VALUE OF MECHANICAL DESIGN IN BUILDINGS
PROPER INFORMATION INPUTS
SYSTEM CREATION
3-D MODELING

by

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ABSTRACT

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Mechanical design of a building is a crucial discipline that focuses on the comfortability of the occupants of the building. Functionality of proper systems within the building is essential in building success and proper design.

Specifically, knowing the factors that affect HVAC design is crucial in designing properly. In addition to this knowledge, one should gain expertise in a program that can generate loads based on a mechanical standpoint.

After loads are generated, the information provided is used to select specific equipment that can satisfy the design required. This is where manufacturers are researched, and data is compared to view the most viable option.

Throughout this process, an Architectural Engineer must know that intense coordination with himself and other disciplines is required for proper design and reduced necessity of mitigation of issues once construction has commenced.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Senior Project is a coordinated project that allows students to extensively reach out into the different disciplines relating to Architectural Engineering. A student graduating with this degree must demonstrate an intense understanding of Accreditation Board for Engineering and Technology (ABET) and must be able to work with peers in putting together a detailed analysis and make crucial decisions on a potential building. Specifically, my group was provided with an Elementary school by Alpha Structural Engineers. The team named it Mansfield Elementary School in accordance with the site location.

The team had to develop architectural, structural, mechanical, electrical, and plumbing components for the building. My role was to contribute to all these fields, but more specifically I had a major influence on the mechanical aspect of the building.

Mechanical design of buildings requires intense concentration with the overlapping disciplines at hand. architectural, structural, electrical, and plumbing features all must be accounted for when making decisions on the mechanical end. One of the first factors that influences design for mechanical features is the architectural design. The orientation, exterior compositions, and general site locations were used throughout the design of this discipline.

The team worked closely with the architectural aspects of the building in order to understand how to implement these factors into the mechanical design. Once the architectural features were finished, the team could begin to work more actively on the mechanical design. One of the first steps made in mechanical and architectural design was to create the spaces of the building and name them in a manner that would help reflect on their positions. All rooms were named according to their functions: classrooms, storages, cafeteria, office, restroom, etc. In addition to naming all these rooms, we also added unique numbers for each room. This would help the people in the building navigate the building better, as well as help the team pinpoint which room a load is reflecting. An example of this practice was that all first-floor rooms were labeled starting with the number one and all second-floor rooms with the number two. This would aid in identifying each room and making sure each room is accounted.

Another architectural aspect that the team made sure to have done is the selection of the envelope. The envelope is essentially the composition of systems that encompasses a building. When designing for HVAC in a building, knowing the composition of the envelope of the building is crucial for running a load. Specifically, the U-values of the envelopes help assess the requirement of CFM and heating and cooling required in each space. We also had to know the dimensions of the fenestrations and the amount of exposure that these features had in accordance with a specific room. In addition, we had to know the square footage and height of each space.

1.1.1 Preliminary Planning

Before inputting values into my load software and designing for mechanical systems, the team had to decide on the type of systems that would be reasonable to use for the building. Alpha Engineering provided us with a larger K-5 elementary school, which we reduced heavily for the project. From the team's experience designing for mechanical systems, it was decided that DX-packaged rooftop units were the best route to take. Hydronic systems were also an alternative, but the high cost of hydronic systems for a smaller elementary school was not beneficial. By using rooftop units, there would also be more space available in the interior of the building, since none of the units would be needed in the interior. The ceiling tile of the building is all square tile, excluding the storm shelter, which is exposed ceiling. For the air devices for the storm shelter, round types of air diffusers and returns were chosen to be designed. In all other spaces of the building, square ceiling tiles would be used. The team analyzed the spaces of the building and also decided to make the larger spaces have a constant airflow volume and smaller spaces to have variable airflow volume types of systems. Variable airflow volume systems would be implemented in the classroom areas, office areas, and any other area where the inhabitant could directly change the temperature of a specific space. Constant airflow volume benefits larger spaces that are open, which means, it majorly benefits cafeteria, gym, or kitchen areas, where multiple thermostats are not necessarily required or desired. I learned and analyzed the different types of HVAC systems and consulted with professionals to reach the most reasonable conclusions. According to code, the team also planned to run exhaust loads for all areas where exhaust is needed. The exhaust spaces would be combined through ductwork and out of the rooftop unit. The rooftop unit would be a downdraft exhaust fan. This would be done multiple times until all exhaust is accounted for and multiple routes were made reasonably.

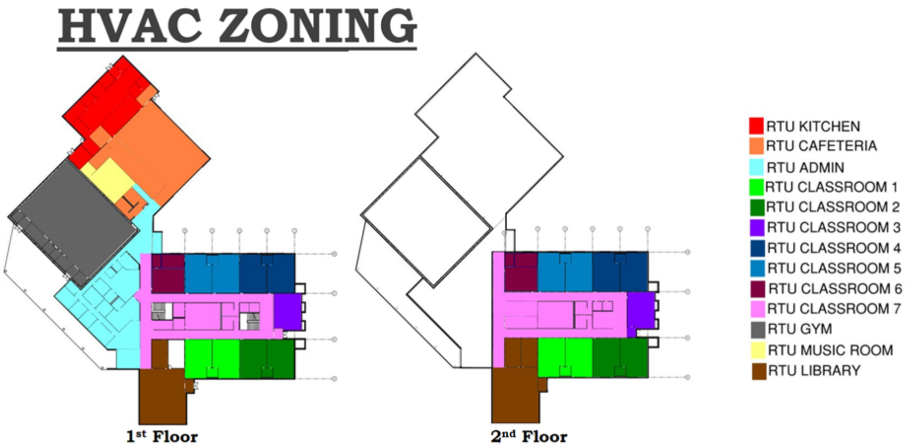


Figure 1.1: HVAC Zoning

The initial planning done prior to load calculation and construction design of documents was crucial in the organization of the project. By making sure that other disciplines were advanced in the design process and by identifying necessary steps for mechanical design, I could continue to look intensively in how to properly design mechanical systems.

