THESIS PROPOSAL

Bronx School for Law, Government, & Justice
Bronx, NY

Prepared By: Yulien Wong
Mechanical Option
Faculty Advisor: Dr. Jelena Srebric
December 11, 2005

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

The general idea for this assignment was to gather what was learned in the previous technical assignments and evaluate possible redesign considerations. In the redesign of the Bronx School for Law, Government & Justice it was concluded that the use of Thermal Energy Storage (TES) would be evaluated. The building predominantly uses electricity as the primary source of energy and the notion to reduce demand cost was the driving factor in the selection of TES.

The addition of TES will have an impact on the electrical systems of the building. Therefore, an analysis will also be done to evaluate how the electrical systems are affected by the addition of additional mechanical equipment. Another topic that will be evaluated in detail will be the life cycle cost of the building. The primary reason for any redesign is to determine whether energy savings can be created enough to cost-justify the often additional of first cost.

Then after the analysis is complete it will be determined whether the use of TES will be an acceptable alternative to the current system without thermal storage.

2.0 EXISTING CONDITIONS

The Bronx High School of Law, Government & Justice utilizes both VAV and constant volume systems. The School contains two 250 ton chillers that provide chilled water for all 10 air handling units. Each air handling unit air handler is pre-packaged units with heating coils. The heating coils are to provide supplemental heating, while the fin tube radiators are the primary heat source. The school has two duel-fired boilers that produce steam for both air handlers and fin tube radiators located throughout the building. The system is controlled by a central control panel located in the mechanical penthouse.

The Bronx School for Law, Government & Justice contains ten air handling units serving all major spaces. The building's top level is a mechanical penthouse and houses all but one of the air handling units. All air handling units are gas fired units capable of supplying heat throughout the building. Table A, from tech. report #1, represents all air handling units, area served, total supply air, outside air and percent outdoor air.

TABLE A [FROM TECH REPORT #1]

Air Handling Units (AHU)	Location	Type	Total CFM	Min. Outdoor Air CFM	OA %
AHU 1 [Classrooms & misc.]	Penthouse	VAV	48000	26000	54.17
AHU 2 [Classrooms & misc.]	Penthouse	VAV	19000	9000	47.37
AHU 3 [Gymnasium]	Penthouse	CAV	18500	7500	40.54
AHU 4 [Library]	Penthouse	CAV	3400	1020	30.00
AHU 5 [Lobby & Corridor]	Penthouse	CAV	12000	6900	57.50
AHU 6 [Kitchen]	Penthouse	CAV	5200/2600	5200/2600	100/100
AHU 7 [Administration]	Cellar	VAV	12000	3800	31.67
AHU 8 [Dining]	Penthouse	CAV	6000	3360	56.00
AHU 9 [Plant Operations]	Penthouse	CAV	7200	2200	30.56
AHU-10 [Orchestra]		CAV	3100	1050	33.87
TOTAL			**133440**	**66030**	**49.13**

The chilled water system in Bronx High School for Law contains two 250 ton chillers with each unit having two independently piped circuits. Each chiller uses R-22 refrigerant and was designed for an entering and leaving temperatures of 55˚F and 44˚F. Air-cooled, roof-mounted condensing units above the penthouse, rejects the heat from the chillers that provide chilled water for the air handling units. Once the chilled water is supplied to the air handlers it is returned by three end suction pumps that pump the return water back to the chillers. An expansion tank is connected to the chilled water system on the inlet (suction) side of the distribution pumps by a branch line. The expansion tank allow for thermal expansion of the chilled water that, if not for the expansion tank, could damage the piping system and the tank provides a location for makeup water to be admitted to the system.

The primary heat source comes from two duel-fired boilers that produce steam for all packaged air handling units and fin tube radiators. The primary source of energy for each boiler is natural gas and the secondary energy is fuel oil. Both boilers send steam to a main distribution steam pipe in which, the respective loads branch off this main pipe. All the steam return is pumped into a boiler feeder tank and then is re-pumped to both boilers at a rated temperature of 212˚F. A chemical feed tank is also provided and is tied into the return back to the boilers. AHU-7, because it is located in the cellar along with the boilers, has an independent supply and return. A separate condensate pump is provided for return steam which is then pumped into the feeder tank. Because the gymnasium is located on the 5th and 6th floors two separate supply and return steam loops were provided for the remaining air handlers in the penthouse. The fin tubes also have a separate loop and the return is done by a vacuum pump the pumps the return steam back to the boiler feeder.

3.0 PROPOSED REDESIGN: THERMAL ENERGY STORAGE

OBJECTIVES:

The following proposal explores alternative design strategies of mechanical systems for the Bronx School for Law, Government & Justice. The assignment is in no way to determine or find errors or flaws in the original design. It is merely for educational purposes for The Penn State Architectural Engineering Department. The goal of the redesign is to improve energy consumption and lower life cycle cost.

