Design of Heating, Ventilation and Air Conditioning (HVAC) and Elevator System for Research Facility and Administration Building in Freedom Island at Parañaque, Metro Manila

Bryan Joe S. Gasang[1], Chad Anthony M. Roldan[2], Neal Niño L. Rosales[3], Zoren H. Ricablanca[4], Engr. Jewel Rhyanne Nycole B. Riosa[5]

College of Engineering, Computer Studies, and Architecture

Lyceum of the Philippines University - Cavite

***Abstract*: The purpose of this study is to give knowledge to the Mechanical Engineering Students of the Lyceum of the Philippines University- Cavite on how to design an air conditioning and elevator system for a Research Facility and Administration building located at Freedom Island Trail (Rail Road), Parañaque City, Metro Manila. The researchers believe that the study would broaden the knowledge of mechanical engineering students about the design of Heating, Ventilating, and Air conditioning (HVAC), what are the things need to consider and how to compute the humidity of the facilities. The researchers made a floor plan as to understand how to compute the materials and to determine the length of each components needed. We referred to ASHRAE data guide to compute and practice safety standards. After computation that we held, we the researchers conclude that the assumption of the datum that we gather is relevant to the real works of the real project.**

***Keywords:* LPU-Cavite, resort Campus, Heating, Ventilating, and Air-conditioning (HVAC), Elevator System, Freedom Island Trail (Rail Road), Parañaque City, Metro Manila, ASHRAE data guide.**

I. INTRODUCTION

By the end of the 19th century, the concept of central heating was fairly well developed, and early in the twentieth century, cooling for comfort started. Since this time there have been many developments to bring the industry to the level of design it has now. The greatest developments have been made in the detailed analytical methods needed for the design of large systems. Air conditioning is the process of removing heat from a confined space, thus cooling the air, and removing humidity. This process is used to achieve a more comfortable interior environment, typically for humans; however, air conditioning is also used to cool/dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and even to display and store artwork. This Design Project is broken down into two parts. The first part is the design of a heating ventilation and air-conditioning system for a research facility. The second part discusses the theoretical aspect of heating ventilation and air conditioning engineering and design. An elevator (US and Canada) or lift (UK, Ireland and Australia) is a type of vertical transportation device that moves people or goods between floors (levels, decks) of a building, vessel, or other structure. Elevators are typically powered by electric motors that drive traction cables and counterweight systems like a hoist, although some pump hydraulic fluid to raise a cylindrical piston like a jack.

II. LITERATURE REVIEW

An air conditioner is a system or a machine that treats air in a defined, usually enclosed area via a refrigeration cycle in which warm air is removed and replaced with cooler air. In construction, a complete system of heating, ventilation, and air conditioning is referred to as HVAC. Whether in homes, offices or vehicles, its purpose is to provide comfort by altering the properties of the air, usually by cooling the air inside. The main function of air conditioner is to change adverse temperature. Ventilation is the process of supplying or removing air to or from any building or space. Such air may or may not have been conditioned. Methods of supplying or removing the air are accomplished by natural ventilation or mechanical methods. Natural ventilation is obtained by opening or closing window sashes and by using vents or ventilation above the roof, chimney drafts, and so on. Mechanical ventilation is produced by the use of fans or other means to force the air through the space to be ventilated.

Air conditioning units not only maintain the right level of moisture and temperature, but they also improve air quality. Air conditioners circulate filtered, clean air into a property. This clean air is free from any dirt particles from outside, free from excess dust, and even free from bacteria that come in through the doors and windows. This filtered air creates a healthier, cleaner environment, which is not only ideal for children and families, but for commercial environments where large amounts of people are working together for many hours per day. Heating, Ventilation and Air-Conditioning (HVAC) system are to help maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort. The Ventilation Moderate internal temperatures. Reduce the accumulation of moisture, odors and other gases that can build up during occupied periods. Moreover, create air movement that improves the comfort of occupants. The HVAC system was a typical HVAC system consisted of an air-to-air heat exchanger and a water-to-air heat exchanger. To get the objective function composed of electrical power of different components in the HVAC system and a fraction of thermal power used by the system. The goals defined for the HVAC system were treated as constraints to the objective function. Refrigerant is a compound typically found in either a fluid or gaseous stat. As refrigerant absorbs heat from indoor air, it transitions from a low-pressure gas to a high-pressure liquid. The lights, occupancy, partition and appliances does create heat that effects the cold temperature inside a room. In addition, it is essential for getting the airflow needed in a room. Heat transfer will delve into the primary application of heat transfer concepts in the HVAC, which is cooling and heating load calculations. Which is essential for computing the sensible and latent heat inside the research facility and administration building.

