Czech Technical University in Prague

FACULTY OF MECHANICAL ENGINEERING

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

DESIGN OF AIR-CONDITIONING SYSTEM FOR AN OFFICE BUILDING

DIPLOMA THESIS

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MASTER‘S THESIS ASSIGNMENT

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Design of an AC system for building, for different climate, thermal gains calculation, system design and calculations, including ventilation.

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Name and workplace of master's thesis supervisor:

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Assignment valid until: ____________

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III. Assignment receipt

The student acknowledges that the master's thesis is an individual work. The student must produce his thesis without the assistance of others, with the exception of provided consultations. Within the master's thesis, the author must state the names of consultants and include a list of references.

24.4.2019 — Date of assignment receipt

Yang Jun Hao — Student's signature

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ÚSTAV TECHNIKY PROSTŘEDÍ

January 4, 2021

REVISION OF DIPLOMA THESIS

Based on the decision of the commission for the State Final Examination of 26th August, 2020, the student is obliged to revise the diploma thesis according to the original assignment.
The student Mr. Jun Hao YANG (personal ID number 473273) was informed that the deadline for submitting the diploma thesis is January 8, 2021.

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I declare that this diploma thesis entitled "Design of air-conditioning system " is my own work performed under the supervision of Ing. Milos Lain, PhD, with the use of the literature presented at the end of my diploma thesis in the list of references

1.7.2021 YangJunHao

Abstract

The design was performed in order to design the air-conditioning system and ventilation system for assigned office building 6th floor. Calculating the heat gains, Sizing the AC units. Design air handing units and Calculation of air volume,velocity,duct dimension, pressure loss,Design technical drawing of air distribution.Briefly discuss the influence of building envelope and meteorological parameters on design,Discuss the energy saving of AC.

And in this design,To have a better analyses, an Comparative design is requested.Use the same building, Change the external conditions and envelop, explore whether the same AC design method is feasible, The three design are in Czech Republic(Prague city)and China(Beijing city).

Making an analyses and discussing about the differences, and what is the similarities even with differences.

ACKNOWLEGGEMENTS

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Content

Symbols

$Q_{totalgains}$	[W]	Total heat gains
Q_{ext}	[W]	external heat gains
Q_{int}	[W]	Internal heat gains
n	[-]	number of occupant
A_{wind}	[m²]	surface of window
I	[W/m²]	intensity of radiation
s	[-]	Shading coefficient
$Q_{extwindrad}$	[W]	External heat gains through window by radiation
U_{wind}	[W/m².K]	Heat transmittance coefficient of the window
To	[°C]	Outdoor temperature
T_i	[°C]	Indoor temperature
$Q_{extwindcond}$	[W]	External heat gain through the window by conductio
A_{wall}	[m²]	Surface of the wall
U_{wall}	[W/m².K]	Heat transmittance coefficient of the wall
$Q_{extwall}$	[W]	External heat gain through the wall
V_{people}	[m³/h]	Volume flow rate according to people
ρ	[kg/m³]	Density of air
V	[m³/h]	Volume flow rate according to people
C	[J/kg.K]	Specific heat capacity of air
△T	[K]	Difference temperature
△h	[kJ/kg]	Difference of enthalpy
A_{pipe}	[m²]	Surface of pipe
d	[m]	Diameter of pipe
$△P_{friction}$	[Pa]	Friction pressure losses
$△P_{local}$	[Pa]	Local pressure losses
λ	[-]	Dimensionless friction factor
$△P_{total}$	[Pa]	Total pressure losses
R	[Pa/m]	Specific pressure drop
L	[m]	Length of pipe
Z	[Pa]	Local pressure losses
$Q_{gain.light}$	[W]	Heat gain from light
w	[m/s]	Velocity of air

1.Chapter I:Introduction

Air conditioning. It refers to the equipment that regulates and controls the parameters such as temperature, humidity, cleanliness and flow rate of the ambient air in the building/structure by manual means.

Ventilation. Is a technique that uses natural or mechanical means to make the wind unobstructed and can pass through to the room or sealed environment to create a suitable air environment for hygiene and safety. Frequent ventilation can improve indoor air quality and be healthy.

In this design,the work will be to design an air conditioning system and ventilation system in two different places(different outdoor conditions)

1 · Design AC and Ventilation in Prague with Czech envelop

2 · Design AC and Ventilation in Beijing with Czech envelop

3 · Design AC and Ventilation in Beijing with Beijing envelop

To make the analyses easy and proper one, the study will use the same building shape,same architecture plans in the two designs.

The purpose of this study is to see how big is the difference of the design of air conditioning for offices between two totally different climates and two different envelop.

The design of the air conditioning of a building requires to follow some methods,procedures and steps of calculation, taking in account the climate data, indoor conditions, and building characteristics.

The building 6th floor

1.1The influence of building envelope structure on design

The envelope structure is divided into two parts: transparent and opaque: the opaque maintenance structure includes walls, roofs and floors; the transparent envelope structure includes windows, skylights and balcony doors.

The building envelope refers to the components that enclose the walls, doors, and windows around the building space to form the building space and resist the adverse effects of the environment. According to the position in the building, the envelope structure is divided into outer envelope structure and inner envelope structure. The outer protective structure includes outer walls, roofs, side windows, outer doors, etc., to resist wind and rain, temperature changes, solar radiation, etc., and should have heat preservation, heat insulation, sound insulation, waterproof, moisture proof, fire resistance, and durability. Internal enclosure structures such as partition walls, floor slabs, internal doors and windows, etc., play a role in separating the indoor space, and should have the performance of sound insulation, line of sight and some special requirements[1]. Envelope structure usually refers to the outer envelope structure such as exterior wall and roof.

1.1.1 Structure：

The materials of the outer protective structure include brick, stone,concrete, fiber cement board, steel plate, glass, and plastic etc. According to the structure, the outer protective structure can be divided into two types: single-layer and multi-layer composite. Single-layer structures such as brick walls of various thicknesses, concrete walls, metal profiled panels, asbestos cement panels, and glass panels. The multi-layer composite structure enclosure structure can be arranged in layers according to different requirements and combined material characteristics. Usually the outer layer is a protective layer, the middle is a heat preservation or heat insulation layer (if necessary, a vapor barrier layer can be provided), and the inner layer is an inner surface layer. Each layer uses a skeleton as a supporting structure or a reinforced inner protective layer as a supporting structure[2].

1.1.2 The enclosure structure should have the following functions:

-Thermal insulation：

The enclosure structure should have the ability to resist outdoor heat in summer. Under the action of solar radiant heat and outdoor high temperature, if the inner surface of the envelope structure can maintain a temperature that meets the needs of the building, it indicates good thermal insulation performance; otherwise, it indicates poor thermal insulation performance[3]. Measures to improve the thermal insulation performance of the enclosure structure include: installing a thermal insulation layer to increase thermal resistance; using materials with high solar radiation heat reflectivity on the outer surface.

In cold regions, thermal insulation is closely related to the quality of the house and energy consumption. The enclosure structure should have the ability to maintain indoor heat and reduce heat loss in winter. Its thermal insulation performance is measured by thermal resistance and thermal stability. Thermal insulation measures include: increasing wall thickness; using materials with good thermal insulation performance[3].

-Waterproof and moisture-proof:

Waterproof and moisture-proof There are different requirements on the waterproof and moisture-proof performance of components located in different parts. The roof should have reliable waterproof performance, that is, the water absorption of the roofing material should be small and the impermeability should be high. The exterior wall should have moisture-proof performance.

In order to prevent the wall from being damp, dense materials should be used as the exterior surface, the wall base moisture-proof layer and the gas-proof layer should be installed at the appropriate position[4].

-Other functions include sound insulation, fire resistance, durability, etc.

The enclosure structure's ability to insulate air and impact sound. Walls, doors and windows and other components are mainly to isolate air noise; floor slabs are mainly to isolate impact sound

The envelope structure must have the ability to resist fire, which is often measured by the combustion performance and fire resistance limit of the components. Components can be divided into combustible, hard-to-combust, and non-combustible according to their combustion performance.

The enclosure structure can still maintain the required quality of use performance under long-term use and normal maintenance conditions.Concrete or reinforced concrete enclosure structures have stronger resistance to adverse effects. In order to improve durability, wood enclosures should mainly be protected against dry and wet alternation and biological attack; for steel or aluminum alloy plates, surface protection and reasonable structural treatment should be used to prevent chemical corrosion.[4] The outer protective structure made of organic materials will age and deteriorate under the long-term effects of sunlight, wind, rain, cold and heat, oxygen, etc., and a protective layer can be provided.

1.2Building overview

This office building. A total of 9 floors. Facing North,South,East and West. The design scope of this project is designed for the sixth floor of the office building. Includes air conditioning and ventilation design.

The exterior of the building consists of the following parts：

Mainly composed of concrete and reinforced concrete and some insulation.

The windows of the building：Standard glass with moving shutters as internal shading

For the number of people in the office：each office considers two people

Apparatus：each person considers one computer

Lights：Provided by professional building electrical manufacturers, consider the heat of each room lamp is 10 watts per square meter

1.3Meteorological parameters

Air conditioning design meteorological parameters, including design dry bulb temperature, wet bulb temperature and solar radiation, are necessary and basic data for building air conditioning system design. They act on the building at the same time, which is the driving force leading to the heat transfer of the envelope structure and the direct mass exchange through infiltration and ventilation. The design weather conditions that occur simultaneously in the air conditioning system are the conditions necessary to determine the peak cooling load of the air conditioning system capacity. Inappropriate design of meteorological data will cause HVAC systems with excessive or small capacity, unnecessary additional initial investment and lower part-load efficiency, or often fail to provide sufficient cooling capacity.

1.4A Brief Introduction to Building environment and energy saving of air conditioning

With the advancement of global modern science and technology, the demand for resources has reached an unprecedented scale, and the earth's resources are limited, and countries around the world are facing the problem of tight energy supply.

1.4.1Indoor environmental impact：

The indoor environment is not only closely related to the building's shape factor, window-to-wall ratio, building orientation and plane layout, but also related to the wall materials and door and window glass materials used in the building envelope, as well as the insulation measures and exterior Window shading measures are related[5]. Whether the indoor environment is reasonable or not has a great impact on building energy consumption, especially air conditioning energy consumption.

1.4.2The influence of indoor environment on energy saving of HVAC

And to provide comfortable indoor air temperature, humidity, air velocity and heat radiation environment for people's life and work is the purpose of HVAC. By using the thermal characteristics of the building envelope, it can resist outdoor temperature changes, and provide people with a comfortable living and working environment. If the indoor temperature of a building is too high or too low, it will cause discomfort to the human body[5]. It is necessary to make full use of the building environment and choose a suitable indoor temperature to avoid energy waste, so that HVAC energy saving can be better realized.

1.4.3Outdoor environment impact：

To determine the HVAC load, it is necessary to fully study the influencing factors of the outdoor environment. Only by making full use of the favorable factors of the outdoor environment can it have a positive effect on the indoor environment.

1.4.4The influence of weather conditions on air conditioning load

When designing building HVAC, the load value of air conditioning needs to be combined with outdoor climatic characteristics. Climate factors such as outdoor relative humidity, sunlight radiation, and outdoor temperature have a greater impact on the load of the building’ s air conditioning system[5]. Building HVAC designers need to fully investigate the local climate characteristics, and effectively combine the local building HVAC system with atmospheric circulation and geographical characteristics, so that the air conditioning energy-saving design load requirements.

1.5indoor air conditions for people's thermal comfort

In today's world, people's requirements for all aspects of life tend to be idealized, especially for the comfort of living environment. Most of people's working life is spent indoors. So the indoor physical environment, especially the indoor thermal environment, has a great impact on the comfort of human body and the improvement of work efficiency. Therefore, the research on thermal comfort of indoor thermal environment evaluation has always been a hot issue in the field of air conditioning.

Evaluation of the thermal environment can be carried out according to three different standards (1)Living environment: Because human body temperature affects the speed of chemical reactions in the body, especially the maintenance of the best working state of the enzyme system, only body temperature is allowed to fluctuate within a very narrow range. Therefore, the primary task of the body's thermal regulation system is to make people at rest Can keep the body temperature constant at about 37 degrees, two degrees above or below the standard body temperature, it can be tolerated in a short time, but if it takes too long, it will damage health and even endanger life.(2)Comfort standard:The thermal environment that humans can adapt to are often not necessarily comfortable for humans. In the thermal environment that humans rely on for survival, only a small range can be defined as thermal comfort zone(3)Work efficiency standard:The thermal environment will affect people's sensitivity, alertness, fatigue, concentration and boredom. The above effects will affect the efficiency of physical labor and mental labor[6].

According to the research results of relevant health departments around the world, when the human body is properly dressed, warm enough and in a quiet state, the indoor temperature of 20℃ is relatively comfortable, 18℃has no cold sensation, and 15℃is the temperature limit that produces a significant cold sensation. In order to improve the quality of life and meet the requirements of adjustable room temperature, the indoor temperature range of the main rooms of civil buildings is set at 18~28℃[6].

For indoor air conditioning design parameters：

-Indoor dry bulb temperature:

Air conditioning in summer should be 22～28℃. High-level civil buildings or buildings with long staying time can be lower values, and general buildings or buildings with short staying time should be higher values.

The air conditioning in winter should be 18～24℃. High-class civil buildings or buildings with long staying time of people can take a high value, and general buildings or buildings with short staying time of people should take a low value.

-Indoor relative humidity:

In summer, air conditioning should be 40% to 65%, and higher values can be used for general or short-stay buildings.

Air conditioning in winter should be 30-60%.

Central air-conditioning systems are generally used in high-end apartments, villas and small offices, shops, restaurants, entertainment and other public places. For the owner, it is hoped that the air-conditioning system can provide a comfortable indoor environment, and the operating cost of the air-conditioning system is also as low as possible. The air conditioning load calculation surface, the indoor temperature increases by 1℃, the relative humidity increases by 5%, and the air conditioning load will decrease by 6% to 8%[6]. Therefore, the standards for indoor design parameters such as temperature and relative humidity should not be too high.

