Thesis Proposal

201 Rouse Boulevard

The Navy Yard
Philadelphia, PA 19112

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Executive Summary

Being erected in Philadelphia, Pennsylvania, 201 Rouse is a 84,500 sq ft office building. Under construction now and to be finished in early 2015, 201 Rouse is a concrete on metal deck steel framed four story building skinned in a zinc clad facade. Liberty Property Trust (owner) and Turner Construction (general contractor) are aiming to have the property be LEED certified and are designing for the gold rating.

The objective of this proposal is to present a scope of redesign to 201 Rouse based upon the existing conditions and energy analysis conducted in Technical Reports I, II, and III. Covering the building's mechanical, structural, and lighting systems the scope of this proposal's redesign is comprehensive and aimed at value engineering, energy savings, and additional LEED credits.

With the weight of the proposal centered around 201 Rouse's mechanical systems, multiple options for redesign were considered:

- Combined Heat and Power Plant Powered by Natural Gas
- Onsite Electrical Generation with Photovoltaic Arrays
- Water Sourced Geothermal Heat Pump

The scope of the redesign settles upon a ground source geothermal heat pump (GHP) that takes advantage of the sites ample room and Philadelphia's heating dominated climate. The GHP will be a closed loop vertical well system that will pair with a new radiant floor system in the building to properly and efficiently condition the building's spaces.

Due to substantial changes to the building's mechanical systems and characteristic architectural features additional components of the building are proposed to be altered as breaths. By downsizing the structural system and creating a interior design to maximize daylighting, the 201 Rouse building project could both save money and become a more habitable space.

Building Overview

Name:
201 Rouse Boulevard
Location:
201 Rouse Boulevard
The Navy Yard
Philadelphia, PA 19112
Occupant:
Franklin Square Capital Partners
Function:
Class A Office Space, Cafe, Fitness Center
Size:
84,500 square feet
Construction:
September 2013 to Q1 2015
Project Team:
Architects:
- DIGSAU (Primary Architect)
- Re:vision Architects (LEED Consultant)
- Francis Cauffman (Interior Architecture)
- Fury Design (Interior Design)

Engineers:
- Environetics (Structural Design)
- Pennoni Associates (Site and Civil)
- In Posse (Energy Consultants)

Owners:
- Liberty Property Trust (owner)
- Synterra Partners (Developers)

Construction:
- Turner Construction (General Contractor)

Existing Conditions

Building

201 Rouse is a mixed use 84,000 sq ft office building in a corporate campus in southern Philadelphia, Pennsylvania. Four floors high, the office building strikes a distinctive look with a zinc facade and large swaths of floor to ceiling windows on a large landscaped plot, complete with a ~150 car parking lot.

Heating & Cooling

201 Rouse Boulevard's heating and cooling is provided via three rooftop packaged units in conjunction with four electric unit heaters (used at entrances and equipment spaces). The building's primary spaces are conditioned by two large 33,600 SCFM (standard cubic feet per min.) rooftop air handling units (AHUs) with variable frequency drives (VFDs) that provide up to 1,500 kBTU/hr cooling (using R-410A refrigerant and an Energy Efficiency Ratio of 9.8) and 750 kBTU/hr heating each. Both AHUs utilize an economizer system balancing the return air and outside air based upon outside air (OA) requirements and relative humidity. The third rooftop unit is a smaller 1,600 SCFM packaged unit that conditions the bathrooms and building core. Additionally, 201 Rouse Boulevard utilizes single duct Variable Air Volume (VAV) Terminals of four varying sizes; all with electric reheat coils. The locations of the VAVs have not been specified yet as the layout of the office spaces has yet to be finalized.

Ventilation

Building ventilation is handled by providing over 16,000 SCFMs of outside air during occupied times. Additional exhaust is handled by two rooftop exhaust fans, with additional localized exhaust provided by transfer fans. The rooftop units are belt driven centrifugal exhaust fans that provide 5,300 SCFM and 865 SCFM for toilet exhaust and janitor's closets (always on) respectively. The smaller (~400 SCFM) transfer fans handle the ventilation from the electric closets and machine rooms and are controlled by the space's thermostat. In addition to the exhaust systems, each of the two large rooftop AHUs have a return system with 27,500 SCFM capacity each. This air return system uses the mechanical riser shaft as the return system and is integrated in the AHUs with air side economizers.