1.1.2 Scope of Work

This honors project focused heavily on building design and analysis. Mechanical design was a key fundamental discipline incorporated in my honors section of the project. As a key component, the mechanical design of the project had to function well with all other disciplines that architectural engineer's study. Coordination with other disciplines was one of the main instigators for proper design and function. In addition, methodical and calculated decisions had to be made, through the aid of code handbooks and programs that are relevant to the honors work pertained. Proper equipment sizing was also necessary, while always keeping in mind the client's goals and the project's budgeting. Different manufacturers were contacted and analyzed to concur with the most viable option.

CHAPTER 2

PROGRAM INPUTS AND GUIDELINES

2.1 Loads

To start the load calculations for HVAC in each space, the information of each space would be input into an Hourly Analysis Program (HAP). This software is a load estimation program for mechanical design that uses ASHRAE 90.1 for guidelines in design.

The first step taken in this program was to generate the envelope system in terms of U-value. The U-value is a thermal conductance coefficient for the envelope of a building. It is a key indicator of the amount of heat that can be transferred from outside a building to the inside. In the architectural analysis of the project, I developed wall systems that would be up to code, specifically Table C402.1.4 of the IECC code handbook. The designed U-values for the building would be used as a guideline for information in the Hourly Analysis Program or (HAP). Some of these architectural components consist of the walls, roofs, fenestrations, and doors. The orientation and location of the building was also an important factor to input into the HAP.

Once the architectural values were input into HAP, each space of the building could be inserted into the program. Since I classified each room with a specific label at this point of the project, I could easily identify each room and their placement within the building. When inputting each space of the building into HAP, there would be specific information needed to be input regarding the room. This consisted of type of room, exposure in area of the outside, level of the space, infiltration values, window ratios, amount of people expected to be in the room, activities of people in the room, estimated lighting load on the room, and other factors that would affect the loads. Since this program is guided by ASHRAE 90.1, values of load per person and other functions of the specific space are automatically accounted for load generation.

One of the components that was calculated was the total occupant capacity for each space. I used Table 6.2.2.1 to calculate the total occupancy; In terms of mechanical design for each space. The table provides different load factors for varying spaces, which were utilized to attain the total occupant capacity. The occupant densities of different spaces were multiplied by the square footage of the specific space to attain an estimated amount of people present in the space. The number calculated was rounded up to the nearest whole number for design. These numbers were input into the program since they affect HVAC loads considering people emit heat.

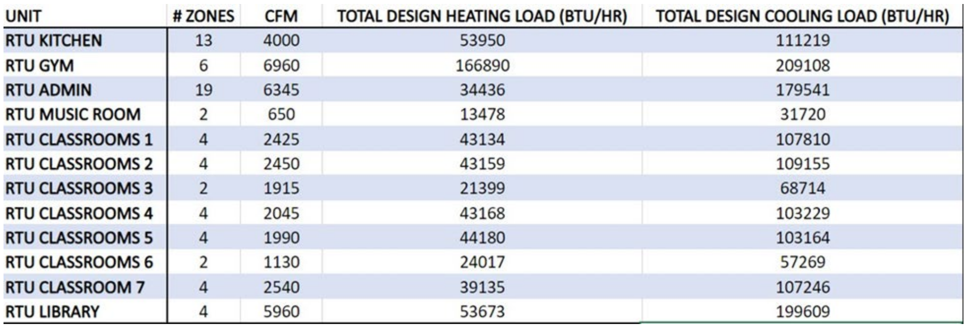
Another important factor input into HAP was exposure to the outside. The ceiling of most areas in the building was either eight feet or nine feet tall. This is important to consider; Because it allows for proper area calculation exposed for outdoors for the space that will be conditioned. After inputting these areas, windows could be added to account for the heating loads going through the window. These windows were added in quantity and in dimension analysis, which were all input into the program. Another important component to consider is whether a space is slab on grade or above conditioned space. A slab on grade space has higher heating loads due to the ground heat transfer to the inside of the building. Similarly, a space had to be identified on whether it had a roof or a second story. Typically, spaces that had a roof are also exposed to a larger heating load since there is less mediation between the outside and inside.

Once all the spaces were implemented, systems could be created. Since a preliminary design was made, the systems on this design, DX package units in the form of CAV and VAV, were created. In the systems category, different dry bulb/wet bulb temperatures were adjusted to fit the site conditions, as well as specific features desired for the unit. For this aspect of the project, I consulted with professional mechanical designers and worked on psychrometric charts to identify input values for temperature into HAP. Notably, zones were implemented on the different systems to account for all building spaces. Each zone labeled on the HAP software refers to the space inputs made prior. Some systems account for more zones than others. This depended on the preliminary analysis done prior. This preliminary analysis included the best routes for ductwork, which heavily impacted the number of systems and the specific zones they supply.

2.1.1 Running Data

Once all these factors were adjusted and added, a load could be run for each system, which generated heating loads, cooling loads, CFM values, and more information that aided in design for duct layout and mechanical equipment selection. Once the load was run through the software, it would provide a detailed description for each unit and each space, breaking down any sensible or latent load summaries made through the program. In the industry it is important to consider. When designing HVAC, a designer must have justification for the decisions made. Typically, a designer may have a very accurate idea on how to design mechanical systems, but the data generated by a program like HAP reinforces the decisions created. In the long run, if there is an issue with the mechanical systems in a building, a designer can justify their decisions based on the form of calculation taken. Many times, using programs; Like HAP, can sway any liability concerns that are brought up later in the construction process. Moreover, the manufacturer vendors also have more information based on the HAP data generation.