1.6Heat gain calculation and formula

For any design of heating in winter or cooling in summer, every HVAC designer must

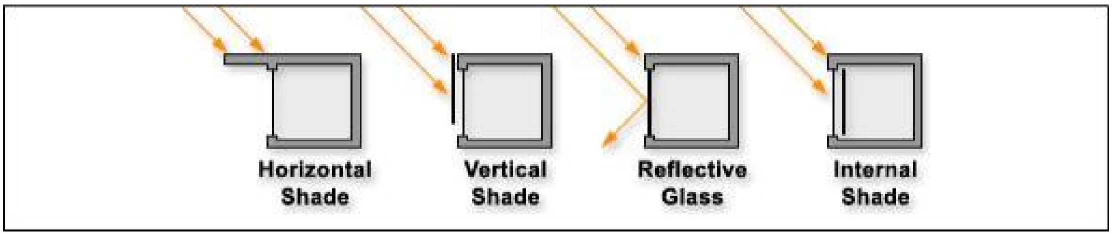
take in consideration the insulation, it means the amount of heat losses/gains through the materials (walls, roofs, windows,), and this is highly depending on the thermal transmittance coefficient “U”, which is in his turn also depends on three main parameters, outdoor heat transfer coefficient by convection, heat transfer coefficient by conduction,and indoor heat transfer coefficient by convection.

In other terms, the thermal transmittance coefficient is the rate of transfer of heat through one square meter of a structure divided by the difference in temperature across the structure.

1.6.1Shading and Shading Coefficient:

Building shading is a necessary measure to avoid direct sunlight into the room, prevent the building's outer protective structure from being overheated by sunlight, prevent local overheating and glare, and protect various indoor objects. Its reasonable design is an important factor for improving indoor thermal comfort in summer and reducing building energy consumption[7].

Whether for transparent windows, or for other opaque building envelopes, such as roofs, exterior walls, etc. Most of the solar radiation can enter the room through them, and the room temperature rises rapidly due to the greenhouse effect, which is one of the main reasons for the high indoor temperature in summer. Due to the widespread use of large-area glass on the facade of modern buildings, coupled with the widespread use of lightweight structures in industrialization, the deterioration of the indoor thermal and physical environment has been aggravated. This situation exists even in cold areas. Therefore, this part of the solar radiation heat The control is very important. The control of solar radiation heat in a room mainly involves three aspects: the orientation and size of windows; the choice of building envelope structure materials; and building shading technology[7]. Among these three elements, shading technology is the most effective and economical way to control solar radiation heat.



Type of Shading [1]

1.6.2Shading Coefficient

The shading coefficient, as the name implies, is the ability of the glass to block or resist sunlight.Characterizes the degree of attenuation of solar radiant heat transmitted by glazing without other shading measures. The value is the ratio of the heat of the solar radiation passing through the window glass to the heat of the solar radiation passing through the 3 mm thick ordinary transparent window glass. In the summer, the air conditioning load entering the room through the window is mainly from solar radiation, and the main energy consumption is also from solar radiation. To reduce the load and energy consumption of the outer window, effective shading measures must be taken, and the effect of reducing air penetration or reducing the heat transfer coefficient is limited[7]. Therefore, in the calculation of air conditioning building load and building energy efficiency, the calculation of shading is very important.

1.6.3Solar intensity radiation

The solar intensity radiation is composed by the direct beam radiation;

is also sometimes called "beam radiation", It is used to describe solar radiation traveling on a straight line from the sun down to the surface of the earth. and the diffuse radiation, describes the sunlight that has been scattered by molecules and particles in the atmosphere but that has still made it down to the surface of the earth[8].

The position of the sun in a certain time of the day and year is required and important, not only for the solar radiation intensity on its self but also know to get solar direction, in order to calculate the exact amount of heat from the Direct beam, and also to calculate the transmissivity coefficient[8]. The best way to have the values of the solar radiation intensity is measurement from competent authorities.

1.6.4Heat gain

Air conditioning may be required in buildings which have a high heat gain and as a result a high internal temperature. The heat gain may be from solar radiation and/or internal gains such as people, lights and appliances. The heat gain is divided into external and internal gains or sensible and latent heat.

-The external heat gains

-Heat gain radiation by glass:

The glass has high transitivity so that considerable amount of heat is poured directly into the space by sun through the glass. This amount varies from hour to hour, day to day, and latitude to latitude. The details of solar radiation with respect to time of day and situation of glass area given in the guidebook. Solar radiation is often the largest component of the room sensible heat load for a building with considerable window area. It may be necessary to calculate loads for different hours of the day in order to find out maximum load. Usually, to reduce the amount of heat gain, include a shading coefficient (external ,internal, shading in glass)[9]

$$Q_{gain,galzing}=A_{glass}*I*S$$

Where

A_{glass}: surface of window

I: solar intensity radiation

S:shading coefficient

-Heat gain conduction by glass:

Glass which is transparent allows the solar rays to pass through it. This results in heat gain inside the room. and the gain value of conduction depends on surface and temperature different between outdoor and indoor.

$$Q_{gain,win}=A_{win}*U_{win}*(T_o-T_i)$$

Where:

A_{win}: surface of window

U_{win}: total thermal transmittance coefficient

T_i: indoor temperature

T_o: outdoor temperature

-Heat gain conduction by walls:

The Heat gain through the exterior construction (walls and roof) is normally calculated by total heat transmittance coefficient(external and internal convection coefficient and conduction coefficient). The surface of walls and by the temperature difference between the outdoor and indoor air. But important is the surface temperature is not easy to get. So Another simple way to calculate the heat gain conduction by walls is use the solar-air temperature.[9]

$$Q_{gain,wall}=A_{wall}*U_{wall}*(T_{air}-T_i)$$

Where:

A_{wall}: Surface of wall

U_{wall}: total thermal transmittance coefficient

T_{air}: solar-air temperature

T_i: Indoor temperature

-The internal heat gains

-Occupancy Load:

The amount of heat given off by people depends on the degree of activity .The amount of heat liberated by the occupant when seated at rest by 115w out of which 70w is of sensible heat and 45w is of latent heat. In my design. Considers occupancy load is 68w.

-Lighting:

Lights generate sensible heat by the conversion of the electrical power input into light and heat. The heat is dissipated by radiation to the surrounding surfaces, by conduction into the adjacent materials and by convection to the surrounding air.

This calculation is not always necessary, designers can use directly some approximations like for modern lights, they produce from 9 to 20 Watt/m2 floor area. In my project I choose 10Watt/m2 for calculations[9].

-Appliances:

Most applications contribute heat to a space. Electric appliances contribute latent heat, only by virtue of the function they perform that is, drying, cooking, etc. In this case. Because it is designed for an office building air conditioning and ventilation system. So, the main device that generates heat is the computer. So in order to facilitate the calculation, assuming that each computer generates 150w of heat, each person owns one computer.

1.7Introduction of air conditioning system

Air conditioning is to send air after a certain treatment into the room in a certain way, so that the indoor temperature, relative humidity, cleanliness and flow speed are controlled within an appropriate range to meet the needs of living comfort and production technology.

1.7.1Classification of central air conditioning

According to the medium used to bear the indoor heat and humidity load, it can be divided into:

（1）All-air air-conditioning system: The central air-conditioning system is processed by centralized air processing equipment (cooling or heating), and the processed air is sent to the room. This system is called an all-air air-conditioning system. The all-air air-conditioning system uses air as the conveying medium. It uses the outdoor host to intensively generate cold/heat. The return air (or the mixed air of return air and fresh air) brought back from the room is cooled/heated, and then sent to the room to eliminate it. Air conditioning cold/heat load. The advantages of the all-air

air-conditioning system are simple configuration, small initial investment, fresh air can be introduced, and air quality and human comfort can be improved.

（2）All-water air-conditioning system: An air-conditioning system in which all the hot (cold) and wet loads in the air-conditioned room are borne by water, called an all-water air-conditioning system. The delivery medium of all-water air-conditioning systems is usually water. It generates air-conditioning cold/hot water through the outdoor host, which is delivered by the pipeline system to the indoor terminal devices. At the terminal devices, the cold/hot water exchanges heat with the indoor air to generate cold/hot air, thereby eliminating room air conditioning cold. /Heat load. The indoor end device of the system is usually a fan coil. At present, the fan coil unit adjusts the amount of water passing through the coil through the bypass valve (the fan speed can be adjusted), thereby regulating the cold/heat in the delivery room, so it can meet the different needs of each room, and its energy saving is also better. Generally used in occasions where there are many rooms and the use time is different, such as hotel rooms, KTV, small meeting rooms, hotel rooms, etc.

（3）Air-water air-conditioning system: The air-conditioning system in which the heat and humidity load in the air-conditioned room is borne by water and air is called air-water air-conditioning system. The typical device is a fan coil unit and fresh air system. The air-water air-conditioning system uses fan coils or inducers to heat and humidify the air in the air-conditioned room, and the air required by the air-conditioned room is processed by the centralized air-conditioning system, and then sent to each air-conditioned room by the air supply duct Inside.

（4）Refrigerant System ： The refrigerant type air-conditioning system is a system in which the load of the air-conditioned room is directly borne by the refrigerant. The evaporator or condenser of the refrigeration system directly absorbs (or releases) heat from the air-conditioned room. The refrigerant type air conditioning system is also called the unit type system. This is an effective control technology for indoor hot and humid environment. The refrigerant system is divided into unit type air conditioner system, window type air conditioner system, split type air conditioner system, which is directly placed in the room by the evaporator of the refrigeration system to eliminate indoor waste heat and humidity, and cannot improve indoor air quality. , But the application is simple and convenient. This kind of system has compact structure, small size, small floor space and high degree of automation. The air-conditioning unit can be directly placed indoors, with a small floor area, and the units are distributed. Each room can start and stop its own units according to their needs to meet Different needs, when a fire occurs, it will not spread through the air duct, which is effective for building fire protection.[10]

1.8Selection and determination of air conditioning scheme

This design is an air conditioning design for the office building on the 6th floor. The floor height is low. The indoor temperature control is required for comfort. There are many rooms in the building, and the load of different rooms is different. Good ability to independently control the indoor temperature and humidity, and shut down the machine according to demand.

According to my research and understanding, the refrigerant system is the most commonly used now, and VRV in the refrigerant system is the most suitable for this design. The following is an introduction.

The full name of VRV air conditioning system is Varied Refrigerant Volume, which is a refrigerant type air conditioning system. It uses refrigerant as the transport medium. The outdoor host is composed of outdoor heat exchanger, compressors and other refrigeration accessories. Indoor unit composed of heat exchanger and fan. One outdoor unit can deliver refrigerant liquid to several indoor units through pipelines. By controlling the refrigerant circulation of the compressor and the refrigerant flow into the indoor heat exchanger, the indoor cooling and heating load requirements can be timely met. The VRV system has many advantages such as energy saving, comfort, and stable operation, and each room can be independent Adjustment can meet the needs of different air conditioning loads in different rooms[11].

1.8.1The advantages of VRV compared with other central air conditioning

VRV air-conditioning is one of the most popular air-conditioning systems at present. Compared with other mainstream air-conditioning systems, VRV air-conditioning has advantages that other air-conditioning systems cannot match.

Compared with the air-cooled central air-conditioning system, the VRV variable frequency central air-conditioning system saves the initial investment and operating costs of the chilled water system. The refrigerant is directly used for cooling in the entire air-conditioning system; the outdoor unit of the VRV variable frequency central air-conditioning unit is small in size , Can be placed on the roof of the building or on each floor of the building, easy to install, no need to set up a separate refrigeration room, saving the occupied area of the unit equipment

-Reduce energy loss: VRV air-conditioning system has obvious energy-saving and comfortable effects. The system runs continuously at different speeds according to the indoor load, reducing the energy loss caused by frequent start and stop of the compressor;

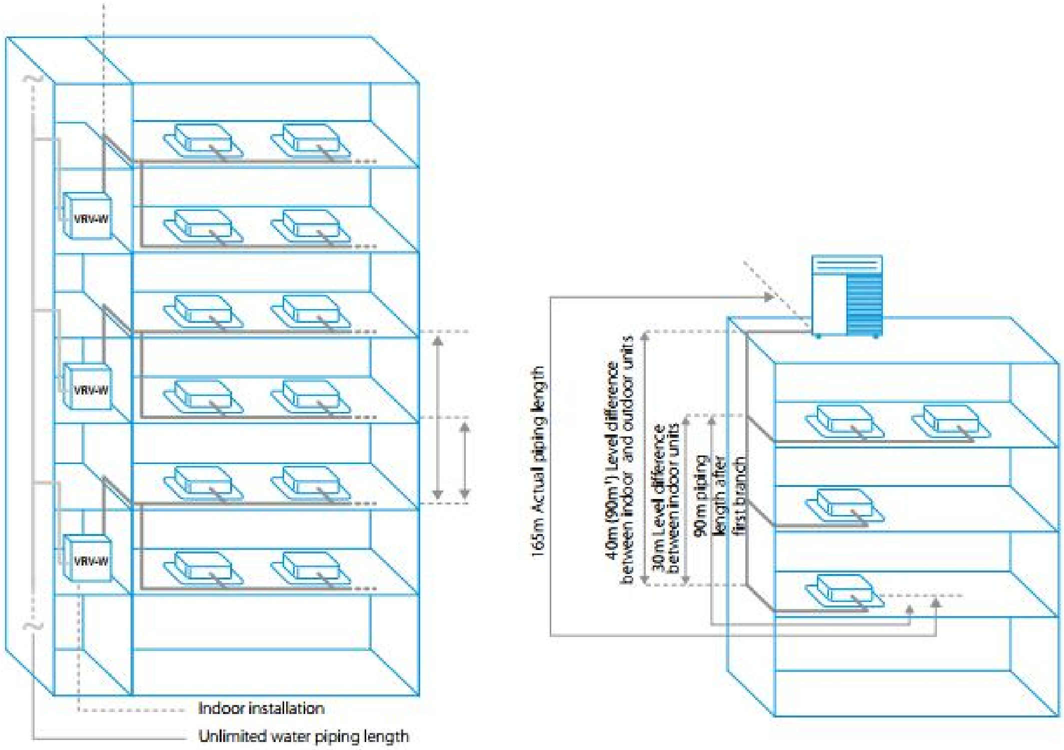
-Energy saving: The compressor is started at low frequency, which reduces the starting current, and the electrical equipment will greatly save energy, while avoiding the impact on other electrical equipment; it has the characteristic of adjusting the capacity and improving the indoor comfort.

