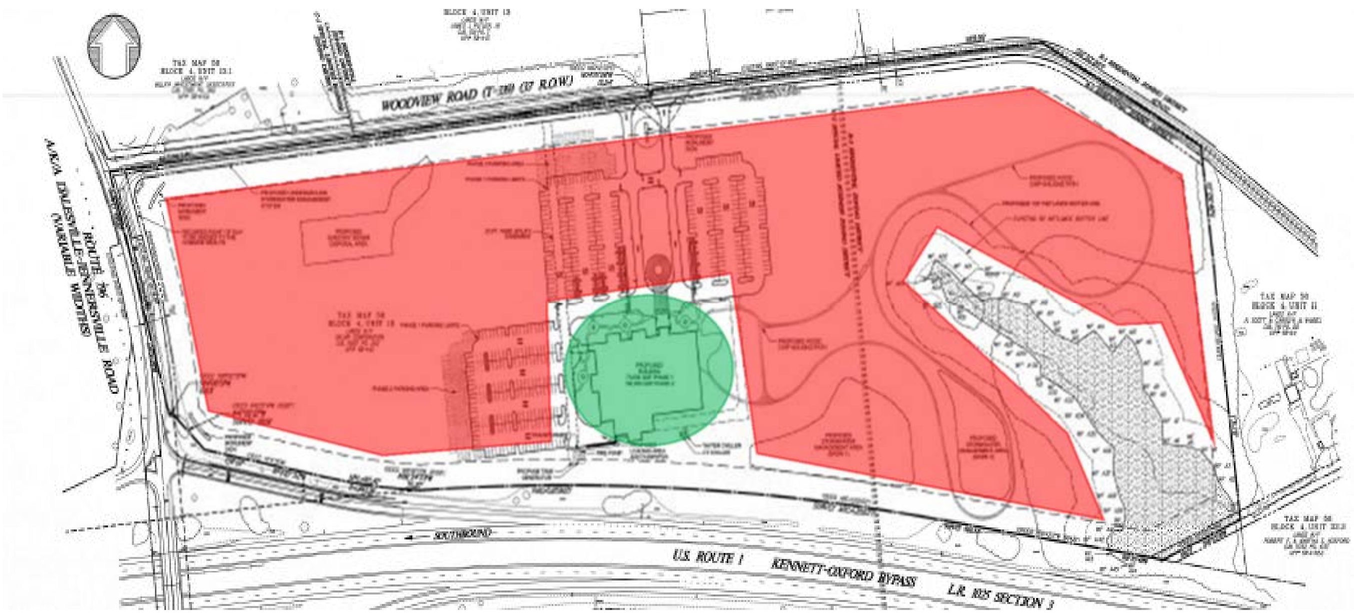


Figure 1: Potential locations of geothermal wells. Green is the building location. Red is the potential well locations.

Breadth Topics

Structural Breadth

There are currently two roof top units located on the roof of the Medical Office Building with each being able to handle about 50 tons each. With current technology, geothermal compatible roof top units can only handle 20 tons each. To meet the heating and cooling requirements of the building, there will be a need for about three more units to sit on the roof. The current structure needs to be analyzed to determine if it will be able to support this added load and if it cannot, it will need to be redesigned.

Electrical Breadth

The current electrical design is for only two roof top units. Since a geothermal will cause an added three units to the roof, the electrical system will most likely not be able to support this added load. The electrical system will have to be analyzed and redesigned to handle the extra load caused by the extra three roof top units. The electrical system may also not be able to support the added pumps that come with using a geothermal system.

Tools and Methods

Trane Trace 700

The load modeling software of Trane Trace will be used to determine what the changes will be in the system energy usage when the system is changed from propane gas heating and a refrigerant based cooling to geothermal heating and cooling. The program will also be used to determine the effect of adding three more roof top units to the building.

Well Analysis

Research will be done to determine the size and depth of the wells needed for geothermal. Due to different soil types, a standard distance will need to be determined for how close the wells are to each other to have the maximum effectiveness in heat transfer.