Table 2.1: RTU Load Summary



UNIT	# ZONES	CFM	TOTAL DESIGN HEATING LOAD (BTU/HR)	TOTAL DESIGN COOLING LOAD (BTU/HR)
RTU KITCHEN	13	4000	53950	111219
RTU GYM	6	6960	166890	209108
RTU ADMIN	19	6345	34436	179541
RTU MUSIC ROOM	2	650	13478	31720
RTU CLASSROOMS 1	4	2425	43134	107810
RTU CLASSROOMS 2	4	2450	43159	109155
RTU CLASSROOMS 3	2	1915	21399	68714
RTU CLASSROOMS 4	4	2045	43168	103229
RTU CLASSROOMS 5	4	1990	44180	103164
RTU CLASSROOMS 6	2	1130	24017	57269
RTU CLASSROOM 7	4	2540	39135	107246
RTU LIBRARY	4	5960	53673	199609

Table 2.1 indicates a summary of heating and cooling loads for each rooftop unit input into the HAP program. These loads become crucial in the design process, because it becomes a baseline for choosing the model and manufacturing company for mechanical equipment.

2.1.2 Exhaust Generation

There is one specific portion of load analyzation that was not input into the HAP program, referred to as the exhaust of a building. Table 6.5 of ASHRAE was used to calculate the exhaust required for different rooms in the building. Typical rooms that needed exhaust were restrooms, art classrooms, clinic rooms, kitchens, locker rooms, specific storage designations, and other categories listed in this table. The reason that these rooms need exhaust is to create negative pressure in the space. Many times, these rooms exert strong odors. The way to create a negatively pressured space is by removing more air than your supply. For instance, if a room is being exhausted 75 cubic feet per minute or CFM, then less than 75 CFM should be supplied. A value of 40 CFM could be a decent value to go with for the supply. By doing this, the air within the exhaust space will want to stay inside and not travel into other areas of the building where it brings unpleasantness to the inhabitants. This table indicates the unit value of exhaust required per square footage of area. To calculate total CFM required to extract from a specific space, the square footage of the space was multiplied by the designated rate of the table. This was done for all the spaces.

Once the CFM of each space designated for exhaust was known, the ductwork could be designed, as well as the air device for the exhaust. The team had to develop a method of linking these spaces together and up on the rooftop to connect to an exhaust fan. The team had to work closely with the other disciplines to make sure that the exhaust ductwork coincided with the architectural, structural, electrical, and plumbing disciplines.

CHAPTER 3

MECHANICAL DESIGN

3.1 Duct Layout

In mechanical design, ductwork is one of the main features of a building mechanical plan. It consists of different sized ductwork that is interconnected for the end goal of supplying, returning, or exhausting air. There are certain criteria taken into duct sizing. One must account for the proper flow of air and reduce noise pollution within the building.

Mansfield Elementary School was designed for three different types of ductworks: exhaust, return, and supply. Exhaust ductwork links back to the exhaust fans on the rooftop. Return and supply will link back to the rooftop DX unit.

