GLEN A. WEED LIBRARY

COASTAL UNIVERSITY

Wilmington, NC

Existing Mechanical Systems Narrative
Technical Assignment 1
AE 481W - Thesis

Glen Library Entrance Rendering

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EXECUTIVE SUMMARY

Glen A. Weed Library is a new 253,000 square foot library located in Wilmington, North Carolina.* Opened in January of 2013, Glen Library serves Coastal University's extensive library system and was constructed as part of a master plan to centralize their information database. Glen Library is an icon on campus that was designed not to mimic surrounding buildings but to compliment them with a futuristic look. Its main feature is the self-automated book retrieval system, also known as the bookBot, which holds up to a two-million volume collection to reduce the building footprint size by almost 40%. Functional spaces within the building include open collaboration spaces, group study rooms, an auditorium, technology labs, and creativity studios all to enable learning, research, and collaboration.

The total project cost for this new library was $93,750,000, leaving the cost per square foot to equal almost $400. In comparison, most libraries in the past have cost less than $200 per square foot to build. High investments were made towards sustainability efforts for this library including the incorporation of a solar thermal collector, active chilled beams and radiant panels, low-flow plumbing fixtures, a green roof and integral shading devices on the exterior facade. These features along with others collectively contributed to a LEED Silver certification.

Mechanical systems were designed within Glen Library using a prescriptive approach to comply with the 2009 North Carolina State Building Code, applicable ASHRAE Standards and LEED Certification requirements. Design criteria was used from the building location in Climate Zone 4 according to the Department of Energy Climate Zone Map. Within the building, there are four air handling units that primarily serve for ventilation purposes and perimeter cooling, where AHU-1 serves the North section of the building, AHU-2 serves the South section, AHU-3 serves the Auditorium and ARU-1 serves the bookBot space. Chilled water and steam are brought into the building from the Central Utility Plant campus loop. The high-pressure steam is converted to lower pressures within the building. The chilled water, steam and heating hot water are then distributed to active chilled beams, radiant panels, and fan coil units for space conditioning. The solar thermal collector assists in heating domestic hot water.

Because such great efforts were made towards sustainability and the design of efficient mechanical systems in Glen Library, future design alternatives and improvements will be investigated with the goal of reducing the overall project cost. Investigations may be made on the implementation of a combined heat and power at the Central Utility Plant to improve energy payback of thermal and electric demands of this building.

* Please note that a fictitious name and location were used for owner confidentiality.

INTRODUCTION

This report will cover the site location and how the campus utility plant interfaces with Glen Library. Additionally, it will review the main parts of the mechanical systems within the building including equipment components, operational summaries and control sequences in concurrence with the building automation system (BAS). Floor plans, sections, and mechanical schematic diagrams are included for clarity to improve reader understanding of system layouts within the building.

SITE UTILITIES

The University has two utility plants that distribute chilled water and high-pressure steam to all buildings on its campus. The original North Utility Plant has recently been converted to combined heat and power. However, Glen Library is served by the Central Utility Plant that has conventional generation. The Central Utility Plant uses a monitoring and graphical interface system that includes information on chilled water supply and return temperatures, high pressure steam flow rates, pumped condensate temperature and flow rates, and differential pressures. Metering is provided for chilled water, makeup water, steam and steam condensate. Two-way control valves provide the ability for Glen Library to be decoupled from the campus distribution loop in normal operating mode.