-Comfort: If you talk about the benefits of central air conditioning, the first word that comes to mind is comfort. It can be said that the comfort of central air conditioners is more advantageous than many other traditional air conditioners, allowing people to feel comfortable and enjoy luxurious experience.

-Beautiful: In addition, the central air conditioner can be installed in the ceiling, which will not conflict with the interior decoration.

-Mute: The central air conditioner has low operating noise, creating a quiet and warm room space, ensuring the user's sleep quality at night, and improving work quality during the day.

-Flexible piping design: The long piping lengths, high level differences and small refrigerant piping allows for a design with little limitations and leaving maximum space[11].



Piping [2]

1.8.2Indoor Units

After selecting the correct outdoor unit, also need to select the indoor unit. The air cooled by the refrigerant needs to be delivered to each room through the indoor unit, and each room has different requirements, so it is necessary to calculate the heat gain of each room according to the calculation method introduced earlier. Choose the appropriate indoor unit according to the independent requirements of each room.

Indoor Units [3]

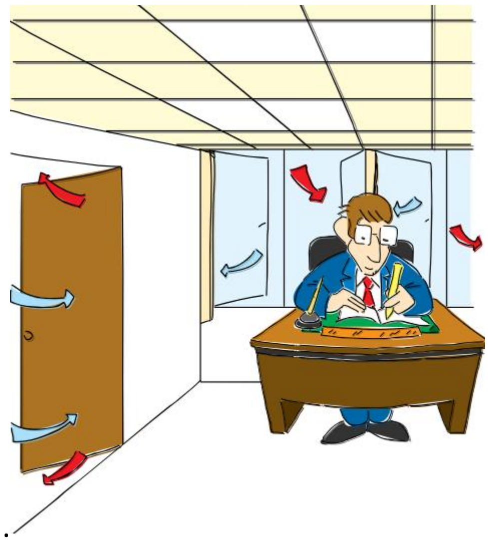
Indoor Units [4]

Indoor Units [5]

1.9.The necessity of ventilation system

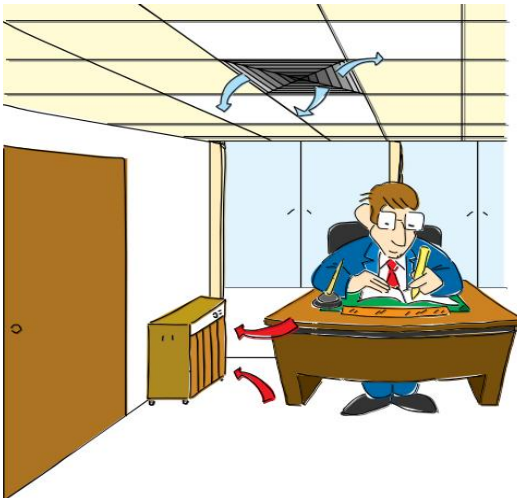
Ventilation is the process of supplying and removing air by natural or mechanical means to and from a building.

“Natural ventilation” covers uncontrolled inward air leakage through cracks, windows,doorways and infiltration as well as air leaving a room through the same routes. Natural ventilation is strongly affected by weather conditions and is often unreliable.



Natural Ventilation [6]

Mechanical or forced ventilation is provided by air movers or fans in the wall, roof or air-conditioning system of a building. It promotes the supply or exhaust air flow in a controllable manner.



Mechanical Ventilation [7]

Ventilation in a building serves to provide fresh and clean air, to maintain a thermally comfortable work environment, and to remove or dilute airborne contaminants in order to prevent their accumulation in the air. Air-conditioning is a common type of ventilation system in modern office buildings. It draws in outside air and after filtration, heating or cooling and humidification, circulates it throughout the building. A small portion of the return air is expelled to the outside environment to control the level of indoor air contaminants.

A comfortable environment may improve productivity and reduce errors and accidents.Excessive heat can strongly influence working capacity. Ventilation is essential for maintaining an acceptable environment in terms of humidity, heat or cold. In a normal air-conditioned workplace, temperature and humidity can be controlled - the optimum temperature range is 20ºC - 26ºC and relative humidity 40% - 70%. A poorly designed ventilation system may cause uneven distribution of the supply air, resulting in cooler environment at the front part of the ventilation line, and warmer at the back.[12]

An important indicator of the ventilation system is the ventilation rate.

The basis for the occupancy ventilation rates is an underlying minimum outdoor airflow per occupant as a means of controlling CO2 to a concentration of 1000ppm. The indoor air quality procedure offers an analytic alternative, allowing the designer to determine the ventilation rate based upon knowledge of the contaminants being generated within the space and the capability of the ventilation air supply to limit them to acceptable levels.

Pettenkofer criterion, CO_2 concentration in indoor environments informs about quality of ventilation with limit concentration equal to 0.1%.Volume = 1000ppm, so the amount of fresh air per person required is $25m^3/h$.

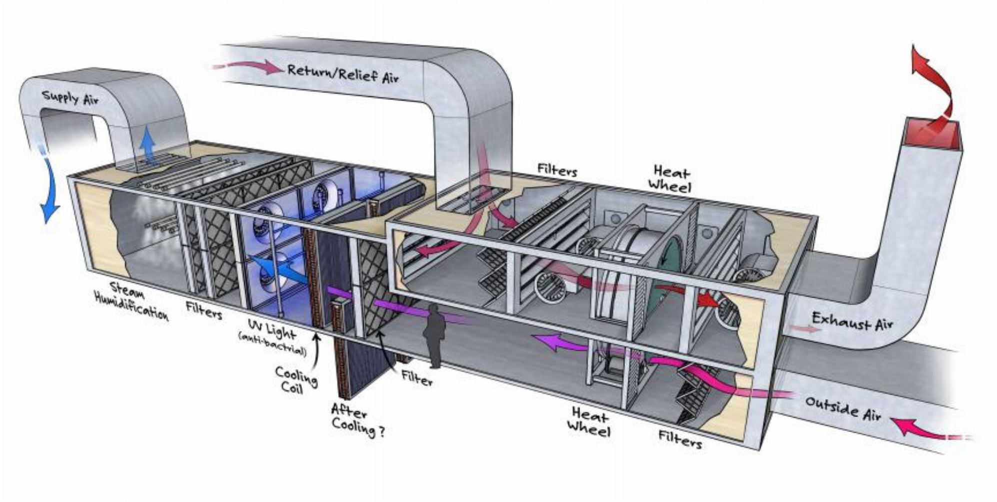
In this case, For the good healthy environmental, assume two people in one office. According to standards, a person needs $50m^3/h$ Volume flow rate.

1.10Air handling unit

Air handling unit often abbreviated to AHU, is a device used to condition and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system.

It is an equipment used to adjust the temperature, humidity and cleanliness of indoor air. There are air heaters, air coolers, and air humidifiers that meet the requirements of heat and humidity treatment.Air filter for purifying air, mixing box for adjusting fresh air and return air,And the muffler used to reduce the noise of the ventilator.

It has the advantages of large air volume, high air quality, energy saving, etc., especially suitable for places with large spaces such as shopping malls, office buildings, and airports.[13]



Air handling unit [8]

Air handling unit [9]

1.11Air distribution and Duct design

A duct system is also called ductwork.in a forced air system, accomplished using ductwork. Ducts are a series of sectioned conduits, or tubes, which convey fresh air from the AHU throughout the building. Planning (laying out), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design.[14]

Pipes used to transfer gas, water or refrigerant are not ductwork. Only air is moved via ductwork. What's more, there are many ductwork constructions and shapes can choose from. It may come in oval, round or rectangular shapes. It might be fashioned from a wide range of materials like flexible plastics, fiberglass or different metals[15].

Ductwork [10]

1.11.1Air velocity in duct

Low air velocity affects the capability of ventilation systems to maintain temperature uniformity throughout the occupied area and dilute the pollutants generated in the area. the comfort of passengers is affected by the low total airflow in the space, even if the space temperature is well kept within the comfort range. And for design air velocity. The most common value are 9~10m/s from unit to the main pipe,6~8m/s from main pipe to the pipe distribution and 4~6m/s for the pipe to the room

1.11.2Duct dimension

The length of the pipe installation is arbitrary depending on the architecture plans, and on the installation.The main purpose of designing a pipe is to calculate the pipe diameter. Calculating the pipe diameter requires an expected air flow rate. The expected air flow rate is described in the previous section. Calculate the pipe diameter according to the formula, and then select the actual pipe diameter according to the selected pipe material, and then calculate the actual flow velocity according to the actual pipe diameter. Finally, based on these values, the pressure loss can be calculated.

Where the principle is :

$$V=A*W=\frac{\pi*d^2}{4}*w$$

$$D=\sqrt{\frac{4*V}{W*\pi}}$$

Where:

V: Volume flow rate

A: surface pipe

W:Velocity

1.11.3Pressure Loss

There are two kinds of resistance to air flow in the air duct. One is the energy loss along the path due to the viscosity of the air itself and the friction between it and the wall. It is called frictional resistance or resistance along the path.

The other is air. When flowing through the tubes and equipment in the duct, the concentrated energy loss due to the change in the magnitude and direction of the flow rate and the generation of eddy currents is called local resistance.

For the friction term principle is:

$$P_f=R*L$$

Where:

R:pressure loss per length pa/m

L: pipe length

Total pressure loss is:

$$P_{total}=R*I+Z$$

Where:

R: specific pressure drop

L: Length

Z: Local pressure losses

And the local pressure loss Depending on the value given by the manufacturer.To calculate the pressure loss for a single room, it is necessary to calculate the pressure loss of all the pipes flowing through the AHU to this room. Each section of the pipeline has a local pressure loss. There is also a pressure loss in the diffuser in the room. However, diffuser has a range of pressure loss to adjust the balance pressure. Thus the pressure loss in each room is essentially the same.

1.11.4Diffuser

After designing the pipe and air distribution. Then need to deliver fresh air into the room, and then choose the right diffuser or indoor units.The way to choose the right and proper distribution air to the room depends highly of the pressure losses.

Therefore, the right diffuser can be selected by calculating the results obtained by the principles described above.

Grill diffuser [11]

Nozzle [12]

1.12Pipeline insulation and anti-corrosion considerations

The purpose of the heat preservation of the piping system: one is to reduce the heat loss (cold loss) of the piping system, and the other is to prevent condensation on the pipe surface.

The performance of thermal insulation material mainly depends on its thermal conductivity. The larger the thermal conductivity, the worse the performance and the worse the thermal insulation effect. Therefore, choosing thermal insulation materials with low thermal conductivity is the first choice. At the same time, the water absorption, use temperature range, service life, aging resistance, mechanical strength, fire resistance, cost and economy of the insulation material must also be considered.

The purpose of pipeline anti-corrosion is to prevent external corrosion of the metal surface， Generally used is coating anti-corrosion[18].

1.13Noise reduction and vibration reduction

Noise reduction and vibration reduction of air-conditioning systems are an important part of air-conditioning design. It is extremely important for reducing noise and vibration, improving people's comfort and work efficiency, and extending the service life of buildings.

For buildings equipped with air-conditioning and other equipment, both indoor and outdoor areas are affected by noise and vibration sources. Generally speaking, outdoor noise sources enter through the enclosure structure. The internal noise, vibration source is mainly generated by air conditioning equipment.

Therefore, attenuating the vibration of the machine is achieved by eliminating the rigid connection between them. That is, a soft connection is set at the connection, and vibration-proof components (such as spring damping or rubber) are installed at the vibration source, so that the vibration can be reduced to a certain extent[19].

2.Chapter II:Design air-conditioning in Prague with Czech envelop

2.1Introduction

This chapter will show the design of the building offices in Prague of Czech republic, following the procedure mentioned in previous chapter, Will see more details in designing an air conditioning.

2.2Building overview

This office building. A total of 9 floors. Facing North,South,East and West. The design scope of this project is designed for the sixth floor of the office building.

2.3Indoor conditions

This design is mainly for indoor weather in summer. Therefore, the indoor situation is that the human body has a comfortable temperature of 25 degrees and humidity of between 30% and 70%.

2.4Outdoor conditions

climatic conditions, are set with measurement using thermometer, the both temperatures dry bulb temperature and wet bulb temperature, using these both temperature on a psychometric chart, the outdoor condition will be set.

Dry bulb temperature:30°C,Wet bulb temperature:20°C,relative humidity:36% In summer.Dry bulb temperature: -15 °C in winter.

2.5Building envelope, heat transmittance coefficient,and shading coefficient

With mentioned before, for any design of heating in winter or cooling in summer, every design must take in consideration the insulation, it means the amount of heat losses/gains through the materials (walls, roofs, windows,), and this is highly depending on the thermal transmittance coefficient “U”, which is in his turn also depends on three main parameters, outdoor heat transfer coefficient by convection, heat transfer coefficient by conduction, and indoor heat transfer coefficient by convection.

The U value can be calculated. But need to know the K values of all the components and the individual components of the material. So for a simple design. It is easy to take the directly value from the construction calculation by the architects before.

Wall：Concrete block (160mm),Gypsum board partition (100mm),Thin wall mortar (20mm),U-Value of wall is 0.3W/m².K.

Windows:Double-glazed.glass is “standard glass” with movable louvers as inner sunshade.U-value of window is 0.8W/m².K,Shading coefficient equal to 0.6 which means that 60 % of the solar beam is getting inside the area through the glazing.