PROPOSED WORK:

Energy is not always produced when and where it is needed. In addition, many electric utilities impose demand charges based on the customer's highest power demand during on-peak hours and/or during the entire billing cycle. Therefore, an effective means of compensating for these problems is the use of Thermal Energy Storage (TES). A TES system contains a storage medium which is chilled during periods of off-peak or low cooling demand, and stored for later to meet the cooling load during peak times. The storage medium is typically chilled water (sensible storage), ice (latent storage) or a phase-change material. Load Shifting is the primary reason for integrating a TES system. TES technologies significantly reduce energy costs by allowing energy-intensive cooling equipment (i.e., chillers, rooftop units) to be predominantly operated during off-peak hours when power rates are lower, and reducing or eliminating on-peak demand charges. The primary strategies for operating thermal energy systems are typically done by full storage or partial storage. The difference between the two is the amount of cooling load that is shifted from on-peak periods to off-peak periods.

The redesign will explore the possibilities of TES for both chilled water and ice storage. Also both strategies of full and partial storage will be evaluated. The chilled water storage strategy will consists of energy analysis by using a stratified tank(s) for storage. Stratified tanks are the most common in TES because of its ability to separate cold stored water from the warm return water. The ice storage approach will consists of multiple forms of ice storage which include, ice harvesting, ice on coil, both external and internal melting, encapsulated ice and ice slurry.

JUSTIFICATION OF WORK:

The primary source of energy needed for the life systems of Bronx School for Law is electricity. The idea to use TES was based on the notion to reduce life cycle cost of the building. The school is owned and operated by the owner, New York School Construction Authority, and therefore, reducing energy cost would be a direct benefit to the owner. TES has the potential not only to reduce or eliminate electric demand cost but also reduce the size of equipment which would lead to a lower first cost for pumps, chillers and pipes.

There are many factors as to why TES was chosen as the basis for redesign. Cooling is only needed when the school is in operation which allows for a time frame for thermal storage. Therefore, the peak demand load, the largest demand in a 24-hour period, is greater than the average demand load throughout a day. The ability to shift part of or the entire demand load to off-peak hours, when the demand charge is at the minimum, will greatly reduce energy cost. The other element in choosing TES was the electric utility rate structure. The school's electric grid is operated by Con Edison, who offer demand charge rebates. The exact figure has yet to be determined but this factor and the peak-load vs. average load make TES an attractive alternative.

INTEGRATION COORDINATION:

Space becomes an issue because of the added equipment needed for TES. However, Bronx School contains a mechanical penthouse which acts like an additional floor dedicated for the systems of the buildings. Careful consideration has to be taken to assure that the TES system is physically feasible in terms of space.

4.0 BREADTH TOPICS

ELECTRICAL:

The first breadth issue will be the impact of TES on the electrical system. The use of TES requires more equipment which would lead to the need to reevaluate the electrical system and determine whether additional capacity is required. Also depending on the results from the TES analysis it may be possible to reduce the size of equipment which entail would also reduce the capacity needed on the electrical system.

CONSTRUCTION MANAGEMENT:

The primary goal of using TES is the reduction or elimination of demand cost. The addition of added equipment will certainly add first cost. Therefore, a detailed analysis of the life cycle cost has to be made to determine whether using TES is cost-justified. Then a comparison would be done to compare the cost with and without TES.

5.0 TOOLS & TECHNIQUES

During the redesign process many computer aided tools will have to be used to determine the feasibility of TES. For example, energy analysis will be done by Carrier's Hour Analysis Program (HAP) to determine the size of equipment that will be needed. Also Engineer's Equation Solver (EES) would be helpful for determining the life cycle cost that will be done.

Techniques that will have to be used are the placement of the equipment. The addition of TES must be carefully laid out both in plan and physically in the building. This is important to maintain efficiency of the system and not increase energy consumption.

6.0 PRELIMINARY RESOURCES

The following is a general list of resources that will be used throughout the redesign process. As the process moves forward more resources will be used and will be cited accordingly.

ASHRAE Handbook, Fundamentals. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, GA 2001.

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.

CoolTools Chilled Water Plant Design and Specification Guide. Pacific Gas and Electric Company, San Francisco, CA 2000.

7.0 TENTATIVE SCHEDULE

The following is a tentative preliminary schedule for the redesign process taking placing the following, Spring 2006. The schedule does not include faculty advisor meetings which will be planned as the semester progresses.

WEEK	DATES	PROPOSED WORK
1	1/9/06-1/15/06	Preliminary Research
2	1/16/06-1/22/06	Simulation Sensible Storage
3	1/23/06-1/29/06	Simulation Sensible Storage Continued
4	1/30/06-2/05/06	Simulation Latent Storage
5	2/06/06-2/12/06	Simulation Latent Storage Continued
6	2/13/06-2/19/06	Simulation Latent Storage Continued
7	2/20/06-2/26/06	Layout of TES
8	2/27/06-3/05/06	Breadth Work: Electrical
9	3/6/06-3/12/06	Life Cycle Analysis
10	3/13/06-3/19/06	Spring Break
11	3/20/06-3/26/06	Life Cycle Analysis Continued
12	3/27/06-4/2/06	Finishing Final Report/Preparing Presentation
13	4/3/06-4/9/06	Final Reports Due/Preparing Presentation
14	4/10/06-4/17/06	Thesis Presentation