Controls

201 Rouse Boulevard has a web accessed native BACnet control system. The primary space AHUs have four scheduling modes: occupied, unoccupied, morning warm-up, and morning cool-down. The smaller core AHU has only two scheduling modes, occupied or unoccupied. When in occupied modes, the control sequence maintains a

minimum outside air flow (set by ASHRAE 62.1), manages the variable volume control of the supply and return fans using system air balancing, uses stepped electric resistance heating to maintain the temperature setpoint, and utilizes economizer cooling when the outdoor air enthalpy is lower than the return air enthalpy. When in unoccupied mode, the outside air dampers are closed and the AHUs cycle to maintain the discharge air temperature setpoints.

Lighting

The occupied areas of 201 Rouse are fit with modern ceiling hung single T5 Lamp fixtures, while the utility areas are fit with standard dual T5 fluorescent fixtures. 201 Rouse has an exterior that is over 45% windows, to take advantage of this abundant daylight there are several photocells to provide daylighting control to the building automation systems. The exterior of the building is lit with recessed can lights, illuminating paths and occupied exterior areas. The ~150 parking lot is lite by single or dual downward facing halogen lamps, while the landscaped areas of the site are illuminated by round diffuse halogen light posts.

Structural

The superstructure of 201 Rouse is structural steel, a substructure of poured concrete, and slab on metal deck floors. The foundation of the building is a wooden pile and concrete cap foundation system, with piles and cap for each column of the superstructure. With no basement, the foundation of 210 Rouse utilizes a 2 foot footing for the exterior walls, and a slab on grade for the floor. The superstructure of the building consists of steel columns, ranging W14X120 to W12X40, beams (typically W21X44 exterior and W24X62 interior), girders(W16X36 and larger), and joist girders (typically 30k7). Typical floor construction is 3"x20 gage galvanized type B composite deck topped with 2 ½" normal weight reinforced concrete (compressive strength of 3500 psi at 28 days).

Depth

Considered

Combined Heat and Power

Growing production of natural gas exploration and production in the Marcellus Shale Region in Northern Pennsylvania is causing Philadelphia to prepare itself to become a Hub for natural gas exportation. With that in mind and the cheaper natural gas prices it will bring, buildings should consider a combined heat and power (CHP) operation utilizing a natural gas turbine. These systems, depicted in Figure 1 below, are 70-80% efficient, protect a building against volatile electricity prices, utilize the now lower costs of natural gas, and produce less source emissions due to coal fired power plant's higher carbon footprints.

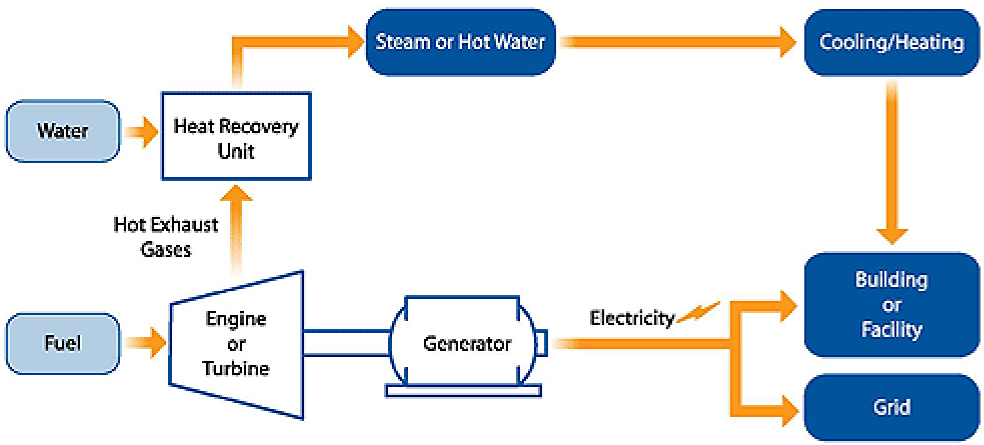


Figure 1: Combined Heat and Power System Configuration

Photovoltaic Array

With each coming year the cost of electricity rises and the production cost of photovoltaic technologies drops (along with increases in efficiency). Photovoltaic (PV) panels take the photos of light and convert it to electricity. Options between thin-film, polycrystalline and monocrystalline (ordered both by cost and efficiency) exist in the PV market and can be used as onsite electricity generation at commercial buildings. In addition to utility savings, utilizing PV arrays can lead to tax incentives and contributes LEED points to a building's LEED certification. The main issue outside of cost for PV arrays is that they take up significant space and would change the architectural look of the building and site.