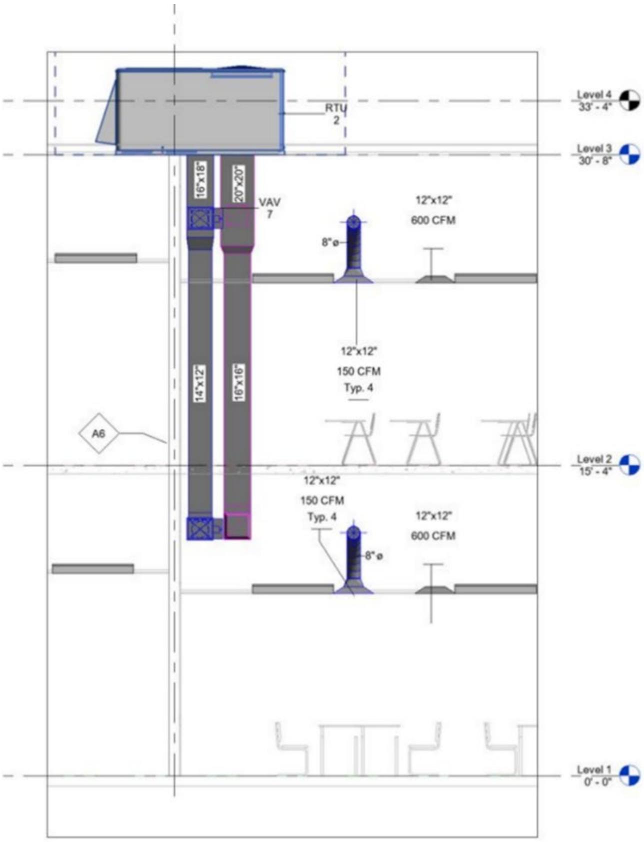


Figure 3.1: Supply and Return Riser Diagram

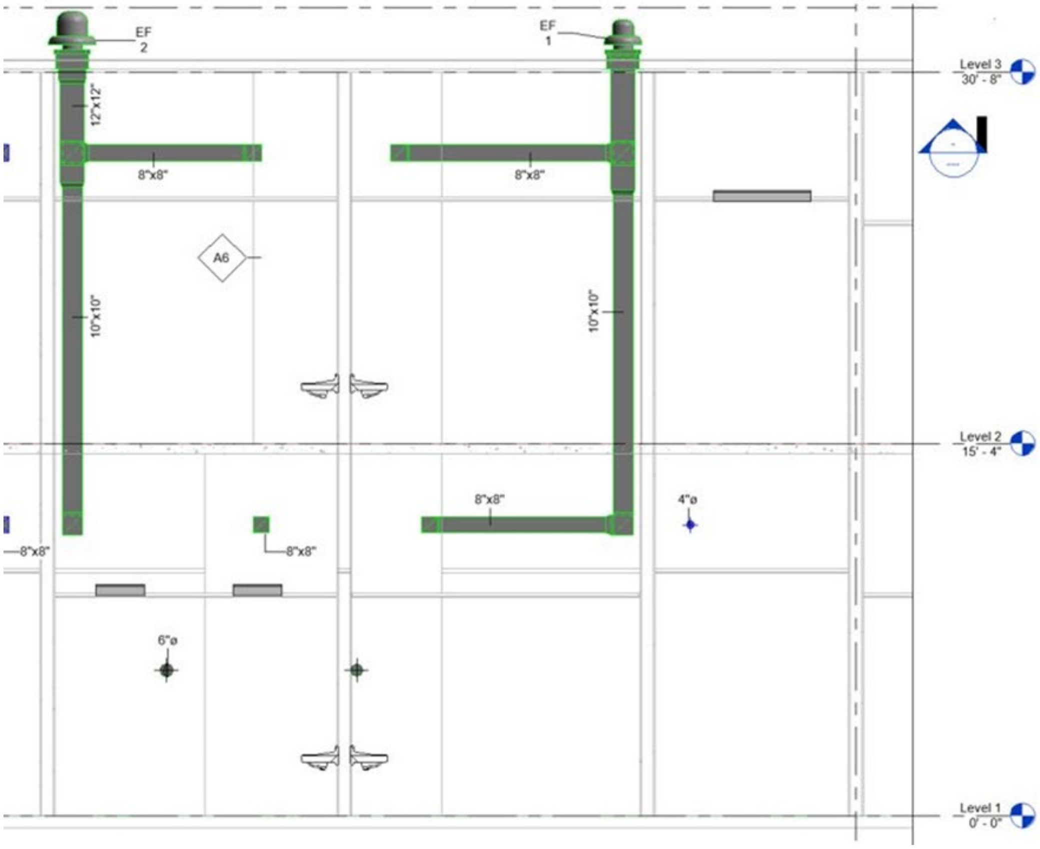
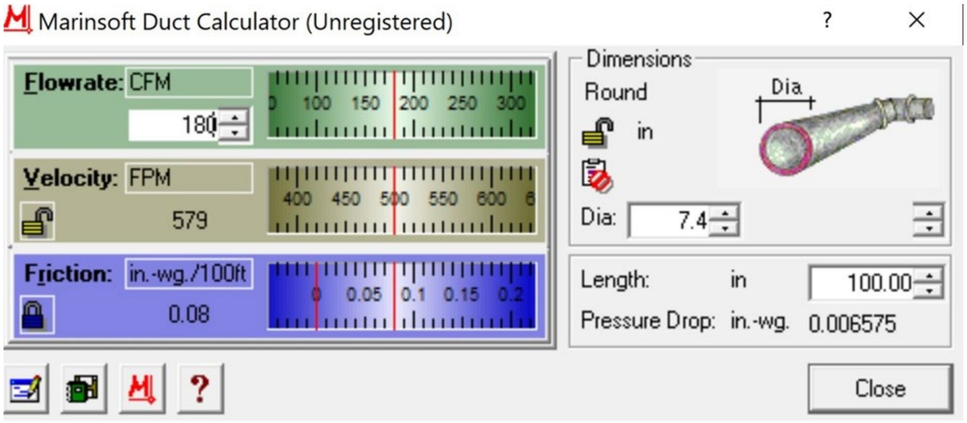


Figure 3.2: Exhaust Riser Diagram

The design of ductwork is based majorly on the CFM being transferred, velocity of air, and static pressure. To design ductwork, three different static pressures were used 0.06 in-w.g./100ft, 0.08 in-w.g./100ft., and 0.15 in-w.g./100ft. In our case, we took advantage that the space between the ceiling and floor is the plenum space. The team was able to implement this factor of design since all the materials in the building were 1 hour rated or more. However, return was also used in certain areas in the building and was sized at 0.06 in-w.g./100ft. 0.08 in-w.g./100ft was used for exhaust ductwork and low-pressure supply. Low pressure supply ductwork indicates all ductwork being linked from the VAV box to the air device diffuser. Typically, the static pressure minimum for this type of supply is smaller so that noise levels are reduced. Medium pressure ductwork was sized at 0.15 in-w.g./100ft. Medium pressure supply ductwork indicated all ductwork linking from the rooftop unit to the VAV box.

When designing ductwork, an online duct calculator was used. In this calculator, one must input the CFM design and lock the desired static pressure. As this was done, the velocity also had to fall below 2000 FPM. This would allow for less noise. The ductwork also had to have a ratio in dimension that was less than 4:1. This is because if a larger ratio is created, the velocity of the air being supplied could cause the duct to shake and cause a dramatic increase in noise. This would impose a problem for the occupants of the building since it could hinder concentration for the students. This shows that even mechanical design can significantly alter the comfortability conditions of the people inside the building.



Marinsoft Duct Calculator (Unregistered)

Flowrate: CFM 180

Velocity: FPM 579

Friction: in.-wg./100ft 0.08

Dimensions

Round

in

Dia: 7.4

Length: in 100.00

Pressure Drop: in.-wg. 0.006575

Figure 3.3: Duct Calculator Tool

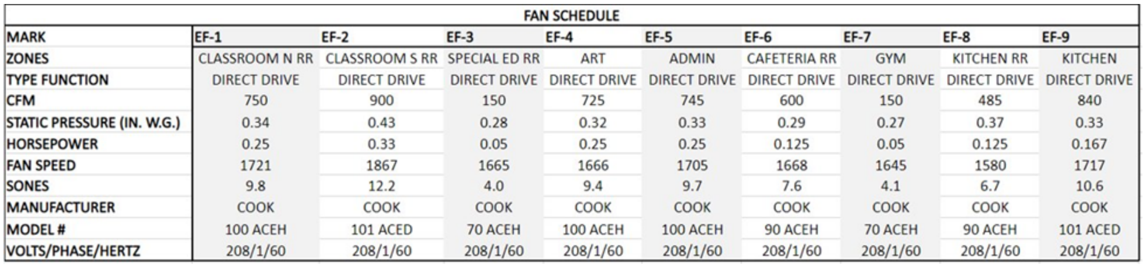
Figure 3.3 illustrates the design criteria utilized in designing ductwork.

