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Quantitative analysis of thermal behavior and ventilation in the buildings of schools in the temperate and humid climate of Rasht city

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Abstract

Introduction: One of the most important issues in the design of educational buildings, especially schools, is providing thermal comfort for students in classrooms. If the design is correct, in addition to providing the thermal comfort needed by the students, we will reduce the energy consumption in these buildings. The purpose of the research: analysis of the thermal behavior in the school buildings of Rasht city, in order to identify the damages and problems in the buildings built by the General Department of Renovation, Development and Equipping of Schools in Gilan Province. Research Methodology: In this research, an attempt has been made to simulate one of the schools in the temperate and humid climate of Rasht city in the accurate design builder software, and with the powerful engine of Energy Plus, the thermal behavior in this school has been tried in order to investigate and generalize it to other schools in the climate. Let's analyze the moderate and humid city of Rasht Geographical scope of the research: This research was conducted in the temperate and humid climate of Gilan province, Rasht city. Results: After the simulation, it was determined that the location of the air intake and exhaust windows was suitable according to the CFD analysis and the building had good natural ventilation throughout the year. Also, the results show that the wall with 23%, lighting with 21%, glass with 20% and equipment with 17% respectively include the most energy loss in this building. Analyzing the heat loss in the coldest month of the year in the studied school, graph 5- but it is facing a big difference with the energy loss in the warm month of the year. In the coldest month of the year, the external wall with 48%, glass with 26% and roof with 20% of energy loss account for the most energy loss in this building.

Keywords: school, stable, ventilation, heat
2020 MSC: 80A05

1 Introduction

From the point of view of the global approach in the field of energy, the increase in energy demand, the limitation of fossil energy resources and the increase in its price, and the lack of security and stability of the energy market in recent decades, along with the issue of pollution and global warming, are the basis of a new approach in the energy issue. Currently, the office and residential building sector accounts for about 40% of the non-renewable energy consumption

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of our country, which is inevitable to focus on this sector in order to optimize energy consumption and control energy demand in buildings [25]. Paying attention to the consequences of excessive energy consumption on the environment and its economic effects, as well as the depletion of fossil fuels in the near future, has caused the reduction of energy consumption, especially fossil fuels, to be noticed by experts in various related sectors; Because the management of the energy sector is very important due to various changes [30]. Buildings are one of the most important energy-consuming sectors in cities, which in different countries have a different share in energy consumption compared to other sectors due to their different characteristics [9]. Optimizing the amount of energy consumption in the building for air heating and cooling is one of the basic issues of optimizing the energy consumption in the building, which depends on various factors such as the constituent materials, the surface of the outer shell of the building, the surface of the roof, the direction of the building, the characteristics of absorbing radiation, Active solar systems and... are effective in this field [21].

The energy crisis in the seventies and the subsequent environmental problems cast a shadow on many human activities and faced a difficult challenge in the field of architectural and urban design, which had a large contribution to energy consumption and environmental pollution. At the same time, the contribution of public buildings in the energy consumption of countries is also significant, for this reason, in the last few decades, in most industrialized countries, basic measures have been taken in the field of reforming the consumption pattern by using different tools. On the other hand, regulating the environmental conditions of educational spaces is one of the most important principles and requirements of education, because until the necessary environmental conditions are established in each educational space, education cannot take place in that space. Therefore, the need to address this issue is important because on the one hand it has brought economic and environmental issues under the radius and on the other hand it can provide a lot of help to the architecture and design of the present era from the cultural and educational aspect. Because the sustainable school building is designed based on the principles of energy saving and environmental protection. And in this type of schools, the only goal is not to consume less energy resources, but its importance is in the effect it has on the students' morale. The entry of natural light into classrooms and the improvement of indoor air quality, two elements of sustainable building design, have direct effects on students' performance [12]. The best time to reduce energy consumption and of course reduce energy consumption costs in the building is during the initial design of the building. One of the important points that is essential to observe and consider in the optimization of energy consumption in the building is the reduction of energy consumption during the operation of the building [3]. This energy consumption is used in order to provide thermal comfort. The importance of school space in the physical and mental health of students and the lack of attention to natural ventilation and the quality of the indoor space in Iranian schools require a deep review in order to improve the quality of educational buildings. The country of Iran, due to its geographical location and climatic characteristics, has There are different climates. This has caused one of the important criteria in the design of buildings to pay attention to the climatic characteristics of different regions. The need of the residents of a building for thermal, visual and acoustic comfort is also different depending on the type of building and climate [16]. Optimizing means providing thermal comfort with the least amount of energy. In Gilan region, one of the main ways to provide thermal comfort is to create a natural ventilation mechanism in the schools of Rasht city.