Water Sourced Geothermal Heat Pump

Situated in the southern extent of Philadelphia, 201 Rouse is close to two potential water sources upon which upon which to utilize a water sourced geothermal heat pump.

The site has potential access to access both the Navy Yard's Reservoir and the Delaware River (see Figure 2 below).

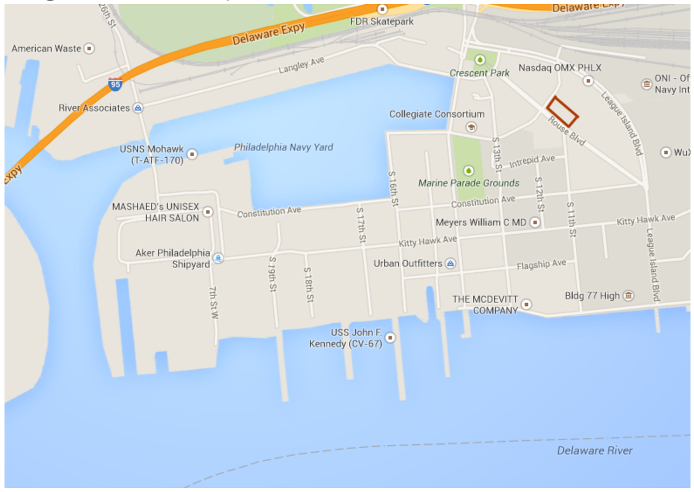


Figure 2: Potential Water Sources for 201 Rouse Geothermal Heat Pump

A water sourced heat pump could be either an open loop system (Figure 3) or a closed loop system (Figure 4). The open loop system would would use the surface water as a heat exchanger for fluid that circulates directly through the heat pumps at the building. Issues with this are that the source water must be relatively clean and additional codes concerning groundwater discharge. Alternatively a closed loop system could be implemented greater than eight feet below the surface of these water sources. These submerged loops would contain the heat exchange fluid that would be pumped through these loops to exchange heat with the water supply. Issues with this are that the water source must meet volume, depth and quality requirements based upon building load. Both of these solutions may be prohibitive due to the distance the fluid would need to be pumped to the building.