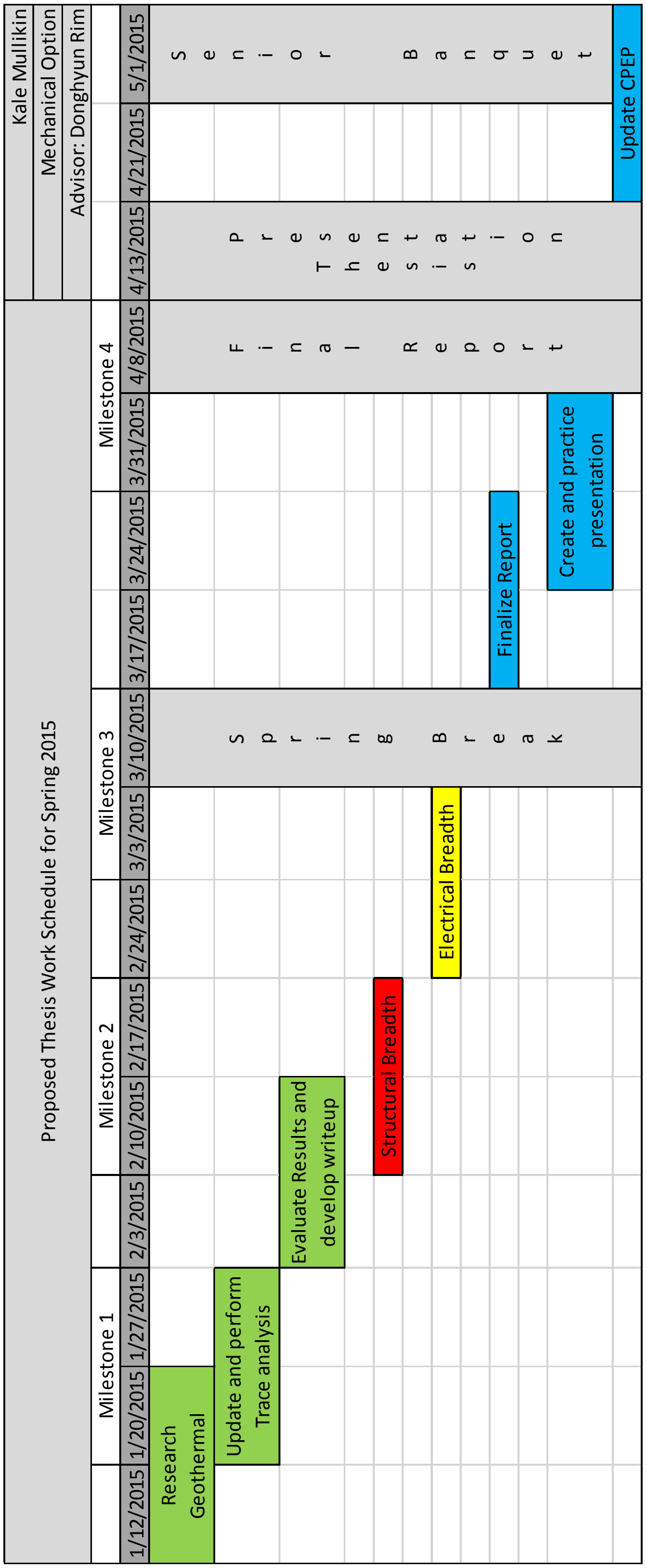
Structural Analysis

The weight of the roof top units will be researched and used to determine what the static load will be on the current members. If the members are unable to support this load, hand calculations will be used to determine the new sizing of the members.

Electrical Analysis

The amount of power that the roof top units will need will be determined from the manufacturer specifications. This information will then be used to determine the amount of power needed to be supplied from the panel. If the panel is unable to support the new load, new panel components will be selected and wire size calculations will be made to determine the new wire sizes.

Schedule of Work



Milestone 1:	100% Research geothermal
	50% Update and perform Trace analysis
Milestone 2:	100% Evaluate results and develop write-up
	25% Structural breadth
Milestone 3:	100% Structural breadth
	75% Electrical breadth
Milestone 4:	100% Finalize report
	75% Create and practice presentation

References

ASHRAE. Standard 62.1-2007, Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE. Standard 90.1-2007, Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.