III. METHODOLOGY

The proponents used to compliance with the standard and to rate the energy efficiency of commercial and high-rise residential buildings with designs that exceed the requirements of Standard 90.1. Use of the PRM for demonstrating compliance with Standard 90.1 is a new feature of the 2016 edition. The procedures and processes described in the PRM reference manual (PRM-RM) are designed to provide consistency and accuracy by filling in gaps and providing additional details needed. These standard materials have been created independently from ASHRAE and Standing Standard Project Committee (SSPC) 90.1 and is neither sanctioned nor approved by either of those entities. The system that we use for our HVAC is PACU-DX type air-con (Package Air-conditioning Unit). We provide PACU per building and make it centralized air-conditioning thru ducting system. HVAC standard used are ASHRAE GRP 158 and ASHRAE STANDARD 62.1. Moreover, for building assembly is ASHRAE Standard 90.1 2016. Ducting system will be provided throughout the research facility and administration building. HVAC is necessary for the researchers and people inside each building. For the elevator system we used the ThyssenKrupp Endura twin post above ground will be provided for the administration building to help the researchers and other people to helping to minimize daily re-occurring movements of climbing stairs and moving heavy and bulky objects becomes easier and spares a lot of wasted time, especially when moving multiple items. Increasing the energy efficiency of systems and components and upgrading the thermal performance of the building envelope. It provides procedures and programs crucial to energy efficient operation, maintenance, management, and monitoring.