3.2 Equipment Selection

The first equipment that was designed was exhaust fans. In this case, the manufacturer COOK was chosen for the selection of exhaust. The team navigated through the company website to design this equipment. The website had inputs like elevation, CFM supply, and static pressure to select fans. Static pressure was calculated through a formula that inputs the longest length of ductwork, number of transitions, elbows, and number of dampers used in the specific run. The length of the ductwork is divided by 100 and multiplied by 0.08 to attain the static pressure value for length of ductwork. Each elbow and transition account for a direct 0.01 in-w.g./100ft increase. Each damper adds 0.1 in-w.g./100ft. In addition, a factor of 1.15 is added to the total calculated static pressure drop to account for miscellaneous factors.

Once these variables and others were input into the website, recommended selections were made. The team decided to choose a downdraft energy-efficient fan to coincide with a highly efficient building. Although more expensive initially, these fans are better in the long run. They exhibit a relatively lower maintenance cost per year. The manufacturing website generates a series of different data that indicates the most beneficial model. I personally analyzed the graphs and data to determine which models were the best in terms of efficiency, cost, and longevity.

Table 3.1: Exhaust Fan Equipment Selection Schedule

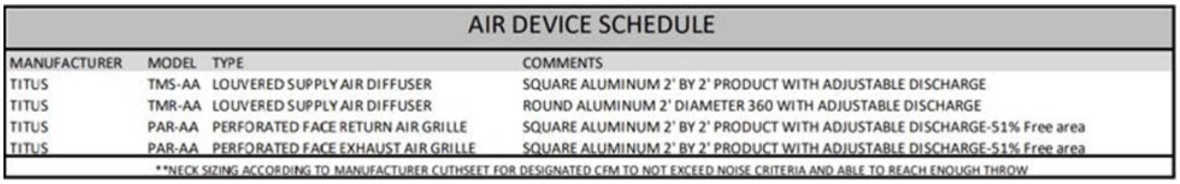


FAN SCHEDULE									
MARK	**EF-1**	**EF-2**	**EF-3**	**EF-4**	**EF-5**	**EF-6**	**EF-7**	**EF-8**	**EF-9**
ZONES	CLASSROOM N RR	CLASSROOM S RR	SPECIAL ED RR	ART	ADMIN	CAFETERIA RR	GYM	KITCHEN RR	KITCHEN
TYPE FUNCTION	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE
CFM	750	900	150	725	745	600	150	485	840
STATIC PRESSURE (IN. W.G.)	0.34	0.43	0.28	0.32	0.33	0.29	0.27	0.37	0.33
HORSEPOWER	0.25	0.33	0.05	0.25	0.25	0.125	0.05	0.125	0.167
FAN SPEED	1721	1867	1665	1666	1705	1668	1645	1580	1717
SONES	9.8	12.2	4.0	9.4	9.7	7.6	4.1	6.7	10.6
MANUFACTURER	COOK	COOK	COOK	COOK	COOK	COOK	COOK	COOK	COOK
MODEL #	100 ACEH	101 ACED	70 ACEH	100 ACEH	100 ACEH	90 ACEH	70 ACEH	90 ACEH	101 ACED
VOLTS/PHASE/HERTZ	208/1/60	208/1/60	208/1/60	208/1/60	208/1/60	208/1/60	208/1/60	208/1/60	208/1/60

Table 3.1 summarized the data necessary for vendor manufacturers to help in selecting the best equipment and for contractors to attain details needed for installation. This data consists of static pressure loss, CFM value, and information regarding the specific model that is recommended.

The next equipment selection that was made was air devices. Air devices are diffusers or grills that aid in the distribution or movement of air. For return grills and exhaust grills, perforated grills were used. For supply grills, round grills were used for the gym for aesthetic purposes. Moreover, square grills were used in all other areas in order to coincide with the 12 in by 12 in ceiling tiles. Each grill had a different neck size that depended on the CFM value that the pathway is to distribute or intake. This neck size is designed based on the cutsheet of the manufacturer. Since the grills are 12 in by 12 in, the neck size could go up to 12, which has a large maximum CFM value capacity. All the CFM values for the air devices in the project were below this maximum CFM value indicated by the manufacturing cut sheets, so we could confidently trust the manufacturer compatibility with the project. Another main determinant of air device design is the noise factor that the air device will exhibit. Since the team is dealing with a school, noise levels should be maintained relatively low. This is to make sure it does not become a distraction once the building can be habitable.