Buildings are designed to achieve a suitable environment for providing human comfort. Environmental and climatic conditions are very important components in building design [10]. The creation of human comfort conditions in different environments is done through the implementation of a series of operations on the air, such as increasing or decreasing the temperature and humidity, as well as reducing the amount of harmful gases and compounds in the air [34]. Among these, one of the most important spaces for providing thermal comfort and reducing the consumption of educational spaces, especially schools. Thermal comfort conditions are a range of temperature and humidity in which the body's thermoregulation mechanism is at its minimum activity [15]. The factors of air temperature, relative humidity, air flow speed, average radiant temperature, body metabolism rate and the amount of body covering are effective in determining the range of thermal comfort [11]. Since natural ventilation regulates humidity and temperature, it can be concluded that one of the most effective factors in creating thermal comfort is ventilation [29]. According to the thermal comfort standard of Olgy, the comfort range in terms of temperature is between 21 and 27.7 degrees Celsius and in terms of humidity between 30 and 65% [24]. According to the standard of the United States of America, this range is between 22.2 and 25.6 degrees Celsius in terms of temperature and between 20 and 80% in terms of humidity [5]. The meaning of natural ventilation is the use of the process of moving air inside the building with fresh air outside the building, without the use of facilities and using fossil energy, the presence of air flow inside the building is a necessary condition for achieving comfort, but it is not sufficient. Therefore, it should be: a) air flow should be established in the required place) this flow should have a suitable speed to create comfort [29]. The driving force of this flow can be thermal or movement (wind) [19] the air moves due to the pressure difference and the wind causes the air to flow from one point to another and plays an important role in the thermal comfort of the house [32]. Heat flow

occurs when there is a difference in density between the internal and external environment, which is also caused by the difference in temperature inside and outside the room [22]. For ventilation inside the building, it is better to have two-way ventilation and the air flow enters from one side and exits from the other side or the ceiling of the room [27].

In this process, the air inside the building, which has become heavy due to exhalation, skin breathing, bad smell, smoking and the like, is replaced with fresh and light air outside. and increases oxygen gas and decreases carbon dioxide inside the building [35]. Air conditioning is the act of replacing or moving air in a space, which is done in order to provide fresh air, remove hot and humid air, cool the space and provide human thermal comfort. In the natural ventilation method, air movement is done through the chimney effect, which is based on the movement of hot air up and the entry of cold air from the bottom instead of it, or through air blinds, where air movement is done through positive and negative wind pressure [27]. Today, attention to the use of natural ventilation in building designs is increasing and designers are trying to increase the satisfaction of the users of the spaces, as well as reduce the costs of construction and maintenance and reduce energy consumption. The forces that cause natural ventilation can be summarized in two general factors [8]. Wind forces and buoyancy. These forces determine the mechanisms involved in natural ventilation. The shape and location of the building (for example, being in an open or dense environment, or being high or low) determines how the building is naturally ventilated. Based on this, three modes for natural ventilation can be considered: one-way ventilation, two-way ventilation and chimney ventilation, each of these modes shows how the air inside the building that needs ventilation is related to the outside air flow [23]. Therefore, the architecture of the temperate and humid climate of the north of the country, especially the city of Rasht, has features to provide the thermal comfort of the building used by the users.

Due to the high level of humidity, no part of the building is located in the basement. Because in addition to the high level of surface water in the area, it is almost impossible to ventilate the basement space. The floor of the building is separated from the ground and the distance between the floor of the building and the ground level varies from one to three meters. In this case, in addition to being cooled by the air flow from under the building, the building is located at a higher height and more air flows into the space. Due to the high rainfall, the roofs are sloped and run with a steep slope, and wide and covered balconies around the rooms are created to protect from the rain. In this climate, the area of openings is more than other climates. According to the specific conditions of the region, these openings are installed in all directions of the building to maximize natural ventilation [27]. Urban texture: It is completely open and wide to provide conditions for ventilation and blinds, and to create an open texture, buildings are built completely separate and apart from each other, but they are connected to each other in urban centers. In this area, the urban spaces are relatively wide, the areas with short walls and the alleys are relatively wide [36]. Building materials: The building materials used in the body of the walls and the body of the building are selected from light materials with low heat capacity and low thickness. to be the materials should be chosen in such a way that, in addition to being resistant to the high humidity of the area, they do not prevent the flow of air into the spaces [36]. This issue should be followed seriously in educational spaces and school buildings.