A. Project Construction Procedures

Project Floor Plan Design of Freedom Island Research Facility

↓

Selection of HVAC System and Elevator System

↓

Determining the Building Components and Materials Construction

↓

Determining the Formulas needed for the Design

↓

Solving for the components

↓

Creating a HVAC and Elevator Design plan layout using AutoCAD and Sketch up

↓

Checking for all the Computations regarding to the HVAC and Elevator Design

B. System Model

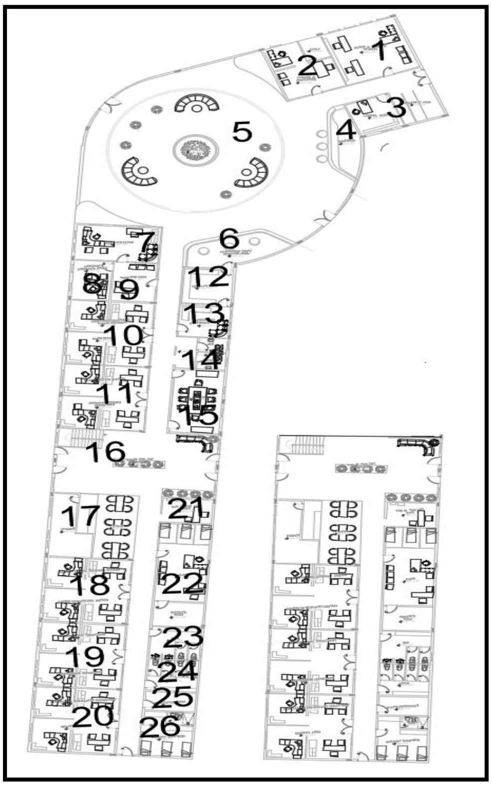

Fig. 1: Administration ground and second floor

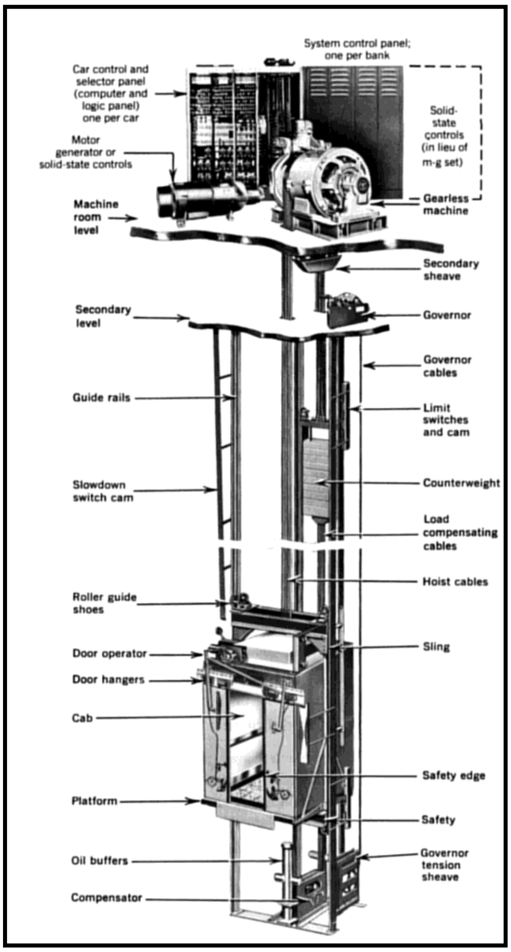

Fig. 3: ThyssenKrupp Endura twin post above ground

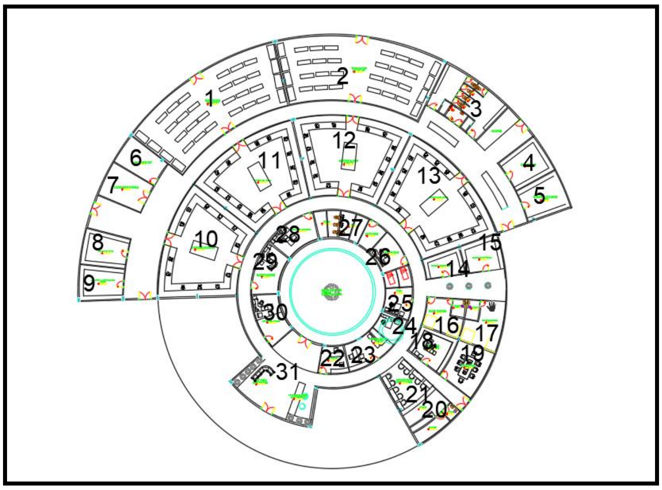

Fig. 2: Research facility floorplan layout design

Many different methods have been devised for heating buildings. Each has its own characteristics, and most methods have at least one objectionable aspect. Most of these heating methods can be classified according to one of the following four criteria: The heat-conveying medium the heat-conveying medium is what carries the heat from the source to the enclosure being heated. In addition, the fuel used the fuel used is a distinguishing characteristic of a heating system. Wood, coal, oil and gas are used to produce heat. The term heat-conveying medium means the substance or combination of substances that carries the heat from its point or origin to the area being heated. There are four mediums for conveying heat. These four mediums are air, water, steam, and Electricity.

Knowing a building's expected capacity and lift waiting times is essential before any detailed planning can start. Considering factors such as the function of the building, the inhabitants, and the inhabitants' distribution within the building will be essential to understand the impact on the number of cars required. Should fast service be required, a lift car per 150 to 200 passengers may be needed. Should economy be the focus, a lower number of lift cars per passenger quota will be required, such as one car per 250 to 300 passengers. Building height will also influence how lifts are installed, with the possibility of more than one lift core being needed. 30 floors or more may require banks of lifts with multiple shafts at different levels, providing sky lobbies for passengers to get on lifts to higher floors. There is a growing need to cater for higher numbers of passengers and taller buildings, and therefore to ensure that the right number of lifts is installed.