2.6Solar intensity radiation

The best way to get the value of solar intensity radiation is Through models and calculations

For each side of the windows, The solar intensity radiation is different every time of the different month. Every day there is a time that solar intensity radiation is maximum value.

For example. On the August. 12AM.The maximum solar intensity is South equal to 552W/m2. For East equal to 123 W/m2. For West equal to 123 W/m2. For North equal to 123 W/m2.

PRILOHA 2
(pokračování)

pokračování tab. 10

			5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
21. červenec z = 5	S	N	45	87	80	100	117	130	139	141	139	130	117	100	80	87	45
	SV	NE	85	287	361	321	217	135	139	141	139	130	117	100	78	53	24
	V	E	83	322	481	539	505	389	232	141	139	130	117	100	78	53	24
	JV	SE	41	180	335	452	511	506	437	316	185	130	117	100	78	53	24
	J	S	24	53	78	128	230	335	409	435	409	335	230	128	78	53	24
	JZ	SW	24	53	78	100	117	130	185	316	437	506	511	452	335	180	41
	Z	W	24	53	78	100	117	130	139	141	232	389	505	539	481	322	83
	SZ	NW	24	53	78	100	117	130	139	141	139	135	217	321	361	287	85
			41	122	249	397	534	640	706	729	706	640	534	397	249	122	41
21. srpen z = 4	S	N	0	41	59	81	99	112	121	123	121	112	99	81	59	41	0
	SV		0	188	316	277	166	112	121	123	121	112	99	81	59	32	0
	V	E	0	230	476	566	536	408	229	123	121	112	99	81	59	32	0
	JV		0	145	366	520	598	599	526	388	222	114	99	81	59	32	0
	J	S	0	32	64	164	306	436	523	552	523	436	306	164	64	32	0
	JZ		0	32	59	81	99	114	222	388	526	599	598	520	366	145	0
	Z	W	0	32	59	81	99	112	121	123	229	400	536	566	476	230	0
	SZ		0	32	59	81	99	112	121	123	121	112	166	277	316	188	0
			0	60	169	317	463	579	652	676	652	579	463	317	169	60	0
	S		0	0	33	59	78	93	101	104	101	93	78	59	33	0	0

Solar intensity chart of Prague [14]

Because it is design in summer , I chose the August data. After the selection of the above table. North wall maximum value is 12AM.South wall maximum value is 12AM.East wall maximum value is 8AM.West wall maximum value is 16PM.So The different wall values for all typical time points are as follows

solar intensity/time	8	12	16
North	81	123	81
South	164	552	164
East	566	123	81
West	87	123	566

Solar intensity of typical time[15]

And Calculate the heat gain passed by each window at each typical time according to the formula below

Usually, to reduce the amount of heat gain, designers, include a shading coefficient (external ,internal, shading in glass)

And the result show as below:

	M^2	8am	12am	16pm
WinN	32	1578 w	2396 w	1578w
WinS	25	2485 w	8364 w	2485 w
WinE	36	12251 w	2662 w	1753 w
WinW	25	1318 w	1864 w	8576 w
Total	119	17632 w	15286 w	14392 w

Windows heat gain of radiation [16]

Because the total of heat gain in 8am is maximum. So I choose 8am for calculation the heat gain of each side window.

8am solar intensity show as below.

solar intensity	W/m^2	Time
North	81	8am
South	552	8am
East	164	8am
West	81	8am

Solar intensity [17]

2.7Heat gains

The heat gains are divided into two parts,. The external heat gain and internal heat gain.So, The total external heat gain is sum of Heat gain radiation by glass, Heat gain conduction by glass and Heat gain conduction by walls.

For example. Room A11

A11	length(m)	height(m)	width(m)	Quantity
Wall1	3.988	3.8	0	1
Wall2	5.418	3.8	0	1
window	1.95	1.85	0	2
ground	5.418	0	3.988	
	W		W	
Htwall	159w			
Hwin,con	29w	Hwin.rad	350w	
Hp	136w			2

Room A11 [18]

All room external heat gain as below:

Room	Htwall	Htwin
A11	159 w	380 w
A12-18	710 w	1242 w
A19	229 w	1399 w
A20	91 w	1209 w
A22-23	172 w	2418 w
A24	91 w	1209 w

A25	185 w	1579 w
A26-33	456 w	2955 w
A34	168 w	559 w
A35	28 w	190 w
A37	28 w	190 w
A38	28 w	190 w
A39	28 w	190 w
A40	28 w	190 w
Total	2401 w	13899 w

All room heat gain by windows and wall [19]

And the internal heat gain is divided into three parts too.

Occupancy Load

As define in the previous, Each occupancy produced 70watt.

Lighting

As define in the previous, Light produced $10w/m^2$

Appliances

As define in the previous, Each occupancy with one computer and each computer produced 150watt.

All room internal heat gain show as below:

Room	Ho	Happ	Hl
A11	136w	300w	216w
A12-18	952w	2100w	1477w
A19	136w	300w	211w
A20	136w	300w	232w
A22-23	272w	600w	616w
A24	136w	300w	323w
A25	136w	300w	214w
A26-33	1088w	2400w	1688w
A34	136w	300w	304w
A35	136w	300w	242w
A37	136w	300w	339w
A38	136w	300w	316w
A39	136w	300w	294w
A40	136w	300w	286w
Total	3808w	8400w	6758w

All room internal heat gain [20]

So the total heat gain is sum of external heat gain an internal heat gain.

The Total heat gain of 6 floor is **35** kw.

2.8Air conditioning outdoor units and indoor units

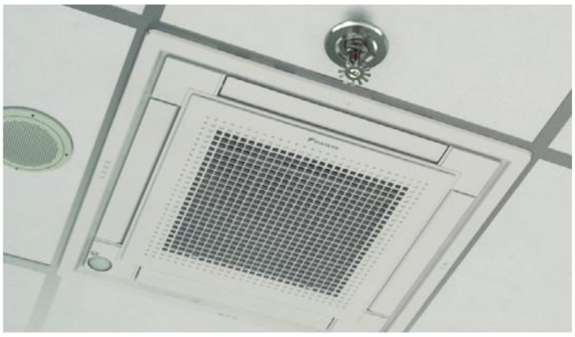
After getting the total heat gain. It is necessary to choose a suitable air conditioning system. As mentioned in the previous chapter, VRV has many benefits, so VRV system is the most suitable air conditioning system.I choose the VRV from the Daikin brand.And the **VRV IV heat recovery** series as my design air conditioning system. And Special anti corrosion treatment to provides 5 to 6 times greater resistance against acid rain and salt corrosion. The provision of rust proof steel sheet on the underside of the unit gives additional protection.And the VRV system of daikin company I chose has good protection to the vibration-free and sufficient light construction of the outdoor units, floors do not need to be reinforced, reducing the overall cost of the building.

Outdoor unit			REYQ	8T	10T	12T	14T	
Capacity range			HP	8	10	12	14	
Cooling capacity	Prated,c		kW	22.4	28.0	33.5	40.0	
Heating capacity	Prated,h		kW	13.7	16.0	18.4	20.6	
	Max.	6°CWB	kW	25.0	31.5	37.5	45.0	
ηs,c			%	212.4	222.0	216.9	226.6	
ηs,h			%	146.8	152.3	155.5	138.4	
SEER				5.4	5.6	5.5	5.7	
SCOP				3.7	3.9	4.0		3.5
Maximum number of connectable indoor units							64 (1)	
Indoor index connection	Min.			100.0	125.0	150.0	175.0	
	Nom.						-	
	Max.			260.0	325.0	390.0	455.0	
Dimensions	Unit	HeightxWidthxDepth	mm	1,685x930x765				
Weight	Unit		kg	210	218		304	
Sound power level	Cooling	Nom.	dBA	78.0	79.0	81.0		
Sound pressure level	Cooling	Nom.	dBA	58.0		61.0		
Operation range	Cooling	Min.~Max.	°CDB				-5.0~43.0	
	Heating	Min.~Max.	°CWB				-20.0~15.5	
Refrigerant	Type/GWP						R-410A/2,087.5	
	Charge		kg/TCO2Eq	9.7/20.2	9.8/20.5	9.9/20.7		
Piping connections	Liquid	OD	mm	9,52			12,7	
	Gas	OD	mm	19.1	22.2			
	HP/LP gas	OD	mm	15.9	19.1			
	Total piping length	System Actual	m				1,000	
Power supply	Phase/Frequency/Voltage		Hz/V				3N~/50/380-415	
Current - 50Hz	Maximum fuse amps (MFA)		A	20	25	32		

Type of outdoor Units [21]

Because in my calculation the total heat gain in 6th floor is **35KW**.So I Choose the TYPE **REYQ14T** as the outdoor air conditioning units.And In the product manual,Maximum number of connectable indoor units is 64,So it is very suitable for this case.

After selecting the outdoor unit, need to calculate the heat gain of each individual room to select the right indoor unit.And I choose the fully flat cassette as the indoor units for air conditioning.Because it is Unique design in the market that integrates fully flat into the ceiling, Advanced technology and top efficiency combined, Most quiet cassette available on the market. Individual flap control: easily control one or more flaps via the wired remote controller when rearranging the room. Most silent cassette (25dBA), important for office applications.



Indoor Units [22]

Indoor unit			FXZQ	15A	20A	25A	32A	40A	50A
Cooling capacity	Total capacity	Nom.	kW	1.70	2.20	2.80	3.60	4.50	5.60
Heating capacity	Total capacity	Nom.	kW	1.90	2.50	3.20	4.00	5.00	6.30
Power input - 50Hz	Cooling	Nom.	kW	0.043			0.045	0.059	0.092
	Heating	Nom.	kW	0.036			0.038	0.053	0.086
Dimensions	Unit	HeightxWidthxDepth	mm	260x575x575					
Weight	Unit		kg	15.5			16.5		18.5
Casing	Material			Galvanised steel plate					
Decoration panel	Model			BYFQ60C2W1W					
	Colour			White (N9.5)					
	Dimensions	HeightxWidthxDepth	mm	46x620x620					
	Weight		kg	2.8					
Decoration panel 2	Model			BYFQ60C2W1S					
	Colour			SILVER					
	Dimensions	HeightxWidthxDepth	mm	46x620x620					
	Weight		kg	2.8					
Decoration panel 3	Model			BYFQ60B2W1					
	Colour			White (RAL9010)					
	Dimensions	HeightxWidthxDepth	mm	55x700x700					
	Weight		kg	2.7					
Decoration panel 4	Model			BYFQ60B3W1					
	Colour			WHITE (RAL9010)					
	Dimensions	HeightxWidthxDepth	mm	55x700x700					
	Weight		kg	2.7					
Fan	Air flow rate - 50Hz	Cooling Low/High	m³/min	6.5/8.5	6.5/8.7	6.5/9.0	7.0/10.0	8.0/11.5	10.0/14.5
		Heating Low/High	m³/min	6.5/8.5	6.5/8.7	6.5/9.0	7.0/10.0	8.0/11.5	10.0/14.5
Air filter	Type			Resin net					
Sound power level	Cooling	High	dBA	49		50	51	54	60
Sound pressure level	Cooling	Low/Nom./High	dBA	25.5/28.0/31.5	25.5/29.5/32.0	25.5/30.0/33.0	26.0/30.0/33.5	28.0/32.0/37.0	33.0/40.0/43.0
	Heating	Low/Nom./High	dBA	25.5/28.0/31.5	25.5/29.5/32.0	25.5/30.0/33.0	26.0/30.0/33.5	28.0/32.0/37.0	33.0/40.0/43.0
Refrigerant	Type/GWP			R-410A/2,087.5					
Piping connections	Liquid	OD	mm	6,35					
	Gas	OD	mm	12.7					
	Drain			VP20 (I.D. 20/O.D. 26)					
Power supply	Phase/Frequency/Voltage		Hz/V	1~/50/60/220-240/220					
Current - 50Hz	Maximum fuse amps (MFA)		A	16					
Control systems	Infrared remote control			BRC7EB530W (standard panel) / BRC7F530W (white panel) / BRC7F530S (grey panel)					
	Wired remote control			BRC1H51(9)W/S/K / BRC1E53A/B/C / BRC1D52					
	Simplified wired remote control for hotel applications			BRC2E52C (heat recovery type) / BRC3E52C (heat pump type)					

Type of Indoor Units [23]

And results of all room heat gain show as below:

Room No	Q_{gain}	Units	A26	1074w	Type 15A
A11	1191w	Type 15A	A27	1074w	Type 15A
A12	926w	Type 15A	A28	1074w	Type 15A

A13	926w	Type 15A	A29	1074w	Type 15A
A14	926w	Type 15A	A30	1074w	Type 15A
A15	926w	Type 15A	A31	1074w	Type 15A
A16	926w	Type 15A	A32	1074w	Type 15A
A17	926w	Type 15A	A33	1074w	Type 15A
A18	926w	Type 15A	A34	1467w	Type 15A
A19	2064w	Type 20A	A35	896w	Type 15A
A20	1969w	Type 20A	A37	992w	Type 15A
A22	2039w	Type 20A	A38	970w	Type 15A
A23	2039w	Type 20A	A39	948w	Type 15A
A24	2059w	Type 20A	A40	939w	Type 15A
A25	2414w	Type 25A			

All room heat gain [24]

And in my calculation except the room **A19~A25**. All rooms use type **15A** as indoor units.Room **A19~A24** use type **20A** as indoor units.Room **A25** us type **25A** as indoor units.

2.9Ventilation system

For large buildings, it is not enough to have an air conditioning system. Therefore, in addition to the installation of the air conditioning system, it is also necessary to install a separate ventilation system.For the good healthy environmental, assume two people in one office. According to empirical standards, a person needs 50m^3/h Volume flow rate.