Table 3.2: Air Device Equipment Schedule



AIR DEVICE SCHEDULE

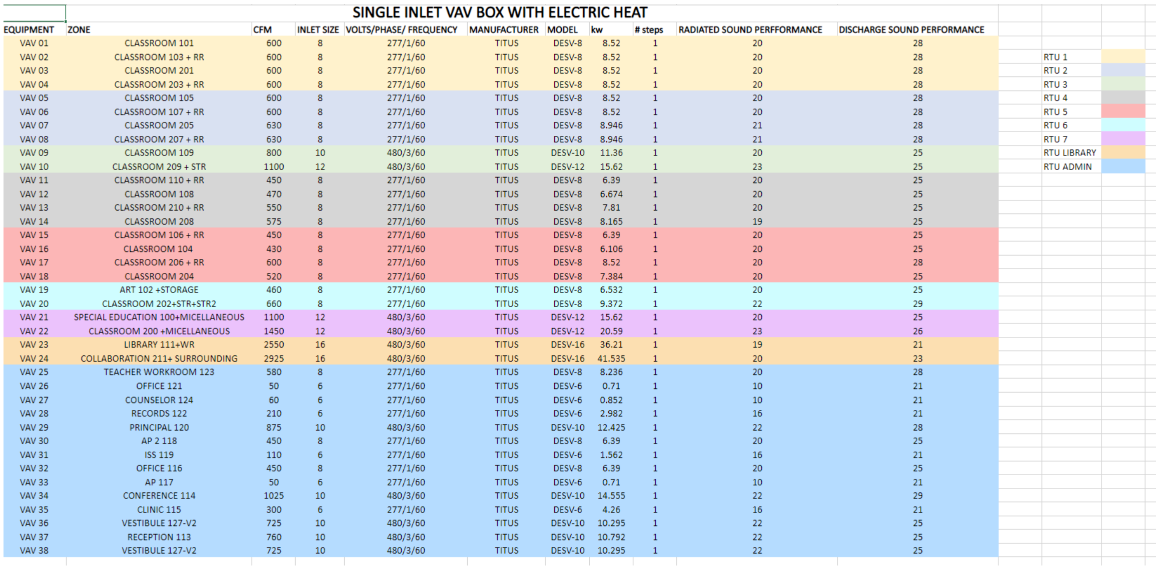
MANUFACTURER	MODEL	TYPE	COMMENTS
TITUS	TMS-AA	LOUVERED SUPPLY AIR DIFFUSER	SQUARE ALUMINUM 2' BY 2' PRODUCT WITH ADJUSTABLE DISCHARGE
TITUS	TMR-AA	LOUVERED SUPPLY AIR DIFFUSER	ROUND ALUMINUM 2' DIAMETER 360 WITH ADJUSTABLE DISCHARGE
TITUS	PAR-AA	PERFORATED FACE RETURN AIR GRILLE	SQUARE ALUMINUM 2' BY 2' PRODUCT WITH ADJUSTABLE DISCHARGE-51% Free area
TITUS	PAR-AA	PERFORATED FACE EXHAUST AIR GRILLE	SQUARE ALUMINUM 2' BY 2' PRODUCT WITH ADJUSTABLE DISCHARGE-51% Free area

**NECK SIZING ACCORDING TO MANUFACTURER CUTHSEET FOR DESIGNATED CFM TO NOT EXCEED NOISE CRITERIA AND ABLE TO REACH ENOUGH THROW

Table 3.2 summarizes the selected model and manufacturer for the air devices selected.

VAV boxes were also utilized for the VAV type of rooftop units. The VAV box is essentially a duct with a damper that turns on and off based on what the thermostat reads. If the thermostat indicates more HVAC needed, then the VAV box will activate, the damper will turn on, and air in that specific zone can be distributed. This allows for temperature control for different spaces in the building. Primarily, the team had to make sure the VAV box could fit the plenum space of the building. Since our ceiling-to-floor and ceiling-to-roof measure was close to six feet, and the VAV boxes typically do not exceed three feet for the small zones being designed for, then we qualified this constraint. The team also sized this equipment based on given CFM and on noise content created. A noise content of under 25 was always desired, and the VAV box had to always satisfy above the CFM requirements.