IV. ANALYSIS AND PRESENTATION OF DATA

A. Summary of Cooling Loads

TABLE I: SUMMARY OF ALL COOLING LOADS IN RESEARCH FACILITY

Load Description	Sensible Heat Loads (Btu/Hr)	Latent Heat Loads (Btu/Hr)	Total Cooling Loads (Btu/hr)
Conduction through Roofs	110,123.5	-	110,123.5
Conduction through Walls	7,054.86	-	7,054.86
Conduction through Glass	5,195.5	-	5,195.5
Solar Radiation through Glass	5,086.95	-	5,086.95
Conduction through Partitions	-	-	-
Heat Gain for Lights	44,570	-	44,570
Heat Gain for People	225,320	88,620	313,940
Heat Gain for Equipment	37,141.72	-	37,141.72
Heat Gain for Infiltration	12,175	18,526	30,701
Total Space Cooling Loads			553,813.53
Ventilation	74,188.4	112,866.36	187,054.8
Total Coil Cooling Loads			740,868.33
Safety Factor and Miscellaneous (5%)			37,043.41
Grand Total Coil Cooling Loads (BTU/hr)			**777,911.75**
Grand Total Coil Cooling Loads (Tons)			**66 TR**

TABLE II: ADMINISTRATION BUILDING 1ST FLOOR SUMMARY OF COOLING LOADS

Load Description	Sensible Heat Loads (Btu/Hr)	Latent Heat Loads (Btu/Hr)	Total Cooling Loads (Btu/hr)
Conduction through Roofs	-	-	-
Conduction through Walls	3,309	-	3,309
Conduction through Glass	7,972	-	7,972
Solar Radiation through Glass	12,752	-	12,752
Conduction through Partitions	-	-	-
Heat Gain for Lights	44,570	-	44,570
Heat Gain for People	15,840	55,440	71,280
Heat Gain for Equipment	22,997	-	22,997
Heat Gain for Infiltration	6,998	10,649.5	17,647.5
Total Space Cooling Loads			180,527.5
Ventilation	74,188.4	112,866.36	187,054.8
Total Coil Cooling Loads			367,582.3
Safety Factor and Miscellaneous (5%)			18,379
Grand Total Coil Cooling Loads (BTU/hr)			**385,961**
Grand Total Coil Cooling Loads (Tons)			**35 TR**

TABLE III: ADMINISTRATION BUILDING 2ND FLOOR SUMMARY OF COOLING LOADS

Load Description	Sensible Heat Loads (Btu/Hr)	Latent Heat Loads (Btu/Hr)	Total Cooling Loads (Btu/hr)
Conduction through Roofs	27,024	-	27,024
Conduction through Walls	3,818	-	3,818
Conduction through Glass	5,058	-	5,058
Solar Radiation through Glass	7,948	-	7,948
Conduction through Partitions	-	-	-
Heat Gain for Lights	25,886.5	-	25,886.5
Heat Gain for People	4,560	15,960	20,520
Heat Gain for Equipment	23,426	-	22,997
Heat Gain for Infiltration	6,687	10,176	16,863
Total Space Cooling Loads			130,114.5
Ventilation	74,188.4	112,866.36	187,054.8
Total Coil Cooling Loads			317,169.3
Safety Factor and Miscellaneous (5%)			15,858.5
Grand Total Coil Cooling Loads (BTU/hr)			**333,027.5**
Grand Total Coil Cooling Loads (Tons)			**30 TR**