For example in room A11. The room have 2 occupancy. So the air flow rate is 0.028 m^3/s.Is 100 m^3/h Volume flow rate is means how many occupancy needs fresh air and how much fresh air the air handing unit need to supply.The Total volume flow rate of 6th floor is 2800 m^3/h

2.10Air handing unit

In the previous calculation, Have got the total air of the entire floor. Then it can choose the air handing unit for ventilation. So in my design, I choose the daikin air handing unit.

Because following reasons: Maximum energy efficiency and indoor air quality, Wide range of functions and options, High quality components, Operation efficiency and energy savings, Heat recovery efficiency up to 93%, Outstanding reliability and performance ,Plug and play concept for easy installation and commissioning[11].

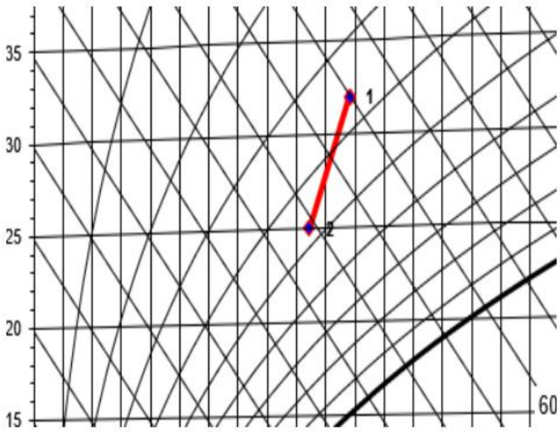
Besides,I choose the Modular P(AHU with plate heat exchanger) as air handing unit for ventilation.

As previous calculation, The total air flow rate is 2800m^3/h. So I choose NO.4 with 3100m^3/h AHU

D-AHU Modular P			4
Airflow		m³/h	3,100
Thermal efficiency		%	93.1
External static pressure	Nom.	Pa	200
Current	Nom.	A	1.67
Power input	Nom.	kW	1.15
SFPv		kW/m³/s	1.34
Electrical supply	Phase	ph	3 + N
	Frequency	Hz	50
	Voltage	V	400
Dimensions unit	Width	mm	1,200
	Height	mm	1,740
	Length	mm	2,660
Weight unit		kg	604

Type of AHU [25]

Whit calculated using the HX-chart from C.I.C.



			1	2
Temperature	t	°C	32.0	25.0
Rel.humidity	φ	%	36%	47%
Abs. humidity	x	g/kg	10.8	9.4
Enthalpy	h	kJ/kg	60.0	49.3
Density	ρ	kg/m3	1.13	1.16
Wet bulb temp.	tv	°C	20.6	17.3
Act. air flow	Vs	m3/h	2,995	2,920
Nom. air flow	Vn	m3/h	2,800	2,800
Thermal power	P	kW		-10.0
Evap. water	qw	kg/h		-4.6

Summer process [26]

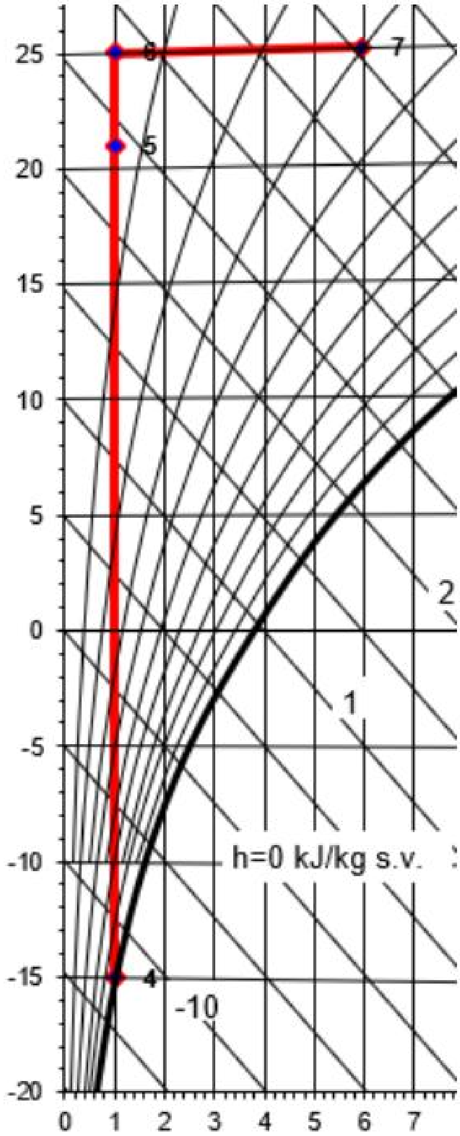
Where:

Point 1:outdoor conditions

Point 2:Supply fresh air from air handing unit

From the result chat show, The total cooling coil capacity is 10KW.

And also should supply fresh in winter. And The winter process is as follows



			4	5	6	7
Temperature	t	°C	-15.0	21.0	25.0	25.0
Rel.humidity	φ	%	97%	6%	5%	30%
Abs. humidity	x	g/kg	1.0	1.0	1.0	6.0
Enthalpy	h	kJ/kg	-12.7	23.8	27.8	40.5
Density	ρ	kg/m3	1.35	1.18	1.17	1.16
Wet bulb temp.	tv	°C	-15.1	7.4	9.2	14.3
Act. air flow	Vs	m3/h	2,494	2,842	2,881	2,903
Nom. air flow	Vn	m3/h	2,800	2,800	2,800	2,800
Thermal power	P	kW		34.0	3.8	11.8
Evap. water	qw	kg/h		0.0	0.0	16.7

Winter process [27]

2.11Indoor units (Diffuser)

In the previous introduction, the appropriate AHU has been selected, and in the previous calculations and introductions, there are two people in each room. One person with 50m^3/h fresh air. Because the floors are all offices, the floor space of each room is basically similar. Each room need 100m3/h fresh air. So I choose DR type Diffuser that made by lindab company for each room.

Indoor Diffuser [28]

The diffuse have a damper. It can adjust the pressure with close damper to fully open damper. So For each room can use the damper for balance the pressure loss compare with the main pipe.

2.12Pressure loss

Design must know the supervisor (especially the longest) in order to get the value of the total pressure loss

The supply main pipe show below:

No	Length(m)	R(Pa/m)	Pf(pa)	Pl(pa)	Ptotal(pa)
20	5.3	5.5	29.15	54	83.15
23	4.15	5.5	22.83	7	29.83
24	4.15	6.5	26.98	5.1	32.08
25	4.15	6	24.9	18	42.9
25.5	8.5	5.8	49.3	19	68.3
26	10	7	33	42.3	75.3
56	3.2	2.5	8	50	58
57	7.6	2	15.2	18	33.2
Total					423

supply main pipe [29]

And For the exhaust air ,The main pipe show below:

No	Length(m)	R(Pa/m)	Pf(pa)	Pl(pa)	Ptotal(pa)
14	12	1.8	21.6	61	83
12	10.5	1.6	16.8	30	47
15	4	1.8	7.2	30	37
16	7.6	1.8	13.68	21	35
Total					201

Exhaust main pipe [30]

2.13Pipeline Design

According to the method introduction in the previous chapter, the actual pipe diameter and pressure can be calculated and the pipeline can be designed

For example pipe No.1

No	L	V	V	u	D	DN	W
-	m	m3/h	m3/s	m/s	mm	m	m/s
1	3.3	100	0.028	6	77	0.08	5.53

Pipe No.1[31]

With the calculation and the table of the select pipe. Then can design all pipe dimensions.

Supply pipeline[32]

In addition to the supply of fresh air, it is also necessary to exhaust the air in the room.

The same method of supply. For example No.1 pipe show below.

No	L	V	V	u	D	DN	W

-	m	m3/h	m3/s	m/s	mm	m	m/s
1	4.75	50	0.014	6	54	0.08	2.76

Exhaust pipe No.1 [33]

And Below it's the exhaust air duct design.

Exhaust pipeline[34]

3.Chapter III:Design air-conditioning in Beijing with Czech envelop

3.1Introduction

This chapter will show the design of the building offices in Beijing of China, following the procedure mentioned in previous chapter, Will see how big is the difference of the design between two totally different country city.

3.2Building overview， heat transmittance coefficient,and shading coefficient

To make the analyses easy and proper one, Will use the same building shape,same architecture plans in this designs.

3.3Indoor conditions

This design is mainly for indoor weather in summer. Therefore, the indoor situation is that the human body has a comfortable temperature of 25 degrees and humidity of between 30% and 70%.

3.4Outdoor conditions

climatic conditions, are set with measurement using thermometer, the both temperatures dry bulb temperature and wet bulb temperature, using these both temperature on a psychometric chart, the outdoor condition will be set.

Dry bulb temperature:34°C,Wet bulb temperature: 20 °C,relative humidity:44 % In summer.Dry bulb temperature: -10 °C in winter.

3.5Solar intensity radiation

序号	城市名称	朝向	当地太阳时													日总量	昼夜平均
			6	7	8	9	10	11	12	13	14	15	16	17	18		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
6	北京	S	30	65	116	245	352	423	447	423	352	245	116	65	30	2909	121.2
		W(E)	30	65	95	118	136	147	151	364	543	662	697	629	441	4078	169.9
		N	148	137	95	118	136	147	151	147	136	118	95	137	148	1713	71.4
		H	139	336	543	730	878	972	1003	972	878	730	543	336	139	8199	341.6

Solar intensity chart of Beijing [35]

I chose the August data. After the selection of the above table. North wall maximum value is at 10AM.South wall maximum value is at 10AM.East wall maximum value is at 14pM.West wall maximum value is at 14PM.So The different wall values for all typical time points are as follows

solar intensity/time	10	14
North	151W/m2	95W/m2
South	447W/m2	115W/m2
East	151W/m2	697W/m2
West	151W/m2	697W/m2

Solar intensity of typical time [36]

And Calculate the heat gain passed by each window at each typical time according to the formula below which describe in the previous chapter.

the result show as below:

	M^2	10	14
WinN	32	2942 w	1851 w
WinS	25	6773 w	1742 w
WinE	36	3268 w	15087 w
WinW	25	2288 w	10561 w
Total	119	15271 w	29240 w

Windows heat gain of radiation [37]

Because the total of heat gain in 14pm is maximum. So I choose 14Pm for calculation the heat gain of each side window.

14Pm solar intensity show as below:

solar intensity	W/m2	Time
North	95	14
South	115	14

East	697	14
West	697	14

Solar intensity [38]

3.6Heat gains

For example. Room A11

A11	length(m)	height(m)	width(m)	Quantity
Wall1	3.988	3.8	0	1
Wall2	5.418	3.8	0	1
window	1.95	1.85	0	2
ground	5.418	0	3.988	
	W		W	
Htwall	124			
Hwin,con	52	Hwin.rad	1714	
Hp	136			2

Room A11 [39]

All room external heat gain as below:

Room	Htwall	Htwin	A26-33	337 w
A11	124 w	1766 w	A34	139 w
A12-18	470 w	10587w	A35	28 w
A19	143 w	1810w	A37	28 w
A20	54 w	275 w	A38	28 w
A22-23	103w	550 w	A39	28 w
A24	54 w	275 w	A40	28 w
A25	118w	1810w	A26-33	337w

All room heat gain by windows and wall [40]

And all room internal heat gain as below：

Room	Ho	Happ	HI
A11	136w	300w	216w
A12-18	952w	2100w	1477w
A19	136w	300w	211w
A20	136w	300w	232w
A22-23	272w	600w	616w
A24	136w	300w	323w
A25	136w	300w	214w
A26-33	1088w	2400w	1688w
A34	136w	300w	304w
A35	136w	300w	242w

A37	136w	300w	339w
A38	136w	300w	316w
A39	136w	300w	294w
A40	136w	300w	286w

All room internal heat gain [41]

So the total heat gain is sum of external heat gain an internal heat gain.So total heat gain is **52** kw.

3.7Air conditioning outdoor units and indoor units

After getting the total heat gain. It is necessary to choose a suitable air conditioning system.Choose the same brand as described in the previous chapter.

Outdoor unit system			REYQ	10T	13T	16T	18T	20T	22T
System	Outdoor unit module 1			REMQ5T			REYQ8T		REYQ10T
	Outdoor unit module 2			REMQ5T	REYQ8T		REYQ10T	REYQ12T	
Capacity range			HP	10	13	16	18	20	22
Cooling capacity	Prated,c		kW	28.0	36.4	44.8	50.4	55.9	61.5
Heating capacity	Prated,h		kW	16.0	21.7	23.2	27.9	31.0	34.4
	Max.	6°CWB	kW	32.0	41.0	50.0	56.5	62.5	69.0
ηs,c			%	224.2	229.3	223.9	222.9	215.0	213.5
ηs,h			%	156.4	148.9	147.4	150.8	152.3	155.7
SEER				5.7	5.8	5.7	5.6	5.5	5.4
SCOP				4.0		3.8		3.9	4.0
Maximum number of connectable indoor units									64 (1)
Indoor index connection	Min.			125.0	163.0	200.0	225.0	250.0	275.0
	Nom.								-
	Max.			325.0	423.0	520.0	585.0	650.0	715.0
Piping connections	Liquid	OD	mm	9,52	12,7			15,9	
	Gas	OD	mm	22.2			28.6		
	HP/LP gas	OD	mm	19.1		22.2			
	Total piping length	System / Actual	m			500			
Power supply	Phase/Frequency/Voltage		Hz/V						3N~/50/380-4
Current - 50Hz	Maximum fuse amps (MFA)		A		40			50	

Type of VRV [42]

And because in my calculation the total heat gain in 6th floor is 52KW.So I Choose the **20T(REYQ8T+REYQ10T)** type VRV as the air conditioning outdoor units.