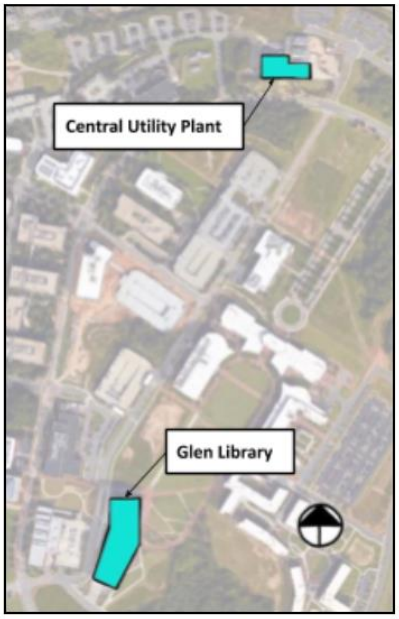

Figure 1: Site Plan

SYSTEM OPERATION NARRATIVE

Chilled Water

There is a primary and a secondary chilled water loop within Glen Library. The primary chilled water loop serves cooling coils in all air handling units and fan coil units. After passing through two plate and frame heat exchangers, the secondary chilled water is distributed to active chilled beams and radiant cooling panels. Two centrifugal VFD pumps distribute primary chilled water where flow modulation is controlled by differential pressure sensors in response to demand. Pumps piped in parallel are in lead-lag mode for both primary and secondary chilled water where the lead pump is controlled based on outside air temperature. Chilled water is delivered at 61°F from campus loop, at least 2°F above the building dew point as sensed on the 3rd floor.