The physical solutions to create natural ventilation can be divided into three types in terms of the place of use: physical arrangements in the roof, physical arrangements in the facade and body of the building, and a combination of the two [8]. In order to use natural ventilation, different solutions are used. Badkhor, badkhan, solar chimneys, ventilated windows on one side or on both sides, double skin facades and the use of atrium based on the effect of chimneys are among the common solutions for natural ventilation [2]. Placement and form of the building: the east-west extension of the building perpendicular to the north-south extension of the land (according to the daily wind direction which is mostly north-south) And avoid designing spaces in a nested and multi-layered manner [7]. In natural ventilation, the roof is very important. Because warm air tends to move upwards due to its lightness. In addition On top of that, the air currents that pass through the roof surface are stronger and more stable, as well as natural ventilation from the roof for low-rise and enclosed buildings, where the air flow around it is low, as well as buildings around which there is noise and Air pollution is high, it is suitable [14]. According to the studies carried out in accordance with the topic of the research, considering the novelty of the work in the field of education in Rasht city. Some of the researches that have been carried out can be mentioned by Shaghaig Mohammad in the research titled "Study of the thermal behavior of common materials in wall construction, case study: residential buildings of Tehran" in which he simulated the behavior of different types of walls that are composed of Clay blocks, Lika, Hablex and thermal insulation are made and are common in residential buildings in Tehran. While paying and analyzing the results, things such as the different role of thermal mass and thermal insulation, definition of dynamic thermal characteristics and the behavior of material cycles in the face of unstable environmental conditions are stated. The research results show the necessity of using unsteady calculations instead of the conventional method of stable calculations. Also, among the types of walls introduced, the wall made of two rows of 10 cm Lika blocks with 5 cm of insulation in the middle is considered the most suitable in terms of the ability to provide thermal comfort [31].

Mehdizadeh et al. in an article titled "The effect of the presence of an entrance on the thermal behavior of the main space in the hot and dry climate of Iran (investigation of old houses in Yazd city)" in this research, the graphs show the positive effect of the anterooms, respectively, in heating and cooling. The main spaces were in the winter and summer seasons. It should be mentioned that the simulation of the conditions in the mentioned software has been done on the two sides of the building, south and north, according to the way the residents use these spaces in different seasons. The positive effect of our intermediate and intermediate spaces between open and closed spaces shows the advantage of using this idea in the new designs of this climate, in addition to using modern equipment and science, traditional architectural design patterns and valuable experiences gained from hundreds of years. The continuous experience of the predecessors is also properly utilized.

In this research, Lai et al. investigates the effective parameters related to building form on the energy used for office buildings in a specific area in China. The input variables to the Fluent software are the relationship ratio, the wall-to-window ratio, the number of floors and all sizes. The results showed that some of the floors have more influence and power in heating the annual energy and are heavily used. as the scale of buildings has the greatest impact on cooling and electricity [37]. In this article, a residential duplex in a region of Italy has been investigated with the following parameters: regional climate, penetration rate, percentage of openings and wind strength in two independent buildings with thermal dynamic simulation. The software used is Energy Pulse and Fluent. And the simulation results show that the geometry structure and surrounding environment play an important role in determining the effect of wind in the building [26].

2 Equations

Today, we see the use of mathematics to solve problems in all sciences [1, 13, 33, 38]. The main structure of problems related to heat transfer and fluids are the governing equations that derive directly from the laws of conservation of the physical properties of the fluid. The conservation laws include three laws in all fluid mechanics problems. The first law is the law of conservation of mass, which is represented by the continuity equation. The second law shows the law of conservation of momentum, which can be calculated using the momentum equation and Newton's second law, and the third law shows the conservation of energy. It should be noted that the energy conservation relationship can be calculated using the first law of thermodynamics or the energy equation. The above laws show that mass, momentum and energy are constant in a closed system. In fact, it can be basically stated that whatever comes into the system (mass, momentum and energy) must go out of the system or somewhere else. Determining the properties of the fluid whose thermal parameters are changing can be done using these three laws of survival. In fact, by using these three governing equations, three main parameters, i.e. pressure p, speed v and temperature T can be measured. For example, when in the governing equations, pressure and temperature are known as two independent thermodynamic variables, other fluid properties such as density, enthalpy, viscosity, and thermal conductivity can be expressed in terms of these two parameters (pressure and temperature). Another point that should be taken care of when starting to use the governing equations and Navier-Stokes equations is the presence of Eulerian and Lagrangian perspectives in fluid mechanics. The Lagrangian perspective follows the properties of a sufficiently large fluid particle. In this case, the initial position at time t0 and the final position at time t1 must be calculated, but it is impossible to follow millions of particles separately from each other in a fluid flow. In the second method, the Eulerian method, the particles are not tracked individually and instead, the velocity field is studied as a function of space and time.