And results of all room heat gain show as below:

Room	Q_{gain}	Untis	Room	Q_{gain}	Units
A11	2542w	Type 25A	A26	2224w	Type 25A
A12	2227w	Type 25A	A27	2224w	Type 25A
A13	2227w	Type 25A	A28	2224w	Type 25A
A14	2227w	Type 25A	A29	2224w	Type 25A
A15	2227w	Type 25A	A30	2224w	Type 25A

A16	2227w	Type 25A	A31	2224w	Type 25A
A17	2227w	Type 25A	A32	2224w	Type 25A
A18	2227w	Type 25A	A33	2224w	Type 25A
A19	2389w	Type 25A	A34	2645w	Type 25A
A20	998w	Type 15A	A35	937w	Type 15A
A22	1071w	Type 15A	A37	1034w	Type 15A
A23	1071w	Type 15A	A38	1012w	Type 15A
A24	1088w	Type 15A	A39	990w	Type 15A
A25	2578w	Type 25A	A40	981w	Type 15A

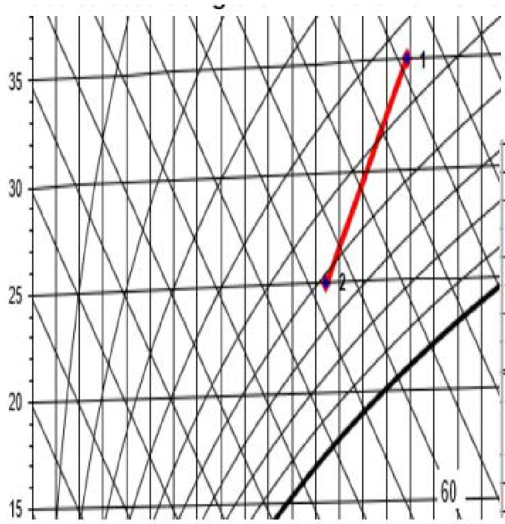
All room heat gain [43]

I choose the fully flat cassette as the indoor units for air conditioning that describe in previous chapter.And in my calculations , Room**A20 A22 A23 A24 A35 A37 A38 A39 A40**. Use type **15A** as indoor units. Other room use type **25A** as indoor units.

3.8Ventilation systems

As previous calculation, The total air flow rate is 2800m3/h. Choose the same brand as described in the previous chapter.So I choose NO.4 D-AHU modular P with 3100m3/h as AHU.

Calculated load using the HX-chart from C.I.C.



			1	2
Temperature	t	°C	35.0	25.0
Rel.humidity	φ	%	44%	62%
Abs. humidity	x	g/kg	15.8	12.4
Enthalpy	h	kJ/kg	76.0	56.9
Density	ρ	kg/m3	1.12	1.16
Wet bulb temp.	tv	°C	24.7	19.7
Act. air flow	Vs	m3/h	3,048	2,933
Nom. air flow	Vn	m3/h	2,800	2,800
Thermal power	P	kW		-17.8
Evap. water	qw	kg/h		-11.5

Summer Process [44]

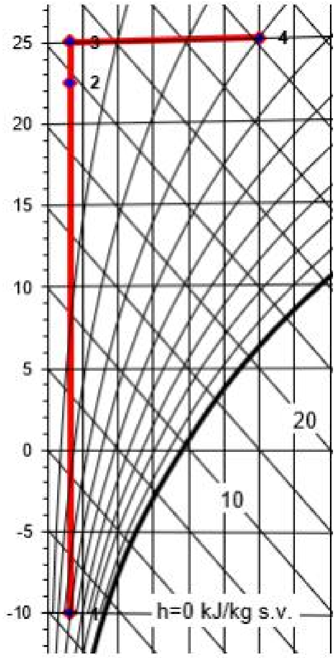
Where:

Point 1:outdoor conditions

Point 2:Supply fresh air from air handing unit

From the result chat show, The total cooling coil capacity is 17.8 KW.

And also should supply fresh in winter. The winter process is as follows:



			1	2	3	4
Temperature	t	°C	-10.0	22.5	25.0	25.0
Rel.humidity	φ	%	40%	4%	3%	30%
Abs. humidity	x	g/kg	0.6	0.6	0.6	6.0
Enthalpy	h	kJ/kg	-8.5	24.4	26.9	40.5
Density	ρ	kg/m3	1.32	1.18	1.17	1.16
Wet bulb temp.	tv	°C	-11.8	7.7	8.8	14.3
Act. air flow	Vs	m3/h	2,541	2,855	2,879	2,903
Nom. air flow	Vn	m3/h	2,800	2,800	2,800	2,800
Thermal power	P	kW		30.7	2.4	12.7
Evap. water	qw	kg/h		0.0	0.0	17.9

Winter process [45]

Although the outdoor temperature is different from the previous chapter, the indoor ventilation rate is the same, only related to the number of people and the room type. So the result of the pipeline calculation is actually the same, and the design of the pipeline is also the same. Refer to the previous chapter for details.

4.Chapter IV:Design air-conditioning in Beijing with Beijing envelop

4.1Introduction

To make the analyses easy and proper one, Will use the same building shape,same architecture plans in this designs.The difference is the enclosure structure.And indoor condition is same.

The building envelop is based on Beijing’s standards.

Wall:Use High-performance Aerated Concrete Blocks(250mm) plus Stone wool board(50mm).U-Value of wall is 0.4W/m².K.

Windows:Use Double-glazed(6+6mm).glass is “standard glass” with Sun-roller-blinds as inner sunshade.Shading coefficient is 0.7.U-value of window is 1.5W/m².K.

4.2Outdoor conditions and Solar intensity radiation

Because it is also in Beijing, it is the same as the value in the previous chapter

4.3Heat gains

For example. Room A11:

A11	length(m)	height(m)	width(m)	Quantity
Wall1	3.988	3.8	0	1
Wall2	5.418	3.8	0	1
window	1.95	1.85	0	2
ground	5.418	0	3.988	
	W		W	
Htwall	331			
Hwin,con	97	Hwin.rad	1714	
Hp	136			2

Room A11 [46]

All room external heat gain as below:

Room	Htwall	Htwin
A11	331 w	1812 w
A12-18	1254w	10609w
A19	382 w	1855w
A20	145 w	298 w
A22-23	273 w	595 w
A24	145 w	298 w
A25	316 w	1855 w
A26-33	898 w	12459w
A34	370 w	1812w
A35	74 w	254 w
A37	74 w	254 w
A38	74 w	254 w
A39	74 w	254 w
A40	74 w	254w

All room heat gain by windows and wall [47]

And all room internal heat gain as below：

Room	Ho	Happ	Hl
A11	136w	300w	216w
A12-18	952w	2100w	1477w
A19	136w	300w	211w
A20	136w	300w	232w
A22-23	272w	600w	616w
A24	136w	300w	323w
A25	136w	300w	214w
A26-33	1088w	2400w	1688w
A34	136w	300w	304w
A35	136w	300w	242w
A37	136w	300w	339w
A38	136w	300w	316w
A39	136w	300w	294w
A40	136w	300w	286w

All room internal heat gain [48]

So the total heat gain is sum of external heat gain an internal heat gain.So total heat gain is **56** kw.

4.4Air conditioning outdoor units and indoor units

After getting the total heat gain. It is necessary to choose a suitable air conditioning system.Choose the same brand as described in the previous chapter.

And because in my calculation the total heat gain in 6th floor is 56KW.So I Choose the **22T（REYQ10T+REYQ12T）** type VRV as the air conditioning outdoor units.

And results of all room heat gain show as below:

Room	Qgain	Units	Room	Qgain	Units
A11	2795w	Type 25A	A26	2317w	Type 25A
A12	2342w	Type 25A	A27	2317w	Type 25A
A13	2342w	Type 25A	A28	2317w	Type 25A
A14	2342w	Type 25A	A29	2317w	Type 25A
A15	2342w	Type 25A	A30	2317w	Type 25A
A16	2342w	Type 25A	A31	2317w	Type 25A
A17	2342w	Type 25A	A32	2317w	Type 25A
A18	2342w	Type 25A	A33	2317w	Type 25A
A19	2673w	Type 25A	A34	2921w	Type 32A
A20	1111w	Type 15A	A35	1007w	Type 15A
A22	1179w	Type 15A	A37	1103w	Type 15A
A23	1179w	Type 15A	A38	1081w	Type 15A
A24	1202w	Type 15A	A39	1059w	Type 15A
A25	2821w	Type 32A	A40	1050w	Type 15A

All room heat gain [49]

I choose the fully flat cassette as the indoor units for air conditioning that describe in previous chapter.And in my calculations , Room**A20~A24,A35~A40**. Use type **15A** as indoor units. Room **A25 A34** use type **32A**,Other room use type **25A** as indoor units.

4.5Ventilation systems

Because it is also designed in Beijing, the external and internal conditions have not changed, and the design of the ventilation system is not affected by the building envelop, So according to the previous design and calculation, The ventilation system is the same in this case.

5.Chapter V:Comparative analysis and Conclusion

After finish all calculations of three design for two places. make a comparative analysis and conclusion.and also speaking about the similarities.

Comparative of heat gains between three designs

1. Design AC and Ventilation in Prague with Czech envelop
2. Design AC and Ventilation in Beijing with Czech envelop
3. Design AC and Ventilation in Beijing with Beijing envelop

For design no.1

Total heat gain	2.4Kw(wall)	13.9Kw(windows)	16.3Kw （total）

For design no.2

Total heat gain	1.7Kw(wall)	32.3w(windows)	34Kw （total）

For design no.3

Total heat gain	4.5Kw(wall)	32.9Kw(windows)	37.4Kw （total）

Comparing 1 and 2, the wall heat gains is reduced by about 29%,and the window heat gains is increased by about 130%,and the overall gains increase is about 108%.Due to the difference of the outdoor conditions. Mainly because of the different geographical locations of Prague and Beijing, the heat exposure of the sun is very different. The main heat gain for windows is radiation gain，That’s why there is a big difference in heat gain of glass.And this determines that different outdoor conditions require air conditioning equipment with different loads.

Compared with 2 and 3, the wall heat gains is increased by about 164%,The window heat gains increased by about 3%, and the overall gains increase was about 10%.Due to the insulation in building in other terms difference of the heat transmittance coefficient (U-value).The difference in building insulation materials causes different heat gains to pass through the wall. Although the structure of the windows is different, But the main heat gain of the windows comes from solar radiation, so there is no big difference here.

Compared with 1 and 3, the wall heat gains is reduced by about 87%,and the window heat gains is increased by about 136%,and the overall gains increase is about 130%.Due to both differences of outdoor conditions and insulation(U-value).

For the design **no.1**, The AC outdoor units is VRV **Type REYQ14T**,Indoor units for different room are Type **FXZQ**,Room no.**A19~A24** use type **20A**,.Room no.**A25** use type **25A**,Other room use type **15A**.

For the design **no.2**, The AC outdoor units is VRV Type **REYQ 20T(REYQ8T+REYQ10T)**,Indoor units for different room are Type **FXZQ**,Room no.**A20,A22,A23,A24,A35,A37,A38,A39,A40**. Use type **15A**,Other room use type **25A.**

For the design **no.3**, The AC outdoor units is VRV Type **REYQ 22T(REYQ10T+REYQ12T)**,Indoor units for different room are Type **FXZQ**,Room **A20~A24,A35~A40**. Use type **15A**. Room no.**A25 A34** use type **32A**,Other room use type **25A**.

And for the Ventilation system,The ventilation flow rate is 2800 m^3/h, Because the ventilation flow rate only depends on the indoor conditions. So for three design the flow rate are same that have same indoor conditions and relative to the number of occupants.

Although the flow rate is the same, the coil capacity is different because of the difference external temperature.In Beijing, The higher temperature in summer, Need cooling coil capacity is larger than the demand in Prague.In winter,The temperature is higher too, So the heat coil capacity is smaller than the demand in Prague.

Last. Even the differences between the two outdoor condition and the building envelop(Czech and China). But the air-conditioning and ventilation is useful for any places using the same design principle and after analyzing.The only difference is the load, Because of the world climate,So only need to select the corresponding equipment according to the different load to meet people's comfort needs.And the differences is not too much, But the general concept remains the same.

Finally, because a comfortable indoor environment has a very important impact on people's life and work, AC and ventilation are needed everywhere. And follow the same rules for calculation and design .

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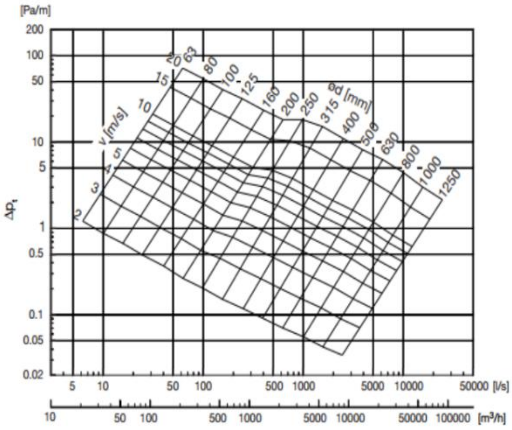
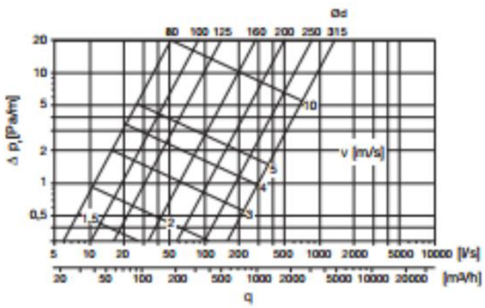
7.Appendix

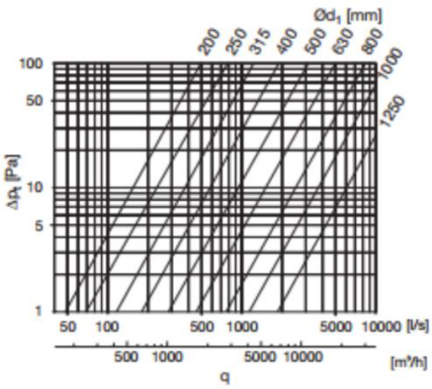
Table A: pressure loss chat from LINDAB



Duct and Duct pressure loss/Per length



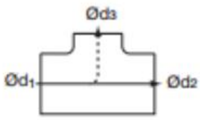
Flexible duct and Duct pressure loss/per length



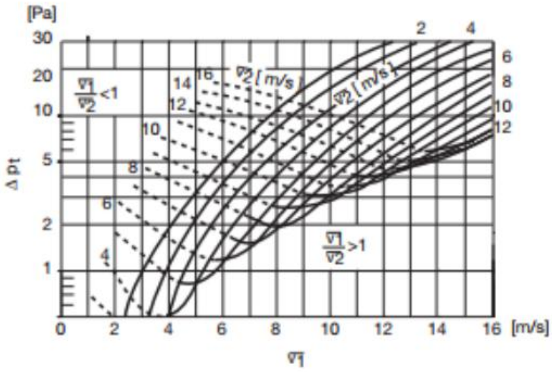
BKFU90 and BKU90 pressure loss

Tcpu

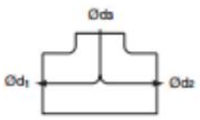
Diverging flow

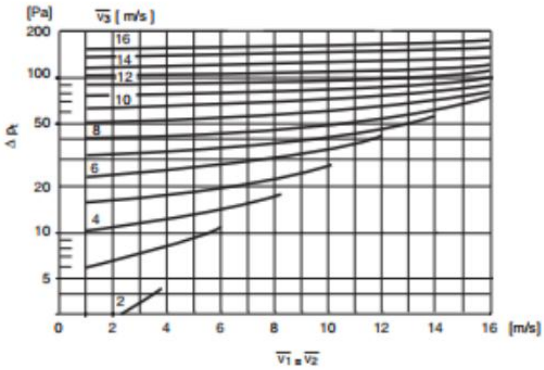


The diagram is also applicable to reduction in $Ød_2$.