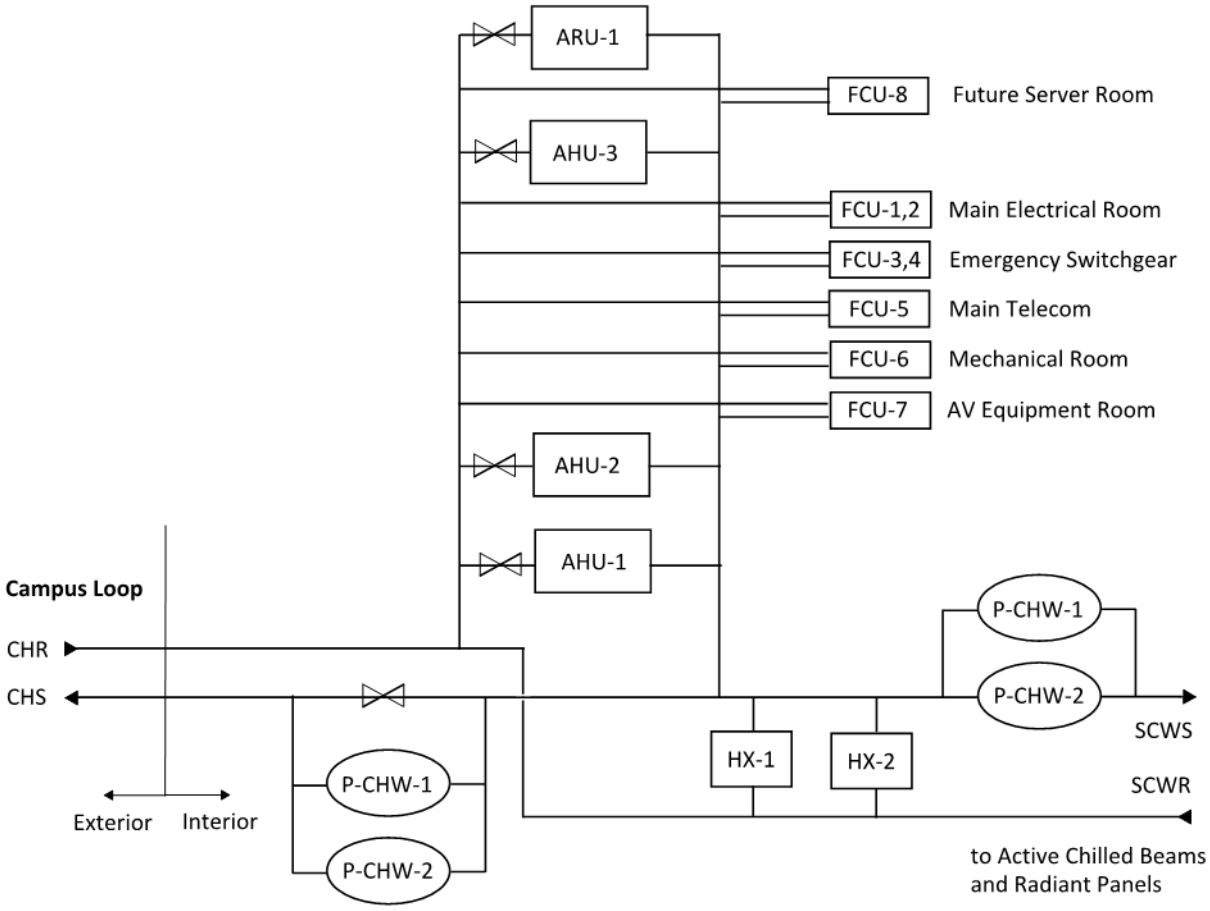

Figure 2: Chilled Water Schematic

Heating Hot Water

High pressure steam is delivered to Glen Library at 125 psig from the Central Utility Plant distribution system. There is one pressure reducing valve within the building that reduces the high-pressure steam to both 80 psig and a lower pressure. Two shell and tube steam to water converters, CV-1 and CV-2, generate heating hot water. The converters are sized for 100% of the total preheat and reheat load and are piped in parallel in lead-lag mode. Hot water temperature is set at 180°F and is controlled by a thermostat with sensors in each leaving line of the converters. Once the hot water leaves the converters, it is distributed to four air handling units, active chilled beams, radiant heating panels and fan coil units throughout the building. Isolation valves are included on header and branch lines for maintenance if needed.