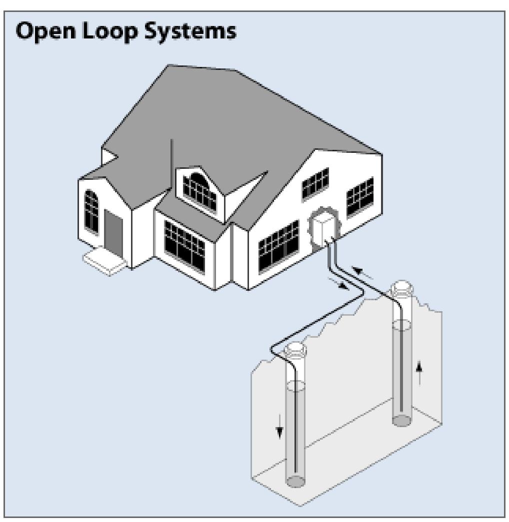


Figure 3: Open Loop System

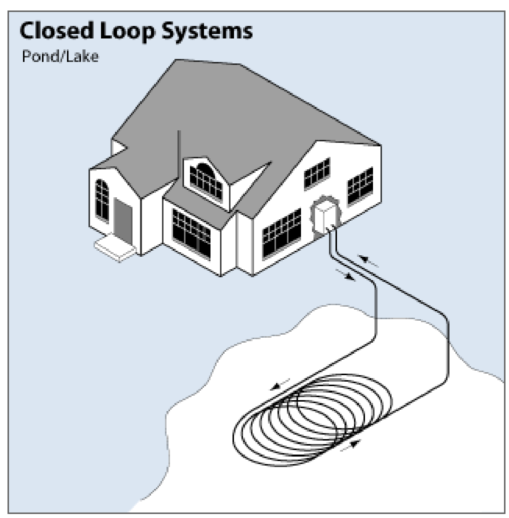


Figure 4: Closed Loop System

Proposed

One of the most popular sustainable improvements to modern building design is the inclusion of ground source geothermal heat pumps. As the cost of energy rose and the technologies involved became more reliable and cheaper these heat pump systems, that rely on the constant temperatures found below the frost depth, have become a valuable alternative to conventional space conditioning. A closed loop geothermal system (Figure 5) circulates a antifreeze solution through a series of underground pipes, then through a heat exchanger that transfers heat from the antifreeze solution to a refrigerant. In the Philadelphia region, to get the benefit of the constant ground temperatures vertical wells would have to be drilled below 30 ft to access the constant temperatures between 55^{oF} or below 12 ft to get season dependent (+/- 5^{oF}) groundwater temperatures of 62^{oF}[1]. One of the primary requirements of a ground source geothermal heat pump is access to enough soil space to adequately transfer enough heat to meet the design requirements of the building. The site 201 Rouse sits on contains a landscaping and a ~150 car parking lot covering over 130,000 sq ft, see Figure 6. All of this space would be available to drill and install the piping required to build a suitable geothermal heat pump system for 201 Rouse to entirely replace the existing electric AHUs.

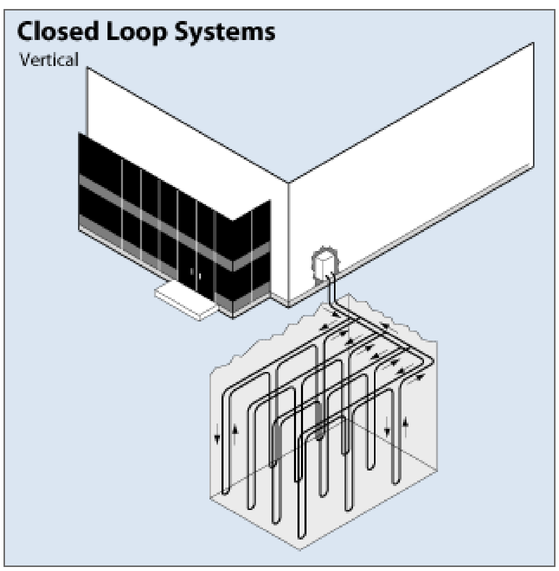


Figure 5: Ground Sourced Closed Loop Geothermal Heat Pump (GHP)

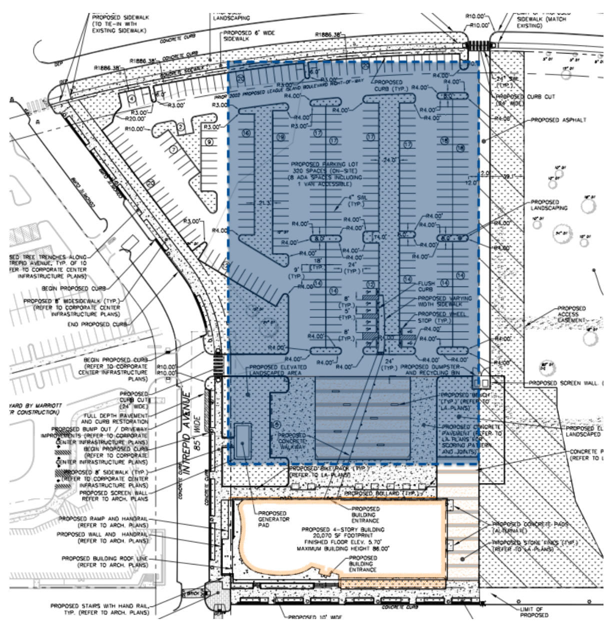


Figure 6: Potential Area for Vertical Ground Sourced GHP Wells

According to the Department of Energy, a geothermal heat pump system can use 25-50% less electricity and 72% less emissions than conventional electric conditioning systems. These energy savings are coupled with the additional

[1] McQuay Geothermal Heat Pump Design Manual

opportunities to get over eight LEED points in the Energy & Atmosphere Category which could be critical to achieve the LEED target of Gold; the project is currently six points short of the Gold rating, which is a goal of the developer.

To take advantage of the proposed closed loop ground source geothermal system the current forced air with VAV reheat system will be replaced with a commercial grade radiant floor system for heating and cooling. As Philadelphia is a heating dominated climate (five times as many heating degree days as cooling) a hydronic radiant floor system is a cost effective way to deliver heating from the heat exchanger of the GHP system. In today's day and age radiant systems come in a couple of varieties. In the design of the system for 201 Rouse a "dry" floor, in which the piping is in an air space below the floor, and a "wet" installation of piping in the existing thick concrete slab will be weighed as the primary options. While the "wet" system has a slower thermal response time and is more expensive and less efficient with a carpet covering, it is the easiest to implement in the current design; while the "dry" option is faster and cheaper the system must operate at a higher temperature which will reduce the efficiency of the GHP.