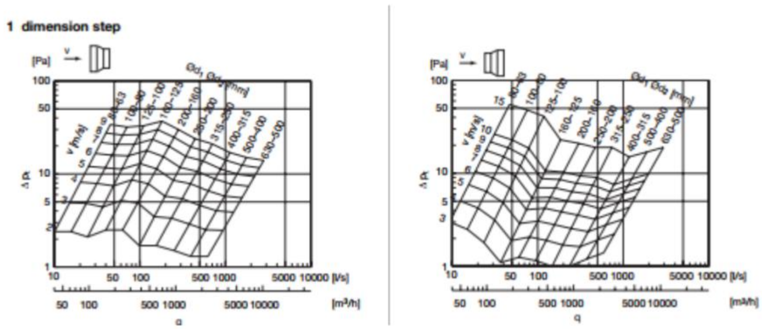
Diverging flow





Pressure loss for T-piece

Reducer(RCFU)



Reducer pressure loss

Table B: Room external heat gain (Prague)

A11	length(m)	height(m)	width(m)	Quantity	
Wall1	3.988	3.8	0	1	W
Wall2	5.418	3.8	0	1	N
window	1.95	1.85	0	2	
ground	5.418	0	3.988		
	W		W		
Htwall	159				
Hwin.con	29	Hwin.rad	351		
Hp	136			2	

A12-18	length(m)	height(m)	width(m)	Quantity	
Wall	3.925	3.8	0	1	W
window	1.95	1.85	0	1	
ground	5.375	0	3.925		
	W		W		
Htwall	101				
Hwin.con	14	Hwin.rad	175		
Hp	136			2	

A19	length(m)	height(m)	width(m)	Quantity
Wall1	3.925	3.8	0	1
Wall2	5.375	3.8	0	1
window	1.95	1.85	0	2
ground	5.375	0	3.925	
	W		W	
Htwall	229			
Hwin.con	29	Hwin.rad	1370	
Hp	136			2

A20	length(m)	height(m)	width(m)	Quantity	
Wall	4.11	3.8	0	1	S
window	1.95	1.85	0	1	
ground	5.65	0	4.11		
	W		W		
Htwall	91				
Hwin.con	14	Hwin.rad	1195		
Hp	136			2	

A22-23	length(m)	height(m)	width(m)	Quantity	
Wall	3.928	3.8	0	1	S
window	1.95	1.85	0	1	
ground	7.85	0	3.928		
	W		W		
Htwall	86				
Hwin.con	14	Hwin.rad	1195		
Hp	136			2	

A24	length(m)	height(m)	width(m)	Quantity
Wall	4.113	3.8	0	1
window	1.95	1.85	0	1
ground	7.85	0	4.113	
	W		W	
Htwall	91			
Hwin.con	14	Hwin.rad	1195	
Hp	136			2

A25	length(m)	height(m)	width(m)	Quantity	
Wall1	3.202	3.8	0	1	E
Wall2	5.38	3.8	0	1	S
window	1.95	1.85	0	2	
ground	5.38	0	3.985		
	W		W		
Htwall	185				
Hwin.con	29	Hwin.rad	1550		
Hp	136			2	

A26-33	length(m)	height(m)	width(m)	Quantity	
Wall	3.202	3.8	0	1	E
window	1.95	1.85	0	1	
ground	5.38	0	3.925		
	W		W		
Htwall	57				
Hwin.con	14	Hwin.rad	355		
Hp	136			2	

A34	length(m)	height(m)	width(m)	Quantity
Wall1	5.407	3.8	0	1
Wall2	5.616	3.8	0	1
window	1.95	1.85	0	2
ground	5.616	0	5.407	
	W		W	
Htwall	168			
Hwin.con	29	Hwin.rad	530	
Hp	136			2

A35	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.11	0	3.962		
	W		W		
Htwall	28				
Hwin.con	14	Hwin.rad	175		
Hp	136			2	

A37	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	8.635	0	3.925		
	W		W		
Htwall	28				
Hwin.con	14	Hwin.rad	175		
Hp	136			2	

A38	length(m)	height(m)	width(m)	Quantity
Wall	3.188	3.8	0	1
window	1.95	1.85	0	1
ground	8.059	0	3.925	
	W		W	
Htwall	28			
Hwin.con	14	Hwin.rad	175	
Hp	136			2

A39	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	7.501	0	3.925		
	W		W		
Htwall	28				
Hwin.con	14	Hwin.rad	175		
Hp	136			2	

A40	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.942	0	4.113		
	W		W		
Htwall	28				
Hwin.con	14	Hwin.rad	175		
Hp	136			2	

Table B1: Total heat gain (Prague)

Room	Htwall	Htwin	Ho	Hcom	Hl
A11	159	380	136	300	216
A12-18	710	1242	952	2100	1477
A19	229	1399	136	300	211
A20	91	1209	136	300	232
A22-23	172	2418	272	600	616
A24	91	1209	136	300	323
A25	185	1579	136	300	214
A26-33	456	2955	1088	2400	1688
A34	168	559	136	300	304
A35	28	190	136	300	242
A37	28	190	136	300	339
A38	28	190	136	300	316
A39	28	190	136	300	294
A40	28	190	136	300	286
Total	2401	13899	3808	8400	6758

Table C: Room external heat gain (Beijing)

A11	length(m)	height(m)	width(m)	Quantity	
Wall1	3.988	3.8	0	1	W
Wall2	5.418	3.8	0	1	N
window	1.95	1.85	0	2	
ground	5.418	0	3.988		
	W		W		
Htwall	124				
Hwin.con	52	Hwin.rad	1714		
Hp	136			2	

A12-18	length(m)	height(m)	width(m)	Quantity	
Wall	3.925	3.8	0	1	W
window	1.95	1.85	0	1	
ground	5.375	0	3.925		
	W		W		
Htwall	67				
Hwin.con	26	Hwin.rad	1509		
Hp	136			2	

A19	length(m)	height(m)	width(m)	Quantity
Wall1	3.925	3.8	0	1
Wall2	5.375	3.8	0	1
window	1.95	1.85	0	2
ground	5.375	0	3.925	
	W		W	
Htwall	143			
Hwin.con	52	Hwin.rad	1758	
Hp	136			2

A20	length(m)	height(m)	width(m)	Quantity	
Wall	4.11	3.8	0	1	S
window	1.95	1.85	0	1	
ground	5.65	0	4.11		
	W		W		
Htwall	54				
Hwin.con	26	Hwin.rad	249		
Hp	136			2	

A22-23	length(m)	height(m)	width(m)	Quantity	
Wall	3.928	3.8	0	1	S
window	1.95	1.85	0	1	
ground	7.85	0	3.928		
	W		W		
Htwall	51				
Hwin.con	26	Hwin.rad	249		
Hp	136			2	

A24	length(m)	height(m)	width(m)	Quantity
Wall	4.113	3.8	0	1
window	1.95	1.85	0	1
ground	7.85	0	4.113	
	W		W	
Htwall	54			
Hwin.con	26	Hwin.rad	249	
Hp	136			2

A25	length(m)	height(m)	width(m)	Quantity	
Wall1	3.202	3.8	0	1	E
Wall2	5.38	3.8	0	1	S
window	1.95	1.85	0	2	
ground	5.38	0	3.985		
	W		W		
Htwall	118				
Hwin.con	52	Hwin.rad	1758		
Hp	136			2	

A26-33	length(m)	height(m)	width(m)	Quantity	
Wall	3.202	3.8	0	1	E
window	1.95	1.85	0	1	
ground	5.38	0	3.925		
	W		W		
Htwall	42				
Hwin.con	26	Hwin.rad	1509		
Hp	136			2	

A34	length(m)	height(m)	width(m)	Quantity
Wall1	5.407	3.8	0	1
Wall2	5.616	3.8	0	1
window	1.95	1.85	0	2
ground	5.616	0	5.407	
	W		W	
Htwall	139			
Hwin.con	52	Hwin.rad	1714	
Hp	136			2

A35	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.11	0	3.962		
	W		W		
Htwall	28				
Hwin.con	26	Hwin.rad	206		
Hp	136			2	

A37	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	8.635	0	3.925		
	W		W		
Htwall	28				
Hwin.con	26	Hwin.rad	206		
Hp	136			2	

A38	length(m)	height(m)	width(m)	Quantity
Wall	3.188	3.8	0	1
window	1.95	1.85	0	1
ground	8.059	0	3.925	
	W		W	
Htwall	28			
Hwin.con	26	Hwin.rad	206	
Hp	136			2

A39	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	7.501	0	3.925		
	W		W		
Htwall	28				
Hwin.con	26	Hwin.rad	206		
Hp	136			2	

A40	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.942	0	4.113		
	W		W		
Htwall	28				
Hwin.con	26	Hwin.rad	206		
Hp	136			2	

Table C1: Total heat gain (Beijing)

Room	Htwall	Htwin	Ho	Hcom	Hl
A11	124	1766	136	300	216
A12-18	470	10587	952	2100	1477
A19	143	1810	136	300	211
A20	54	275	136	300	232
A22-23	103	550	272	600	616
A24	54	275	136	300	323
A25	118	1810	136	300	214
A26-33	337	12277	1088	2400	1688
A34	139	1766	136	300	304
A35	28	232	136	300	242
A37	28	232	136	300	339
A38	28	232	136	300	316
A39	28	232	136	300	294
A40	28	232	136	300	286
Total	1682	32273	3808	8400	6758

Table D: Room external heat gain (Beijing envelop)

A11	length(m)	height(m)	width(m)	Quantity	
Wall1	3.988	3.8	0	1	W
Wall2	5.418	3.8	0	1	N
window	1.95	1.85	0	2	
ground	5.418	0	3.988		
	W		W		
Htwall	331				
Hwin.con	97	Hwin.rad	1714		
Hp	136			2	

A12-18	length(m)	height(m)	width(m)	Quantity	
Wall	3.925	3.8	0	1	W
window	1.95	1.85	0	1	
ground	5.375	0	3.925		
	W		W		
Htwall	179				
Hwin.con	49	Hwin.rad	1509		
Hp	136			2	

A19	length(m)	height(m)	width(m)	Quantity
Wall1	3.925	3.8	0	1
Wall2	5.375	3.8	0	1
window	1.95	1.85	0	2
ground	5.375	0	3.925	
	W		W	
Htwall	382			
Hwin.con	97	Hwin.rad	1758	
Hp	136			2

A20	length(m)	height(m)	width(m)	Quantity	
Wall	4.11	3.8	0	1	S
window	1.95	1.85	0	1	
ground	5.65	0	4.11		
	W		W		
Htwall	145				
Hwin.con	49	Hwin.rad	249		
Hp	136			2	

A22-23	length(m)	height(m)	width(m)	Quantity	
Wall	3.928	3.8	0	1	S
window	1.95	1.85	0	1	
ground	7.85	0	3.928		
	W		W		
Htwall	137				
Hwin.con	49	Hwin.rad	249		
Hp	136			2	

A24	length(m)	height(m)	width(m)	Quantity
Wall	4.113	3.8	0	1
window	1.95	1.85	0	1
ground	7.85	0	4.113	
	W		W	
Htwall	145			
Hwin.con	49	Hwin.rad	249	
Hp	136			2

A25	length(m)	height(m)	width(m)	Quantity	
Wall1	3.202	3.8	0	1	E
Wall2	5.38	3.8	0	1	S
window	1.95	1.85	0	2	
ground	5.38	0	3.985		
	W		W		
Htwall	316				
Hwin.con	97	Hwin.rad	1758		
Hp	136			2	

A26-33	length(m)	height(m)	width(m)	Quantity	
Wall	3.202	3.8	0	1	E
window	1.95	1.85	0	1	
ground	5.38	0	3.925		
	W		W		
Htwall	112				
Hwin.con	49	Hwin.rad	1509		
Hp	136			2	

A34	length(m)	height(m)	width(m)	Quantity
Wall1	5.407	3.8	0	1
Wall2	5.616	3.8	0	1
window	1.95	1.85	0	2
ground	5.616	0	5.407	
	W		W	
Htwall	370			
Hwin.con	97	Hwin.rad	1714	
Hp	136			2

A35	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.11	0	3.962		
	W		W		
Htwall	74				
Hwin.con	49	Hwin.rad	206		
Hp	136			2	

A37	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	8.635	0	3.925		
	W		W		
Htwall	74				
Hwin.con	49	Hwin.rad	206		
Hp	136			2	