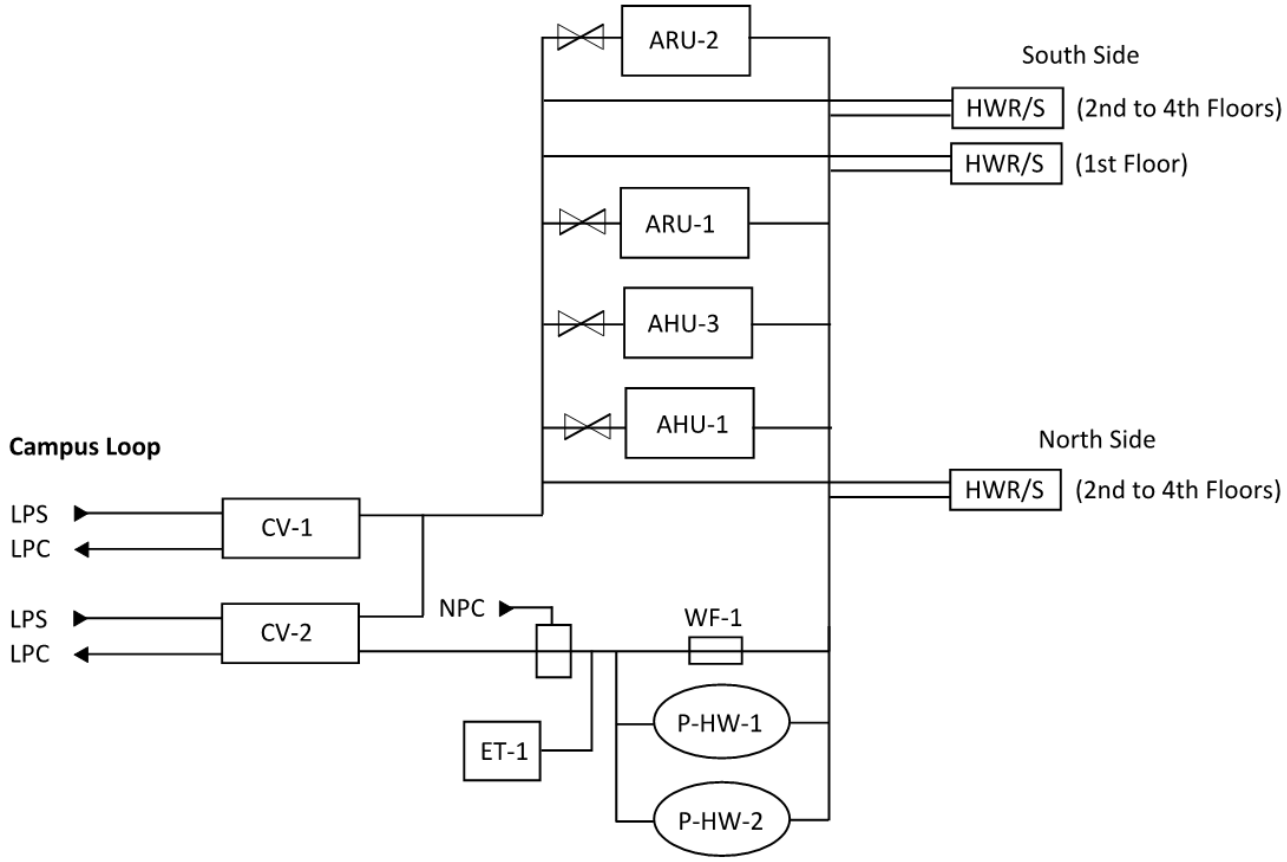

Figure 3: Heating Hot Water Schematic

Air Handling Systems

A conventional VAV reheat system is used within Glen Library. There are three air handling units, AHU-1, AHU-2, and AHU-3, that primarily serve for ventilation and perimeter cooling purposes. AHU-1 serves floors one through five of the north section of the building, AHU-2 serves floors one through five of the south section, and AHU-3 serves Auditorium 1103. AHU-1 and AHU-2 are dedicated outdoor air systems (DOAS) providing 100% outside air and both have dual wheel units with energy recovery and passive dehumidification. AHU-3 is an independent system bringing in approximately 50% outside air to the space it serves. All three air handlers include inlet and discharge smoke detectors and smoke isolation dampers, MERV 8 pre-filters and 13 final filters, and UVC sanitary lamps.

An air recirculation unit, ARU-1, serves as space heating, cooling and humidification for the Automated Storage and Retrieval System (ASRS) which is also referred to as the bookBot where air is distributed through a conventionally ducted system. Four humidifiers are located in AHU-1, AHU-2, AHU-3, and ARU-1 with controls set at 35% RH at 72°F. There is a high limit humidity

sensor located in the supply ductwork downstream in each one of the humidifiers. Ventilation rates for all spaces within Glen Library are determined based on ASHRAE 62.1 and LEED IEQc2, although in many spaces LEED IEQc2 requires 30% more outside air to be provided. Figure 4 to the right illustrates the general locations served by the air handling systems.

Ductwork, Air Terminals and Exhaust Fans

There is galvanized sheet metal ductwork for all supply air, return air, and exhaust air routing wrapped with fiberglass insulation. HVAC zones were determined by grouping similar spaces based on interior or exterior location and function. There are two dedicated exhaust fans, EF-3 and EF-4 that serve the north and south sections of the building when AHU-1 and AHU-2 are running.

Active Chilled Beams and Radiant Panels

Zone setpoints are predetermined by the building operator and include normal (72°F) setback, heating (65°F), and setback cooling (80°F) each with a dead band of 2°F. Only cooling or heating mode can be entered at one time. Active chilled beams and radiant heating and cooling panels maintain setpoint temperatures. Chilled water and hot water valves open when the space temperatures are above or below setpoints. The chilled water supply for the active chilled beams modulates to maintain zone temperature setpoints. Terminal boxes provide air to the active chilled beams with constant airflow. Occupied setpoints within each terminal box are activated when at least one space served by a terminal box is in occupancy mode which is determined by occupancy sensors.