The Lagrangian view always has a time-dependent solution. In fact, considering that this view follows the movement of the fluid particle over time, we can conclude that this view will always be a function of time. So, if the initial location of a particle is represented by b, a and c. The position of this particle at time t can be shown as follows.

$$x = x(a, b, c, t) \qquad y = y(a, b, c, t) \qquad z = z(a, b, c, t)$$

In Eulerian's view, v, u and w represent the three components of the velocity of a point with coordinates (x, y, z) and at time t. In fact, in this case, v, u, and w are our unknowns, which are considered a function of independent variables z, y, x, and t. Therefore, the description of the motion in the Lagrangian perspective for each particle at time t is done using the following functions.

$$u = u(x, y, z, t) \qquad v = v(x, y, z, t) \qquad w = w(x, y, z, t)$$

2.1 survival of the fittest

The equation of conservation of mass can be expressed using the following equation.

$$\frac{D\rho}{Dt} + \rho(\nabla \cdot \vec{v}) = 0$$

In the above relation, ρ represents the density and the vector v represents the speed. Also, the ∇ symbol represents the gradient. The gradient vector is defined using the following relation.

$$\vec{\nabla} = \vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}$$

If the density in a subject is a constant value, the fluid is considered incompressible and the following relation can be expressed for the density $\frac{D\rho}{Dt} = 0$. By applying the above condition in the continuity equation, finally the continuity equation becomes the following simplified form:

$$\nabla \cdot \vec{v} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

Conservation of momentum the conservation of momentum equation can be shown in the following form using the Navier-Stokes equation:

$$\overbrace{\frac{\partial}{\partial t}(\rho\vec{v})}^{I} + \overbrace{\nabla \cdot (\rho\vec{v}\vec{v})}^{II} = \overbrace{-\nabla p}^{III} + \overbrace{\nabla \cdot (\bar{\bar{\tau}})}^{IV} + \overbrace{\rho\vec{g}}^{V}$$

In this regard, p represents the static pressure and τ represents the viscous stress tensor. Also, the term $\rho \longrightarrow g$ represents the force of gravity.

3 Research method

In this research, in order to analyze and calculate the index of changes in thermal behavior and ventilation in order to calculate the amount of energy consumption in the studied sample school, the educational building of the school in the city of Rasht has been analyzed. Before selecting the sample school, several school cases were visited in the field, and finally Hassan Hojjati School was selected as the sample. To a great extent, this school can be a very good representative for new schools built in Rasht. The US Department of Energy is dedicated to introducing selected simulator software; More than 395 energy consumption simulation software have been introduced. These softwares are effective in various fields of measuring the amount of energy efficiency, renewable energy and other aspects of simulation leading to sustainability. A brief explanation of each of the softwares, explaining the required expertise, the type of inputs and outputs, and the strengths and weaknesses of the softwares, is available on the mentioned internet site. It should be mentioned that some of the existing simulation software use common computing engines. For example, EnergyPlus computing engine is used in many simulation tools, including Design Builder software [**?**]. Design Builder software is one of the most reliable energy simulation software in the world, which uses its powerful engine to analyze information. And it is one of the most reliable energy analysis software for carrying out scientific and executive research in the world. which is used in this research.

4 The geographical scope of the research

The northern provinces of Iran are centered on the city of Rasht. This province is connected to the Caspian Sea from the north and has a water border with the countries along the sea, and through Astara it also has a land border with the Republic of Azerbaijan, from the west to Ardabil province, from the south to It is bordered by Zanjan and Qazvin provinces and Mazandaran province from the east. The area of Gilan is 14,044 square kilometers and its population is 2,480,874 people according to the 1391 census. Gilan province is divided into 16 cities, which are: Astara, Astana Ashrafieh, Amlesh, Bandar Anzali, Talesh, Siahkol, Shaft, Rasht, Rudbar, Rudsar, Rezvanshahr, Soumesara, Foman, Lahijan, Langrod, Masal.

Rasht city with an area of about 1215 square kilometers, including 6 districts: Markazi, Khammam, Khokh Bijar, Sangar, Kochsefahan and Lashet Nesha and 18 villages and 296 villages, of which 294 are inhabited and 2 are uninhabited. According to the census of 2008, the population of the city is 918,445 people and the number of households is 293,550. Of this population, 698, 014 people live in urban areas and 220,431 people live in rural areas. In other words, 60.35 percent of the population of Rasht city live in urban areas and 39.65 percent live in rural areas according