TABLE IV: GREENHOUSES SUMMARY OF COOLING LOADS

Load Description	Sensible Heat Loads (Btu/Hr)	Latent Heat Loads (Btu/Hr)	Total Cooling Loads (Btu/hr)
Conduction through Roofs	37,417.42	-	37,417
Solar Radiation through Glass	12,716.25	-	12,716
Conduction through Partitions	-	-	-
Heat Gain for Lights	5907.08	-	5907.08
Heat Gain for Infiltration	2508.91	6304.51	8813.42
Total Space Cooling Loads			64,853
Ventilation	44,921.95	112,866.35	157,787
Total Coil Cooling Loads			222,640
Safety Factor and Miscellaneous (5%)			11132
Grand Total Coil Cooling Loads (BTU/hr)			**233,772**
Grand Total Coil Cooling Loads (Tons)			**19.5TR**

B. Construction

Air conditioning system varies considerably from their energy from many different parameters. Air conditioners almost mandatory in new construction, having changed a lot in the past few years as energy cost rise and power sources change and improve. Creating encasement parts from galvanized sheet metal and structural steels for ducting are the first considered in the designing of our research. This sheet metal is sheared on a sheared press on a fabrication cell soon after arriving from storage or inventory; structural steel shapes are cut and metered on a band saw to from useful brackets and supports. Quality of the individual components is always checked at various stages of the manufacturing process. Outsourced parts must pass an incoming dimensional inspection from a quality assurance representative before being approved for use in the final product. The unit will undergo a performance test when assembly is complete to assure each unit operates efficiently. Same as air conditioning, elevator must be considered by what capacity that can load up and how long the travel time of the elevator in the building. Once we gathered all the data in considering elevator, we started collecting some catalogue and compare the dimensions, capacities, and apply the considerations we gather.

C. Installation

For successful installation of HVAC, the most important is getting the system size right. An oversized unit not only costs more to purchase, but will cool room so quickly that it will cycle off before household air has had time to return to the equipment for re-conditioning. HVAC systems are sized according to the amount of heating and cooling that they generate. A reputable HVAC technician will conduct a load calculation that considers factors like your home's construction, size, design layout and orientation in order to establish the correct system size. Designing the supply and return air duct in the system is vital because the design and install ductwork properly if you want to minimize your energy consumption and losses. Balanced air distribution provides optimal conditions for HVAC function, and prevents energy and air quality issues. Ducts undergo substantial stress over time, due mostly to expansion and contraction from temperature changes. Ensure seal duct connections with collars, mastic and mesh. Anything less likely will cost you more, because you will probably have to pay for ductwork repairs and you will waste energy. We designed ductwork to extend as straight as possible, utilizing sloping turns when necessary to optimize airflow.

D. The external load and internal load

Normally when we consider the capacity of Air-conditioning to be use in a building. We only determine it by the sizes of the rooms. However, for our design to calculate the tons of refrigeration or capacity of each Air-conditioning units to be use to the rooms of research facility and administration building. We consider the external and internal load. The total building cooling load consists of heat transferred through the building envelope (walls, roof, floor, windows, doors etc.) and heat generated by occupants, equipment, and lights. The load due to heat transfer through the envelope is called as external load, while all other loads are called as internal loads. The percentage of external versus internal load varies with building type, site climate, and building design. The total cooling load on any building consists of both sensible as well as latent load components. In externally loaded buildings, the cooling load on the building is mainly due to heat transfer between the surroundings and the internal conditioned space. Since the surrounding conditions are highly variable in any given day, the cooling load of an externally loaded building varies widely. In internally loaded buildings, the cooling load is mainly due to internal heat generating sources such as occupants, lights or appliances.

V. CONCLUSION

Provided the design of HVAC (heat, ventilation and air conditioning) and elevator, were able to distinguish the air conditioning and elevator system will use to the research facilities for two-story and administration building in Freedom Island located at Parañaque, Metro Manila. This design conclude the air conditioning system should control temperature and humidity and elevator system makes more convenient to people to go second floor effortless, can used for people with disabilities and some equipment transfer for first to second floor. A better understanding and knowledge of simple yet effective basic manual calculation still gives you the edge on how the data and formula are being used for a certain application. The use of design software can be advantageously in terms of time but you cannot take into account of every details of the calculation. A designer should be proficient, conversant of all data, formulas and standards used in designing a HVAC system.