Table 3.3: VAV Box Equipment Schedule



SINGLE INLET VAV BOX WITH ELECTRIC HEAT

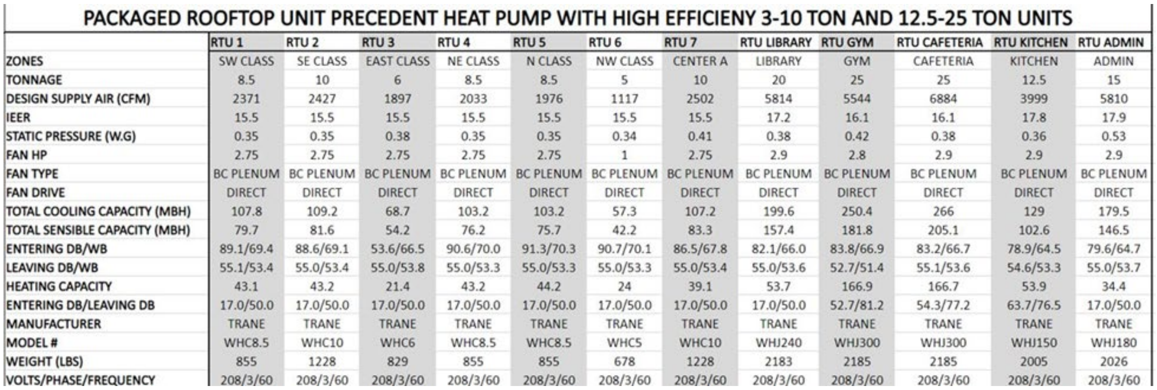
EQUIPMENT	ZONE	CFM	INLET SIZE	VOLTS/PHASE/ FREQUENCY	MANUFACTURER	MODEL	kw	# steps	RADIATED SOUND PERFFORMANCE	DISCHARGE SOUND PERFORMANCE
VAV 01	CLASSROOM 101	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 02	CLASSROOM 103 + RR	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 03	CLASSROOM 201	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 04	CLASSROOM 203 + RR	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 05	CLASSROOM 105	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 06	CLASSROOM 107 + RR	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 07	CLASSROOM 205	630	8	277/1/60	TITUS	DESV-8	8.946	1	21	28
VAV 08	CLASSROOM 207 + RR	630	8	277/1/60	TITUS	DESV-8	8.946	1	21	28
VAV 09	CLASSROOM 109	800	10	480/3/60	TITUS	DESV-10	11.36	1	20	25
VAV 10	CLASSROOM 209 + STR	1100	12	480/3/60	TITUS	DESV-12	15.62	1	23	25
VAV 11	CLASSROOM 110 + RR	450	8	277/1/60	TITUS	DESV-8	6.39	1	20	25
VAV 12	CLASSROOM 108	470	8	277/1/60	TITUS	DESV-8	6.674	1	20	25
VAV 13	CLASSROOM 210 + RR	550	8	277/1/60	TITUS	DESV-8	7.81	1	20	25
VAV 14	CLASSROOM 208	575	8	277/1/60	TITUS	DESV-8	8.165	1	19	25
VAV 15	CLASSROOM 106 + RR	450	8	277/1/60	TITUS	DESV-8	6.39	1	20	25
VAV 16	CLASSROOM 104	430	8	277/1/60	TITUS	DESV-8	6.106	1	20	25
VAV 17	CLASSROOM 206 + RR	600	8	277/1/60	TITUS	DESV-8	8.52	1	20	28
VAV 18	CLASSROOM 204	520	8	277/1/60	TITUS	DESV-8	7.384	1	20	25
VAV 19	ART 102 +STORAGE	460	8	277/1/60	TITUS	DESV-8	6.532	1	20	25
VAV 20	CLASSROOM 202+STR+STR2	660	8	277/1/60	TITUS	DESV-8	9.372	1	22	29
VAV 21	SPECIAL EDUCATION 100+MICELLANEOUS	1100	12	480/3/60	TITUS	DESV-12	15.62	1	20	25
VAV 22	CLASSROOM 200 +MICELLANEOUS	1450	12	480/3/60	TITUS	DESV-12	20.59	1	23	26
VAV 23	LIBRARY 111+WR	2550	16	480/3/60	TITUS	DESV-16	36.21	1	19	21
VAV 24	COLLABORATION 211+ SURROUNDING	2925	16	480/3/60	TITUS	DESV-16	41.535	1	20	23
VAV 25	TEACHER WORKROOM 123	580	8	277/1/60	TITUS	DESV-8	8.236	1	20	28
VAV 26	OFFICE 121	50	6	277/1/60	TITUS	DESV-6	0.71	1	10	21
VAV 27	COUNSELOR 124	60	6	277/1/60	TITUS	DESV-6	0.852	1	10	21
VAV 28	RECORDS 122	210	6	277/1/60	TITUS	DESV-6	2.982	1	16	21
VAV 29	PRINCIPAL 120	875	10	480/3/60	TITUS	DESV-10	12.425	1	22	28
VAV 30	AP 2 118	450	8	277/1/60	TITUS	DESV-8	6.39	1	20	25
VAV 31	ISS 119	110	6	277/1/60	TITUS	DESV-6	1.562	1	16	21
VAV 32	OFFICE 116	450	8	277/1/60	TITUS	DESV-8	6.39	1	20	25
VAV 33	AP 117	50	6	277/1/60	TITUS	DESV-6	0.71	1	10	21
VAV 34	CONFERENCE 114	1025	10	480/3/60	TITUS	DESV-10	14.555	1	22	29
VAV 35	CLINIC 115	300	6	277/1/60	TITUS	DESV-6	4.26	1	16	21
VAV 36	VESTIBULE 127-V2	725	10	480/3/60	TITUS	DESV-10	10.295	1	22	25
VAV 37	RECEPTION 113	760	10	480/3/60	TITUS	DESV-10	10.792	1	22	25
VAV 38	VESTIBULE 127-V2	725	10	480/3/60	TITUS	DESV-10	10.295	1	22	25

RTU 1	🟨
RTU 2	🟦
RTU 3	🟩
RTU 4	⬜
RTU 5	🟥
RTU 6	🟦
RTU 7	🟪
RTU LIBRARY	🟧
RTU ADMIN	🟦

Table 3.3 is a VAV box equipment schedule that summarizes information regarding the selected equipment. In this data, it includes the volts required, CFM capacity, noise capacity, and model number with neck size. This information aids in working with the electrical consultant to ensure adequate voltage is being supplied to the device. In addition, it also provides the contractor with information that will be helpful in the installation of the equipment.

The rooftop unit selection was based on the manufacturer Trane. We used load calculations via the software to determine heating load, cooling load, CFM design, and tonnage selection for the equipment. Each rooftop unit was chosen on this basis. Since all units are on the rooftops, the condensate created by these units is dispersed on the top of the roof, where then the drainage of the roof can account for getting rid of this waste. Once analyzing the manufacturing options of Trane, I concurred in choosing the Precedent Heat Pump with high efficiency for both VAV and CAV types of systems. CAV typically required larger units with the same details. The reason for this larger tonnage of the systems is due mainly to the type of space, square footage, and exposure of fenestrations. Although this model requires electric heat, the heat pump model saves significant energy in comparison with other models. In addition, no gas connection on the units would be required, which would reduce cost and time of construction.