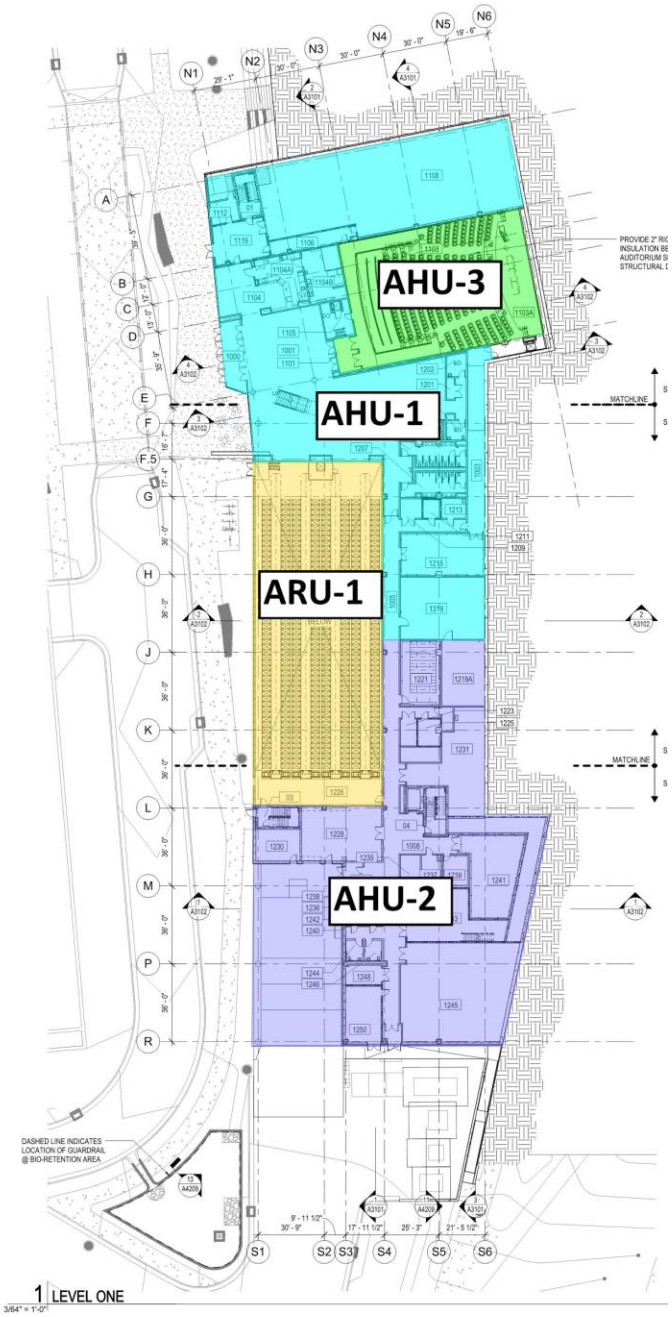

Figure 4: Air-Side System Distribution

Radiant heating panels are located in perimeter zone spaces and are specified as tube and plate panels. They function directly with terminal controls of the thermostats in their zones. For

operational and maintenance purposes, the radiant panels are hinged into the ceiling for easy access. Startup requirements were also considered during the design process for turning on the active chilled beams and radiant panels.

Figure 5: Radiant Ceiling Panels Drawings and Photo of Learning Commons

Domestic Hot Water and Solar Heating

Rooftop solar thermal collectors assist in heating domestic hot water to a temperature of 120°F. Backup hot water is provided through steam supply when the storage tank temperature falls below 115°F. The BAS monitors storage tank temperature and an alarm goes off when the temperature rises above 190°F. The BAS also monitors return water temperature from collectors, flow rates through three circulation pumps, a mixing valve setpoint, and BTU energy metering signal from the solar collector.

Plumbing and Fire Protection

The description for plumbing and fire protection will not go in-depth in this report to allow for a focus on HVAC systems. The scope of design for plumbing and fire protection includes sanitary sewer, stormwater, grease waste and vent, domestic hot and cold water, and sprinkler dry pipe systems. Lavatory flow fixtures such as conventional low flow, dual flush, and ultra low flow were incorporated into the plumbing to contribute towards sustainability efforts in this building.

DESIGN CONSIDERATIONS

Hydronic System Consequences

The total system connected heating load is 5,900 MBH and cooling load is 6,440 MBH. The slightly higher cooling load reflects the location of Glen Library. Energy modeling and computational fluid dynamics (CFD) were utilized during the design process for analysis of temperature variations throughout the spaces as well as response times. The hydronic system has a longer response time than air systems, so this was considered by the design team when

creating occupancy setpoint schedules. Humidity control can also be an issue with chilled beams. This was addressed by placing dew point sensors in local areas as well as humidity sensors within the systems. Chilled beams were also not placed at entrances and each zone has reheat air in its supply.

Sustainability Investments

There was a total 31% energy savings on this project. The energy savings can be broken down into the following categories - 8% for active chilled beams and radiant panels, 6% for building envelope, 5% for lighting and controls, 11% for DOAS and heat recovery, and 1% for domestic hot water. The ASRS, as depicted in the images below, reduced the building footprint by 40%. Additional interesting features include a green roof for stormwater management, fritted low-E glass on the exterior facade to reduce heat gain while still providing high levels of daylighting, and the use of recycled materials with low VOC to improve the indoor air quality.

Figure 6: Automated Storage and Retrieval System (ASRS), or BookBot

PROPOSED IDEAS

Because such great effort was put towards investments in highly efficient mechanical system designs within Glen Library, considerations are being made moving forward to investigation ways of designing these systems more effectively at a lower cost. Implementing a combined heat and power system at the Central Utility Plant may be a solution to reduce the overall project cost of Glen Library. Thermal and electric energy demands have been requested for Glen Library as well as the other buildings on the same distribution loop. Response is also currently pending from the lead mechanical engineer on what energy modeling software was used for this project.

APPENDIX I - LIST OF FIGURES AND TABLES