A38	length(m)	height(m)	width(m)	Quantity
Wall	3.188	3.8	0	1
window	1.95	1.85	0	1
ground	8.059	0	3.925	
	W		W	
Htwall	74			
Hwin.con	49	Hwin.rad	206	
Hp	136			2

A39	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	7.501	0	3.925		
	W		W		
Htwall	74				
Hwin.con	49	Hwin.rad	206		
Hp	136			2	

A40	length(m)	height(m)	width(m)	Quantity	
Wall	3.188	3.8	0	1	N
window	1.95	1.85	0	1	
ground	6.942	0	4.113		
	W		W		
Htwall	74				
Hwin.con	49	Hwin.rad	206		
Hp	136			2	

Table D1: Total heat gain (Beijing envelop)

Room	Htwall	Htwin	Ho	Hcom	Hl
A11	331	1812	136	300	216
A12-18	1254	10609	952	2100	1477
A19	382	1855	136	300	211
A20	145	298	136	300	232
A22-23	273	595	272	600	616
A24	145	298	136	300	323
A25	316	1855	136	300	214
A26-33	898	12459	1088	2400	1688
A34	370	1812	136	300	304
A35	74	254	136	300	242
A37	74	254	136	300	339
A38	74	254	136	300	316
A39	74	254	136	300	294
A40	74	254	136	300	286
Total	4486	32864	3808	8400	6758

Table E: ventilation(supply)

No	L	V	V	u	D	DN	W	P	Ploss	T (BU)	DIFFUSER	RCFU	BFU 15	BKFU
-	m	m3/h	m3/s	m/s	mm	m	m/s	pa/m	pa	PA	PA	PA	PA	PA
1	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	9	108			
2	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
3	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
4	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
5	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	19				
6	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	9	87			
7	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
8	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
9	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18				
10	3.3	100	0.028	6	77	0.08	5.53	5.5	18.15	18	186	3		
11	4.1	100	0.028	8	67	0.08	5.53	5.5	22.55	2		5		
12	4.1	200	0.056	8	94	0.1	7.08	6.5	26.65	1.9		3.2		
13	4.1	300	0.083	8	115	0.125	6.79	6	24.6	1.8		4		
14	4.1	400	0.111	8	133	0.14	7.22	5.8	23.78	2.1		2		
15	4.1	500	0.139	8	149	0.15	7.86	4.8	19.68	17		3		
16	4.1	100	0.028	8	67	0.08	5.53	5.5	22.55	2		5		
17	4.1	200	0.056	8	94	0.1	7.08	6.5	26.65	1.9		3.2		
18	4.1	300	0.083	8	115	0.125	6.79	6	24.6	1.8		4		
19	4.1	400	0.111	8	133	0.14	7.22	5.8	23.78	20		3	1.1	15
20	5.3	100	0.028	6	77	0.08	5.53	5.5	29.15	9	45			
21	5.3	100	0.028	6	77	0.08	5.53	5.5	29.15	18				
22	5.3	100	0.028	6	77	0.08	5.53	5.5	29.15	18				
23	4.15	100	0.028	8	67	0.08	5.53	5.5	22.83	2		5		
24	4.15	200	0.056	8	94	0.1	7.08	6.5	26.98	1.9		3.2		
25	4.15	300	0.083	8	115	0.125	6.79	6	24.90	18				
25.5	8.5	400	0.111	8	133	0.14	7.22	5.8	49.30	19				
27	10.5	100	0.028	6	77	0.08	5.53	5.5	57.75	9	118	3		
28	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	9	93			
29	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
30	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
31	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
32	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	17	207	3		
33	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	9	97			
34	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
35	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
36	3.15	100	0.028	6	77	0.08	5.53	5.5	17.33	18				
37	4.1	100	0.028	8	67	0.08	5.53	5.5	22.55	2		5		
38	4.1	200	0.056	8	94	0.125	4.53	2.5	10.25	1.9		3.2		
39	4.1	300	0.083	8	115	0.14	5.42	5.8	23.78	1.8		4		
40	4.1	400	0.111	8	133	0.15	6.29	4.8	19.68	31				
41	4.1	100	0.028	8	67	0.08	5.53	5.5	22.55	2		5		
42	4.1	200	0.056	8	94	0.1	7.08	6.5	26.65	1.9		3.2		
43	4.1	300	0.083	8	115	0.125	6.79	6	24.6	1.8		4		
44	4.1	400	0.111	8	133	0.14	7.22	5.8	23.78	2.2		3		
26.5	1.4	900	0.250	8	200	0.2	7.96	5.4	7.56	1.6		3.2		
45	4.45	100	0.028	6	77	0.08	5.53	5.5	24.48	9	187			
46	4.45	100	0.028	6	77	0.08	5.53	5.5	24.48	18				
47	3.45	100	0.028	6	77	0.08	5.53	5.5	18.98	18	135			
48	4.45	100	0.028	6	77	0.08	5.53	5.5	24.48	18				
49	4.45	100	0.028	6	77	0.08	5.53	5.5	24.48	18		5		
50	4.2	100	0.028	8	67	0.08	5.53	5.5	23.1	2		5		
51	4.2	200	0.056	8	94	0.1	7.08	6.5	27.3	6				
52	13.8	100	0.028	8	67	0.08	5.53	5.5	75.9	2				
53	4.2	200	0.056	8	94	0.1	7.08	6.5	27.3	1.8		5		
26	10	1300	0.361	8	240	0.25	7.36	3.3	33	38		4.3		
55	10.6	1000	0.278	8	210	0.25	5.66	3.5	37.1	22		4		
54	8.8	500	0.139	8	149	0.15	7.86	7	61.6	40		4		
56	3.2	2300	0.639	10	285	0.315	8.20	2.5	8	50				
57	7.6	2800	0.778	10	315	0.315	9.99	2	15.2	18				

Table E1: ventilation(exhaust)

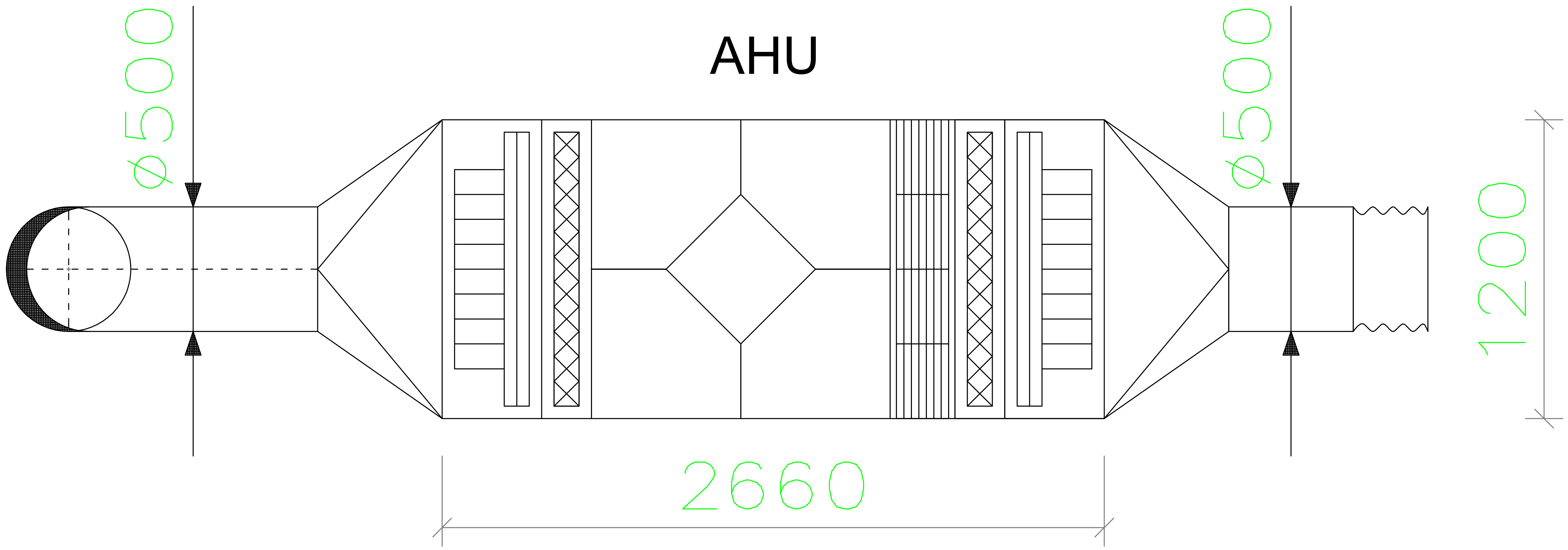
No	L	V	V	u	D	DN	W	P	Ploss	T (BU)	RCFU	Diffuser
-	m	m3/h	m3/s	m/s	mm	m	m/s	pa/m	pa	PA	PA	
1	4.75	50	0.014	6	54	0.08	2.76	1.8	8.55	7.6		76
2	1.6	50	0.014	6	54	0.08	2.76	1.8	2.88	8		
3	1.8	100	0.028	8	67	0.08	5.53	7	12.6	0.8	10	
4	3.85	50	0.014	6	54	0.08	2.76	1.8	6.93	7.5	10	
5	3	150	0.042	8	81	0.1	5.31	2.8	8.4	6		
6	9	150	0.042	8	81	0.1	5.31	2.8	25.2	1.8	4.8	
7	1.8	50	0.014	6	54	0.08	2.76	1.8	3.24	0.8		
8	2.35	100	0.028	6	77	0.08	5.53	7	16.45	1.2	4.8	
9	2.35	150	0.042	6	94	0.125	3.40	1.1	2.585	8		
10	0.5	300	0.083	8	115	0.125	6.79	1.6	0.8	1.8	2	
11	5	1225	0.340	8	233	0.25	6.94	0.7	3.5	30	6	90
12	10.5	1275	0.354	8	237	0.355	3.58	1.6	16.8	30		
13	5.7	1225	0.340	8	233	0.25	6.94	0.7	3.99	12	6	60
14	12	50	0.014	8	47	0.08	2.76	1.8	21.6	12	4	45
15	4	2500	0.694	8	333	0.5	3.54	1.8	7.2	30		
16	7.6	2800	0.778	10	315	0.5	3.96	1.8	13.68	21		

1.1:Difuuser made by lindabType DR24
1.2:AC Indoor units made by Daikin type FXZQ 15A
1.21 type FXZQ 25A
1.22 type FXZQ 20A

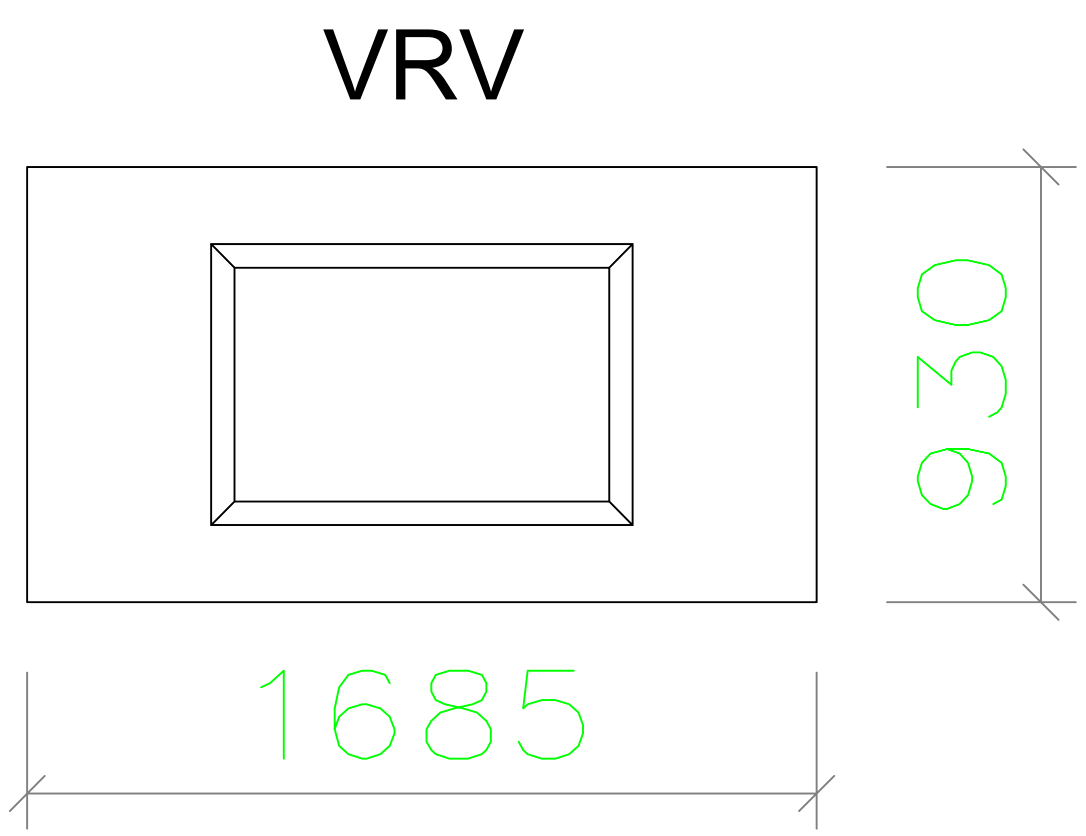
Name: YangJunHao	academic year: 2020-2021	Scale: 1:50
Diploma Thesis: Design AC of a office building		Department of Environmental Engineering
Schematic plan: Supply air plane figure		Date: 12/2020

1.1:Difuuser made by lindabType DR24

Name: YangJunHao	academic year: 2020-2021	Scale: 1:50
Diploma Thesis: Design AC of a office building		Department of Environmental Engineering
Schematic plan: Exhaust air plane figure		Date: 12/2020



AHU:Daikin D-AHU Modular P (4)



VRV:Daikin VRV REYQ14T

Name: YangJunHao	academic year: 2020-2021	Scale: 1:1
Diploma Thesis: Design AC of a office building		Department of Environmental Engineering
Schematic plan: Floor plane figure		Date: 12/2020