Table 3.4: RTU Equipment Schedule



PACKAGED ROOFTOP UNIT PRECEDENT HEAT PUMP WITH HIGH EFFICIENY 3-10 TON AND 12.5-25 TON UNITS

	RTU 1	RTU 2	RTU 3	RTU 4	RTU 5	RTU 6	RTU 7	RTU LIBRARY	RTU GYM	RTU CAFETERIA	RTU KITCHEN	RTU ADMIN
ZONES	SW CLASS	SE CLASS	EAST CLASS	NE CLASS	N CLASS	NW CLASS	CENTER A	LIBRARY	GYM	CAFETERIA	KITCHEN	ADMIN
TONNAGE	8.5	10	6	8.5	8.5	5	10	20	25	25	12.5	15
DESIGN SUPPLY AIR (CFM)	2371	2427	1897	2033	1976	1117	2502	5814	5544	6884	3999	5810
IEER	15.5	15.5	15.5	15.5	15.5	15.5	15.5	17.2	16.1	16.1	17.8	17.9
STATIC PRESSURE (W.G)	0.35	0.35	0.38	0.35	0.35	0.34	0.41	0.38	0.42	0.38	0.36	0.53
FAN HP	2.75	2.75	2.75	2.75	2.75	1	2.75	2.9	2.8	2.9	2.9	2.9
FAN TYPE	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM	BC PLENUM
FAN DRIVE	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT	DIRECT
TOTAL COOLING CAPACITY (MBH)	107.8	109.2	68.7	103.2	103.2	57.3	107.2	199.6	250.4	266	129	179.5
TOTAL SENSIBLE CAPACITY (MBH)	79.7	81.6	54.2	76.2	75.7	42.2	83.3	157.4	181.8	205.1	102.6	146.5
ENTERING DB/WB	89.1/69.4	88.6/69.1	53.6/66.5	90.6/70.0	91.3/70.3	90.7/70.1	86.5/67.8	82.1/66.0	83.8/66.9	83.2/66.7	78.9/64.5	79.6/64.7
LEAVING DB/WB	55.1/53.4	55.0/53.4	55.0/53.8	55.0/53.3	55.0/53.3	55.0/53.3	55.0/53.4	55.0/53.6	52.7/51.4	55.1/53.6	54.6/53.3	55.0/53.7
HEATING CAPACITY	43.1	43.2	21.4	43.2	44.2	24	39.1	53.7	166.9	166.7	53.9	34.4
ENTERING DB/LEAVING DB	17.0/50.0	17.0/50.0	17.0/50.0	17.0/50.0	17.0/50.0	17.0/50.0	17.0/50.0	17.0/50.0	52.7/81.2	54.3/77.2	63.7/76.5	17.0/50.0
MANUFACTURER	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE	TRANE
MODEL #	WHC8.5	WHC10	WHC6	WHC8.5	WHC8.5	WHC5	WHC10	WHJ240	WHJ300	WHJ300	WHJ150	WHJ180
WEIGHT (LBS)	855	1228	829	855	855	678	1228	2183	2185	2185	2005	2026
VOLTS/PHASE/FREQUENCY	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60	208/3/60

Table 3.4 is the RTU schedule for the package units on the rooftop of the building. In the design process for this equipment, the heating loads, cooling loads, and CFM values of the load calculation had to be smaller than the total maximum capacity supplied by the selected equipment. Table 5 also summarizes basic electrical information that is helpful in both design and construction.

In addition to making a schedule for each one of these equipment and covering all spaces with proper mechanical systems, I also added these models to the BIM Revit file and positioned them according to the spot they would lay on the roof.

CHAPTER 4

CONCLUSION

The team needed to constantly assess the decisions made for mechanical design. We needed to communicate with each other to make sure the decisions reached coincided with other disciplines and made sense on a larger scale. For the capstone project, one of the main coordination necessities was routing ductwork according to the plan and space of the building. Since the building had a 2-story area, multiple chases had to be designed in spaces of the building to hide the riser of this ductwork. This was a direct coordination with the internal architecture of the building. The structural members also had to maintain their full integrity. All ductwork had to be routed in a way that it did not go through a beam, column, or girder. Moreover, the mechanical equipment selection guided the electrical consultant in determining electrical components of the building.

When selecting ductwork, load contributions heavily sway the load values generated. Manufacturing companies have equipment that fits the design of these loads. As a mechanical designer, an engineer needs to focus heavily on correctly identifying loads, input them into software, and select equipment that coincides with the data. While taking this into consideration, an engineer must also analyze the cost, longevity, and energy efficiency of the selected equipment.

Selecting equipment can become a simple process, but there are multiple methods of designing. As a professional, one should keep in mind the safety and ABET requirements. In the end, a mechanical designer can choose different methods of designing, but the end goal is to contribute to the overall welfare of society by creating systems within a building that promotes efficiency and a person’s comfortability.

APPENDIX A

ABET ACCREDITATION

ABET Requirements

OBJECTIVE: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

This project has been very resourceful. In this project, I learned to mix the disciplines of architecture, structural engineering, mechanical design, plumbing design, and electrical design into a singular project/building. These disciplines require an enormous amount of coordination, something that I believe my team and I did excellent in mimicking. We were all tasked to work alongside each other, making decisions together, and analyzing various alternatives throughout our design. My additional capstone contribution aided our communication and enhanced my teammates and me in making detailed decisions for mechanical design. The capstone contribution put me in a position of expertise on certain subjects that I feel I will be able to use significantly when starting my career. One of the main key takeaways that was utilized heavily in the project was problem solving. Many times, we did not know where to start or what decisions to make; however, we were able to successfully problem solve our way into making viable selections in our design. It is important for an engineer to be able to problem solve their way in the face of obstacles. In addition, I learned to work with peers and learn from their skillsets and abilities. I feel prepared to take on ABET objectives in the real world and become a contributor to the benefit of society.

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BIOGRAPHICAL INFORMATION

Johnathan Vasquez is an accomplished student at The University of Texas at Arlington. He earned an Honors Bachelor of Science in Architectural Engineering with a minor in Mathematics. He has become involved with ASCE, AEI, and SHPE at his university. These organizations have larger ties that he plans on continuing to become a part of. He has participated in student symposium and has competed with other schools in Timber strong, a competition dedicated to design and construction.

Post-graduation, Johnathan has a full-time commitment to DBR Engineering as a consultant. This company is dedicated to designing mechanical, electrical, and plumbing systems of building. Johnathan has an intense interest in these fields and plans to continue learning and dedicating his time to mastering the different disciplines. His capstone project has earned him the ability to problem solve that he will continue to use in his future employment and career.

Eventually, he plans on making his mark by creating his own design and construction business. Johnathan wants to provide employment opportunities to those willing to work and he plans to communicate with everyone he meets in the process. He is excited for these plans and ambitions.