Breaths

Under the current building conditions and the proposed changes to the HVAC considerable value engineering can be applied to save cost and energy consumption.

Structural

The current structural system of 201 Rouse uses a simple steel frame, with the member selection driven by the building core, glass heavy facade, and an equipment laden roof. With the proposed sustainable mechanical improvements removing over 36,000 lbs in mechanical equipment from the roof of 201 Rouse, the structural frame of the building can be readjusted to these lower load requirements. As can be seen in the column diagram below in Figure 7 the highlighted columns are to support the rooftop loads associated with the air handling units. As these units are being replaced with a much smaller ventilation fan they and the joists and girders (seen in Figure 8: Structural Roof Plan) can be downsized.

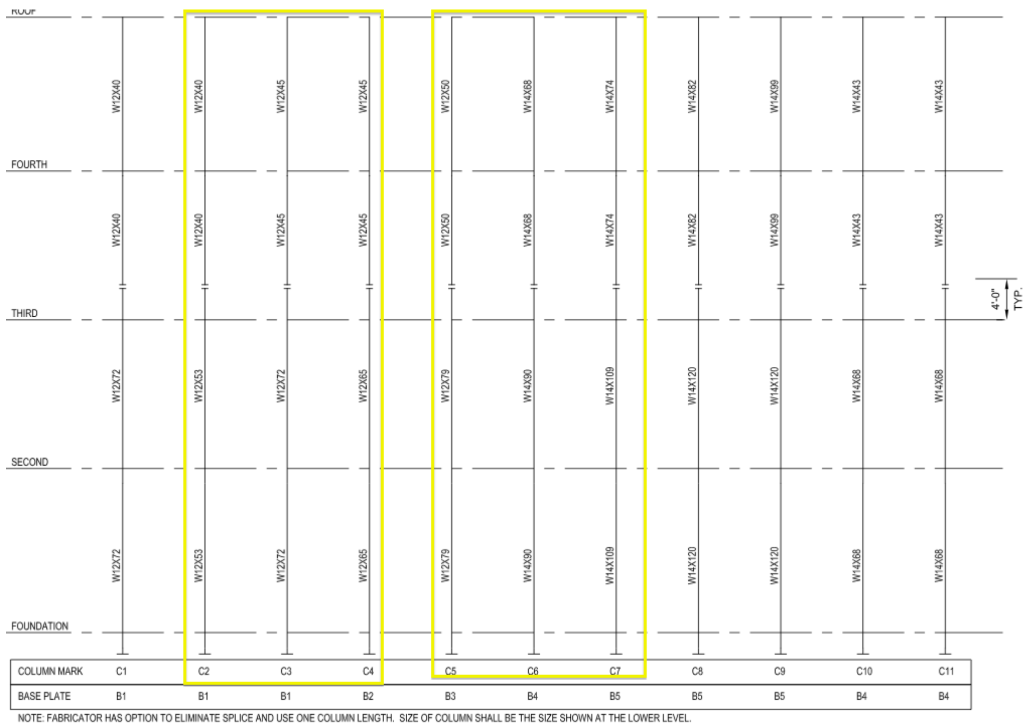


Figure 7:Column Diagram for 201 Rouse (AHU Support Columns Highlighted)