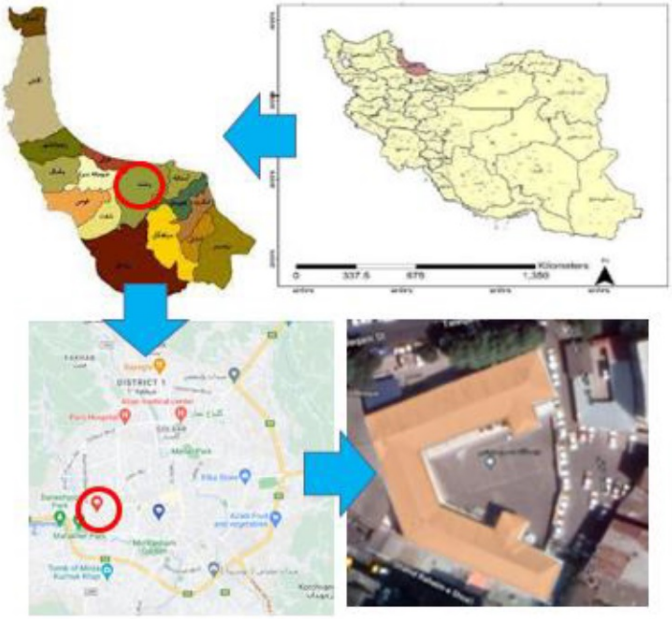

Figure 1: Map of the studied province

to the general population and housing census. This city is made up of three coastal, plain and mountainous areas, and in two different areas, it has a height of 5.26 meters on the shore of the Caspian Sea to 760 meters around Narhasar and Dizkoh. The eastern part of the area corresponds to the active bed of Sefidroud, its tributaries, and the western part of the area corresponds to the plain, and its north is connected to the Caspian coast [4]. The studied school is located in Bay Seton Street in Rasht and is one of the best schools built by the General Department of Equipment and Renovation of Schools in Gilan Province in recent years. Among the natural features and geographical location of the place under study are factors such as the shape of the land, natural vegetation, proximity to significant lowlands and heights, vast expanses of water, forests, proximity to urban residential areas and natural and rural environments. It provides valuable information about the climatic condition of the studied place and the factors affecting it, including local winds [20]. The city of Rasht is located at a height of 8 meters below the sea level, and it can be said that it is located between the sea and an almost mountainous and lowland area, and the humidity of this area reaches 100% on most days of the year. Since the city of Rasht is located in an aura of greenery and a forest full of trees, there are no disturbing and annoying winds for this area, but the air flow is very effective to reduce humidity, especially through blinds around the building. The subject of study is Hasan Hojjati School on Bay Seton Street in Rasht, in a moderate and humid climate, using Design Builder software for energy analysis. According to the reality, the building uses natural ventilation and shutters are used for the windows. It should be noted that the cooling system during the summer is part-time due to the closure of a part of the building.

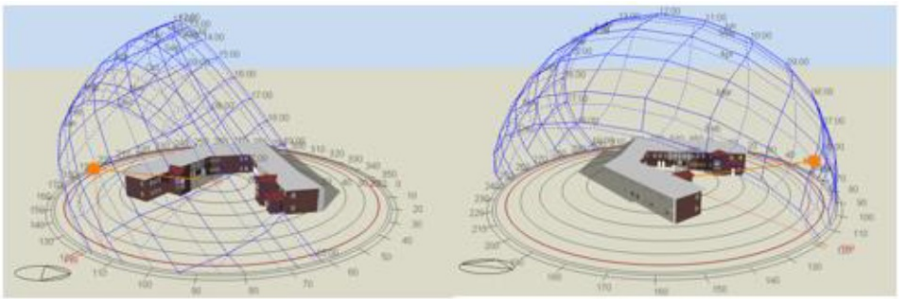

Figure 2: View of the simulated building

5 Findings and discussion

According to what has been said, the activities that are emphasized in this approach are:- How to organize schools and how they operate, designing schools, developing and managing school land, reducing and minimizing resources by schools (water, energy, materials and products), promotion of interactions between schools, the surrounding community and other institutions, protection and care of spiritual values and cultural heritage of schools and its lands, revision of the educational program towards sustainability [18] It is one of the most important social, educational and educational institutions, and the main pillar of education, therefore, in order to properly educate students, the need for suitable educational spaces is felt. Schools, like other buildings, have been affected by various factors such as geographical, climatic, materials, technology, performance and special elements. With the increase in the consumption of fossil fuels and the emergence of economic problems and environmental pollution, experts thought of inventing solutions in order to deal with adverse weather conditions and use natural energy by using a special architectural method to reduce the consumption of fossil fuels in buildings. Therefore, climate design, meaning the creation of climate-compatible architecture, as seen in the background of native architecture in most parts of the world, was again taken into consideration. It is better to teach people to save energy from a young age. Therefore, the construction of schools compatible with the climate has a significant impact in this way. It seems that the best way to achieve these goals is to inform the communities about the principles that reduce harmful energy in Egypt. Perhaps it can be said that the best way to inform communities is to teach these principles in learning environments such as schools. Because students learn this lesson with a sense of comfort in an environment that consumes the least amount of energy [28]. In the school under study, the findings clearly show that the wind speed, wind flow in contact with the building creates a pressure field around the building. The amount of this pressure field is based on the wind speed. In this regard, ventilation is effective only when the wind speed is more than 2.5 m/s (9 km/h). Wind direction: The most basic factor determining how air passes through a building is the wind direction. When wind moves over a building, it creates a variable positive or negative pressure gradient. Then the air flows from areas with positive pressure to areas with negative pressure. Temperature differences: As the temperature increases, the air density decreases and the air moves upwards and is replaced by cooler air.