ACKNOWLEDGMENT

This undergraduate thesis would not have been possible without the support of many people. The researchers wish to express their gratitude to their research teacher and thesis advisor Engr. Jewel Rhyanne Nycole B. Riosa who was always open whenever we had trouble or had a question our research or writing. We would also like to thank the other members of the panel, Engr. Arnel Avelino, Engr. Annalyn Romero and Dr. Francisco Javier, without their knowledge and assistance this study would not have been successful. The researchers would also like to convey thanks to Joel C. Lampaya, P.M.E for providing the validation, instructions and guidance throughout our design. Special thanks also to all their graduate friends, especially ME.501 for sharing their knowledge, ideas and helpful support. The researchers wish to express their love and gratitude to their beloved family for their understanding and endless love, through the duration of their studies. Above all, the researchers would like to give their sincerest and warmest appreciation, to the Lord, and Savior, ALMIGHTY GOD, who is the source of their strength, knowledge and skills, who always hears their prayers, guides their path, and never leaves their side throughout their journey in life.

REFERENCES

[1] Table 3.3 ASHRAE GRP 158 2nd Edition, Climatic Conditions for Other Countries, Saudi Aramco Engineering Standard- Meteorological and Seismic Design Data, October 2006 – January 2011

[2] Table 3.8 Cooling Load Temperature Difference for Calculating Cooling Load from Flat Roof ASHRAE GRP 158

[3] Table 3.12 CLTD Correction for Latitude and Month Applied to Walls and Roofs, North Latitudes ASHRAE GRP 158

[4] Table 3.10 Cooling Load Temperature Difference for Calculating Cooling Load from Sunlit Walls, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[5] Table 3.23 Cooling Load Temperature Difference of Conduction Through Glass and Conduction Through Doors, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[6] Table 3.18 Shading Coefficient for Glass Without or with Interior Shading by Venation Blind or Roller Shades, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[7] Table 3.25 Maximum Solar Heat Gain Factor for Sunlit Glass, North Latitude, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[8] Table 3.27 Cooling Load Factor for Glass without Interior Shading, North Latitudes, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[9] Table 5.2 Rates of Heat Gain from Occupants of Conditioned Spaces, Cooling and Heating Load Calculation Manual ASHRAE GRP 158

[10] Table 10.2 Outdoor Air Requirements of Ventilation, Cooling and Heating Load Calculation Manual ASHRAE GRP 158.

[11] Table 5.1 Typical Diversity Factors for Large Buildings, Cooling and Heating Load Calculation Manual ASHRAE GRP 158

[12] Table 29 Procedure for calculating Space Design Cooling Load by CLTD/SCL/CLF Method ASHRAE Fundamentals 1997 or 1989

[13] Table 6 Circular Equivalent Diameter, equivalent Area and Duct Class of Rectangular Ducts for Equal Friction, System Design Manual, Carrier Air Conditioning Company.

[14] Table 7, Recommended Duct Velocities for Low Velocity Systems, System Design Manual, Carrier Air Conditioning Company.

[15] Chart 7, Friction Loss for Round Duct, System Design Manual, Carrier Air Conditioning Company.

[16] Table 1 & 2, K Factors for Threaded and Flanged Welded Pipe Fittings, 2001 ASHRAE Fundamentals Handbook

[17] Figure 1-page Chapter 35.6 Friction Loss for Water in Commercial Steel Pipe (Schedule 40) 2001 ASHRAE Fundamentals Handbook

[18] ASHRAE 2001 HVAC Fundamentals Handbook, Pipe Sizing Chapter 35 page 35.1 to 35.6

[19] Carrier Air Conditioning System Design Manual Chapter 2, Water Piping, Part 3 Piping Design

[20] ASHRAE 2001 HVAC Fundamentals Handbook, Duct Design Chapter 34 page 34.8.

[21] ASHRAE 2001 HVAC Fundamentals Handbook, Duct Design, Fitting Loss Coefficient of different kind of Duct Fittings Chapter 34 page 34.29 to 34.68