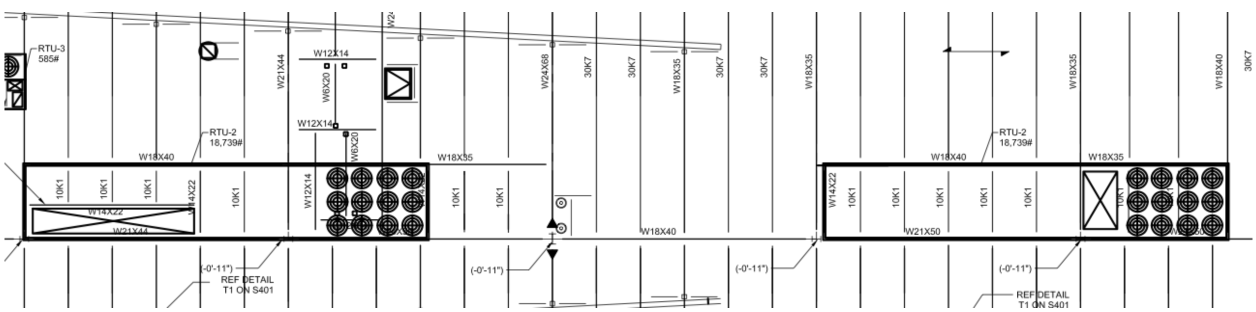
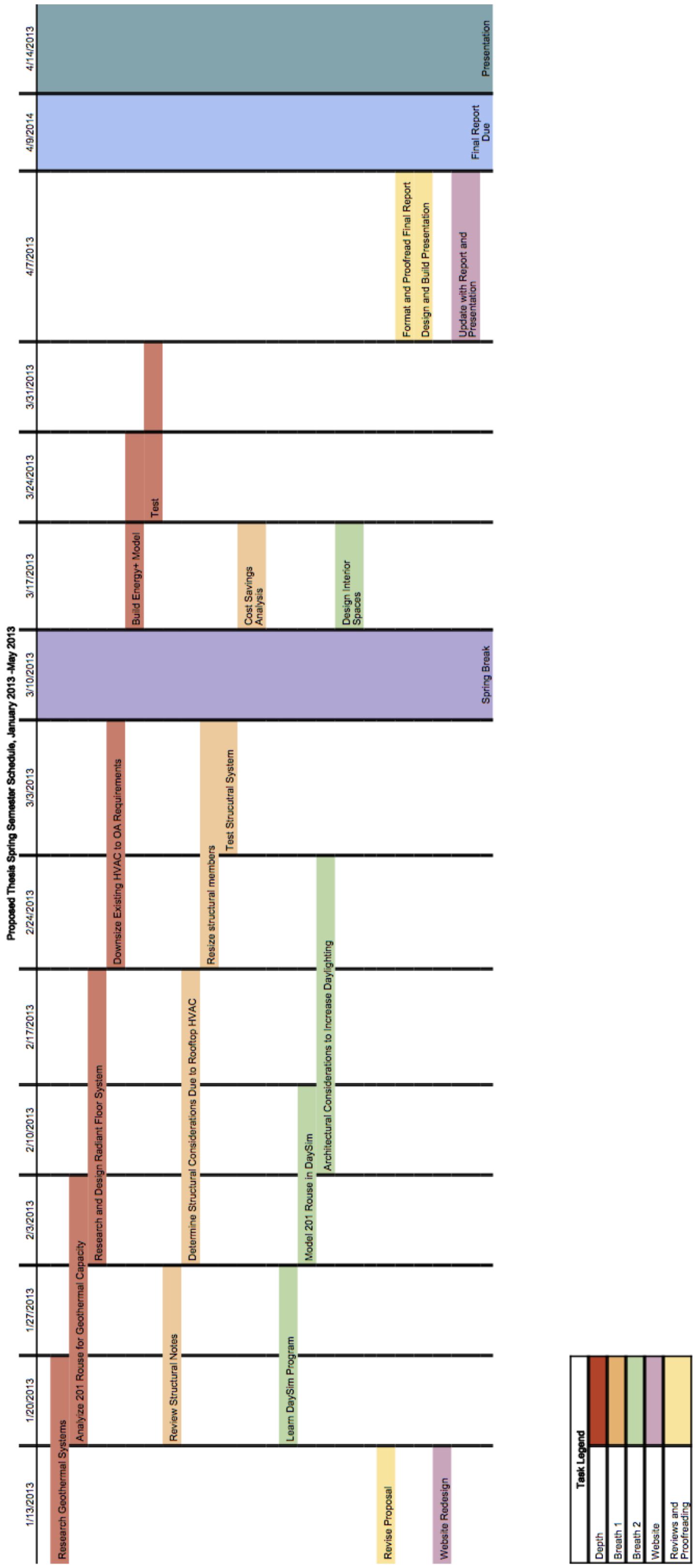


Figure 8: Structural Roof Plan

Electrical

A substantial part of 201 Rouse's electrical system is devoted to supporting the current all electrical packaged units and the VAV boxes. With the mechanical breath's change of the specified HVAC system to an efficient ground source heat pump system with chilled beams airside this portion of the building's electrical arrangement has changed. With all of the the water pumps, heat pumps, and active chilled beams the building's main distribution will have to be adjusted and new panels and wiring put in place to power this replacement mechanical equipment. By configuring the electrical backbone of the geothermal heat pump system a better idea of cost is developed. There is potential savings in downsizing the main distribution or in the number of supporting panels.

Timeline



*Click to access larger schedule

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