Different weather conditions, according to the type of climate and season, have different importance in meeting comfort conditions. At the neighborhood scale, it is very important to have a suitable source of energy in comparison with the confinement of undesirable energy. For example, in a cold climate, having solar energy is more important than trapping wind energy. Because, although design strategies at the scale of a building can be used to contain wind energy; However, if access to the sun is not possible, there is no solution for using solar heating energy in the building [6]. Natural ventilation is necessary and necessary to create health and comfort in educational buildings. Of course, creating natural ventilation to improve indoor air quality and environmental comfort may cause energy wastage. In addition, taking into account the optimization of energy consumption when providing indoor air quality, visual and thermal comfort, control mechanisms in the content of natural ventilation, which optimizes energy without destroying optimal conditions, are measured by these parameters and used in educational buildings. In a research conducted in schools in the region It was found that in addition to thermal comfort and indoor air quality, the amount of energy consumption in the southern parts of the building has been improved by 18% and in the northern parts by 30% with the help of ventilation methods. The corridors are one They are one of the places that are not used except for recreation. These areas can be considered as buffer zones so that in the summer they can remove the heat accumulated in the floors and walls and bring in fresh air as a pre-heat. Getting to classes used in the winter. It seems that in the swing It is possible to increase the amount of natural ventilation by opening the windows of the corridors and classroom doors. The produced air flow can also be directed towards the classrooms through the south and north facing corridors in the winter. In addition, in the summer the air flow that They are entered through the classroom windows and can be taken out through the corridors and lobbies. Energy analysis has been done by Design Builder software in the columnless street of Rasht city and in a moderate and humid climate. According to the reality, the building uses natural ventilation and shutters are used for the windows. It should be noted that the cooling system during the summer is part-time due to the closure of a part of the building. As can be seen in Figure 2, which was obtained by modeling as in real conditions, these results show that the largest building gas consumption is related to building heating, which includes 81% of the total gas consumption of the building. Regarding the electricity consumption of the building, which we have discussed separately in diagram 3 in the modeling, it was also determined that the highest electricity consumption in the Hasan Johti building in Rasht is related to electric lighting, which accounts for 41% of the total energy, as well as equipment with 34% and the use of cooling with 25%, respectively, are electricity consumption cases in this building.

Table 1: The heat transfer coefficient of building surfaces

Row	Executive detail	Heat transfer coefficient $\frac{W}{m^2.k}$
1	The wall is 30 cm brick and plaster and stone facade	1.5
2	concrete and plaster ceiling 20 cm	1.1
3	Double glazed building glass with UPVC frame	2.5

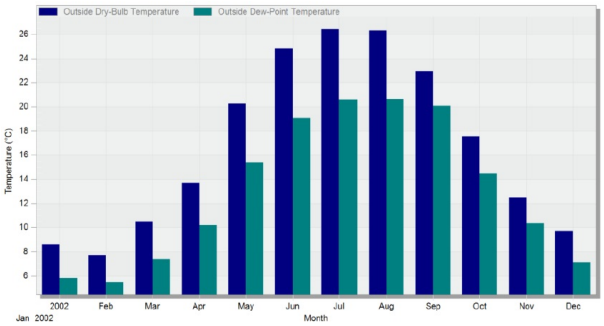

Figure 3: Dry temperature and dew point changes in Rasht climate

5.1 Changes in dry temperature and dew point

In order to compare the buildings in terms of performance, the cooling and heating energy requirement of the building to reach the comfort temperature has been investigated (heating set point 22 and cooling set point 24 degrees Celsius). In this way, any building that has a lower heating requirement means that the average temperature of the building during the day is closer to the comfort temperature. This temperature will depend on parameters such as the climate design of the building, the number of windows, the amount of natural ventilation, shades, etc.

5.2 Building energy loss

With a detailed analysis of the building, the amount of energy wasted in this building has been investigated, and the heat loss in the hottest month of the year shows that the wall with 23%, lighting with 21%, glass with 20%, and equipment with 17%, respectively, are the highest energy loss. are included in this building.

Analyzing the heat loss in the coldest month of the year in the studied school, graph 5 but it is facing a big difference with the energy loss in the warm month of the year. In the coldest month of the year, the external wall with 48%, the glass with 26% and the roof with 20% of energy loss account for the most energy loss in this building. According to this analysis, the walls alone account for nearly half of the loss in takes over The heat absorbed by lighting, equipment, people and incoming radiation from the window is shown in diagram-6 of heat transfer from the walls and different parts of the building. A positive number means gaining heat and a negative number means losing heat. Diagram 4 shows the amount of air exchange due to natural ventilation for the studied building. This ventilation will be done by temperature controls only if the weather is suitable.

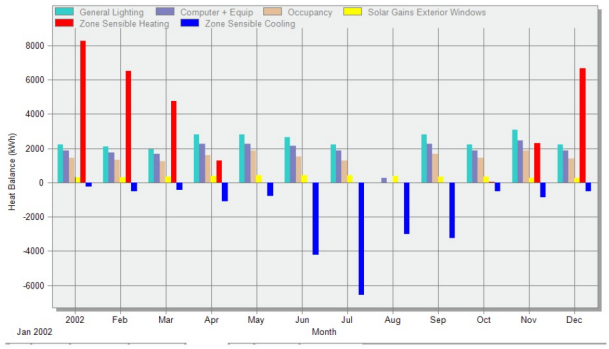

Figure 4: Heat transfer from the glass of the building

5.3 Electricity and gas consumption of the building

The analysis of electricity and gas energy consumption in a one-year period by different months can be seen in graph 5 in this graph, electricity consumption in the building is dark blue, lighting is yellow, heating or red, cooling is blue, hot water is green It is separated in the diagram. This analysis clearly shows that the consumption of hot water, lighting and electricity are almost the same in different months, but cooling and heating have the largest change in consumption according to the season.

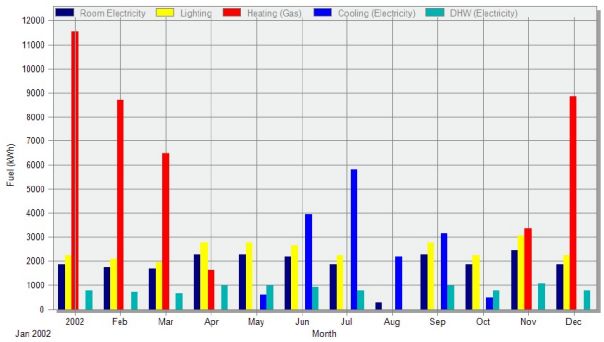

Figure 5: Breakdown of building expenses

5.4 times cooling and heating the building throughout the year

Analysis of cooling and heating of the building according to diagram 6 shows the use of heating and cooling sources analyzed in the model school. This analysis states that the consumption of heating and cooling in which months and the maximum amount is used.

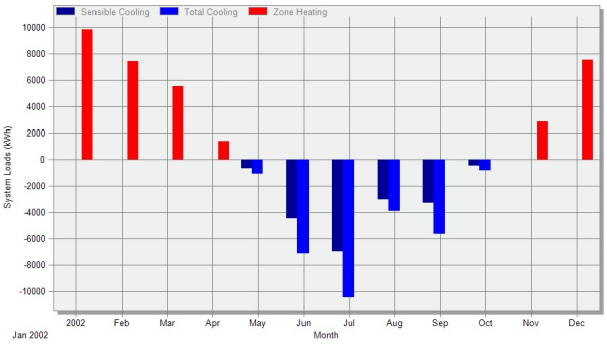

Figure 6: Thermal and cooling load distribution of the building

CFD analysis has been done for the surrounding area of the building. In this analysis, the wind was from the southwest. The contours of air velocity around the building are as follows. The speed values in the figure guide are shown in picture 7, picture 8, picture 9, picture 10. Blue lines mean zero speed or wind shadow.

Air speed around the building Figures 9 and 10 show the air speed around the building, where yellow and red lines mean high air speed and blue lines mean low air speed.

As can be clearly seen in the modeling, the speed of air flow around the building is in a favorable condition, except in limited cases, which helps to create a comfort zone and a green school.

6 Conclusion

The things needed to achieve indoor comfort have been done by researchers in articles on this topic, which are done with the aim of accurately determining the effects of natural ventilation on thermal comfort and indoor air quality. The purpose of creating a sustainable school based on the mentioned cases is to improve the comfort of the indoor environment and reduce energy consumption. The expansion of artificial ventilation systems, in addition to consumption, bring a lot of pollution to the environment, while the different climatic regions of the country are Due

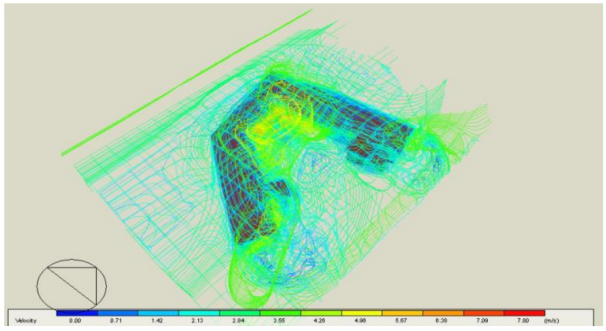

Figure 7: 3D contour of wind speed simulated with Design Builder software

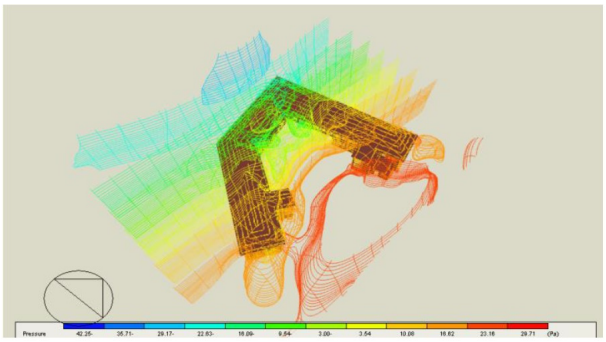

Figure 8: 3D pressure contour simulated with Design Builder software

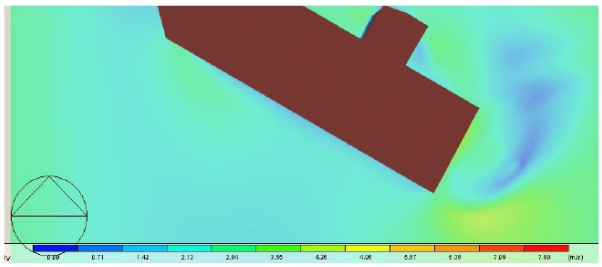

Figure 9: Air flow speed around the building

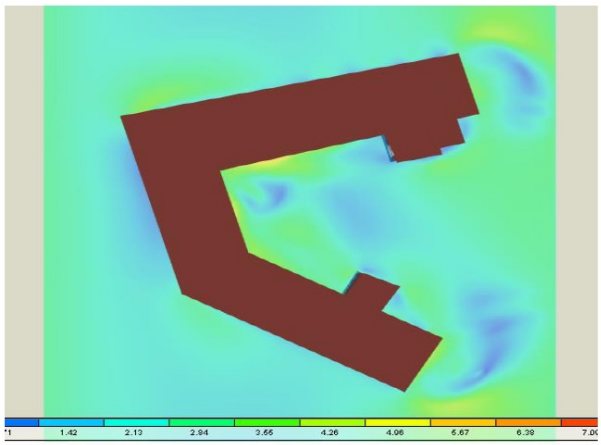

Figure 10: Air flow speed around the building

to the geographical location, they have conditions that, if these natural forces are used correctly, they can be used to respond to the ventilation of buildings and reduce energy consumption to create comfortable conditions. The benefits

of natural ventilation can be mentioned as follows: Reducing energy consumption by reducing the cooling load of the building, improving the comfort of the indoor environment by increasing air flow and reducing or increasing humidity, removing unpleasant odors and indoor air pollution, creating a suitable platform for students to learn, the possibility of school and student interaction with nature, the proper layout of the spaces taking into account the principles of environmental conditions regulation, minimal use of mechanical devices and installations, easier and less expensive setup and maintenance, the modeling done in this article is summarized as follows: Hasan Hojjati school in the region Rasht, which has a humid climate, by software R Design Builder has been energy analyzed. According to the reality, the building uses natural ventilation and shutters are used for the windows. After the simulation, it was determined that the placement of the air intake and exhaust windows was suitable according to the CFD analysis and the building had good natural ventilation throughout the year. The wall and ceiling materials have been selected in such a way that they have energy loss, and in order to reduce energy consumption in the school building and prevent energy wastage, it can still be optimized and heat loss was reduced in this section by using insulation. The heat received from the equipment and lighting was also at the optimal level, but with the use of a smart daylight sensor, the lighting consumption was significantly reduced. In order to compare, the annual average of these indicators in the whole building are compared in the table below. In the UDI index, the best performance related to Hojjati school, in the ASE index, the performance of Hojjati school shows a very good performance.

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