Final Project

Title

Design and analysis of the heating system of a school in Bialystok (Poland)

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Zaragoza, 28/6/2017

Fdo: Pedro José Armañac Cadenas

2016/2017

A mis padres, que me lo han dado todo
A mi hermana, por estar siempre allí

Muchas gracias a Dorota por su paciencia, atención y ayuda

Summary

In this project is detailed the process followed in order to design the heating system of a school. To achieve this I used different tools, including the program Audytor OZC 6.1, trying to combine the knowledge acquired in my previous formation and the information found in the bibliography in order to obtain a good approximation of the optimum power, dimensions and localization of the different elements involved in the heating system.

The first step in this process was the design of the building. I considered parameters like the distribution of the school, which materials should be used in the walls, roof, floor, windows and doors or what is the current legislation in Poland. I also pay attention to other factors like looking the most comfort possible for the teachers, workers and students, always looking for a compromise between quality and price.

After that I used the program Audytor OZC 6.1 to get an approximation of the heat flows in the school. This program involves a part of data entry, in which I put all the information decided in the previous paragraph, as well as other extra parameters such as the orientation of the roof in the different rooms or the particularities of the thermal bridges of the building and another of calculation, a stage that concludes with the results of heat flow in all rooms of the school.

With this information another stage of choosing the equipment to be used is opened. I valued different options, technologies and manufacturers and finally I propose a solution for the boiler, radiators, pipes and connection scheme. All this information is summarized graphically in the section Final Plan, in which you can see all the proposed elements connected on the floor of the building.

In addition, different options for the heat technology of the school, such as radiant floor or pellet boiler, are explored after the previous analysis. I explore what the advantages and disadvantages of these new systems would be in relation to the one proposed in the calculations and what particularities of these should be specially taken into account in the particular case at hand

Finally I also added an annex with information about the process followed in the Audytor OZC 6.1 program to get to the final result, attaching screen captures of the different steps and some examples of parameter input.

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Introduction

The school is located in the northeast of Poland, specifically in Bialystok, and the first important parameter to consider is the climate in this location.

Bialystok has a continental climate with very cold winters and low humidity, and also dry and hot summers. The external temperature considered in this project is -22℃, factor for which I pay special attention to the design of external barriers.

It is essential to take into account the special characteristics of the building that is going to be designed. It is very important that the school gathers the ideal characteristics for students and teachers to study and work in the conditions of greatest comfort possible. Different investigations carried out around the impact that the environmental and ergonomic conditions of the educational centers have on the performance of the students and on the work of the teachers confirm that these factors can be a key factor in students` academic performance.

So for example the lighting should be very taken into account. The main idea is to get the maximum use of natural light and that`s why most of the classes are oriented to the south and also I incorporate two windows in each classroom and large windows in the other administrative stays. In addition the disposition of the classes will be towards the west in order to get that the natural light affects of lateral form in the students when they work.

The noise levels in the building are also very important. Attempts should be made to ensure that the minimum sounds reach a class where the students are being taught in order that they are not disturbed and also to avoid that the teacher has to raise the voice in excess. In order to achieve these objectives it is proposed to move away the areas where activities are carried out outside the part of the building that contains the classes and the design of interior walls with good sound insulation as well as thermal (I am going to detail that later).

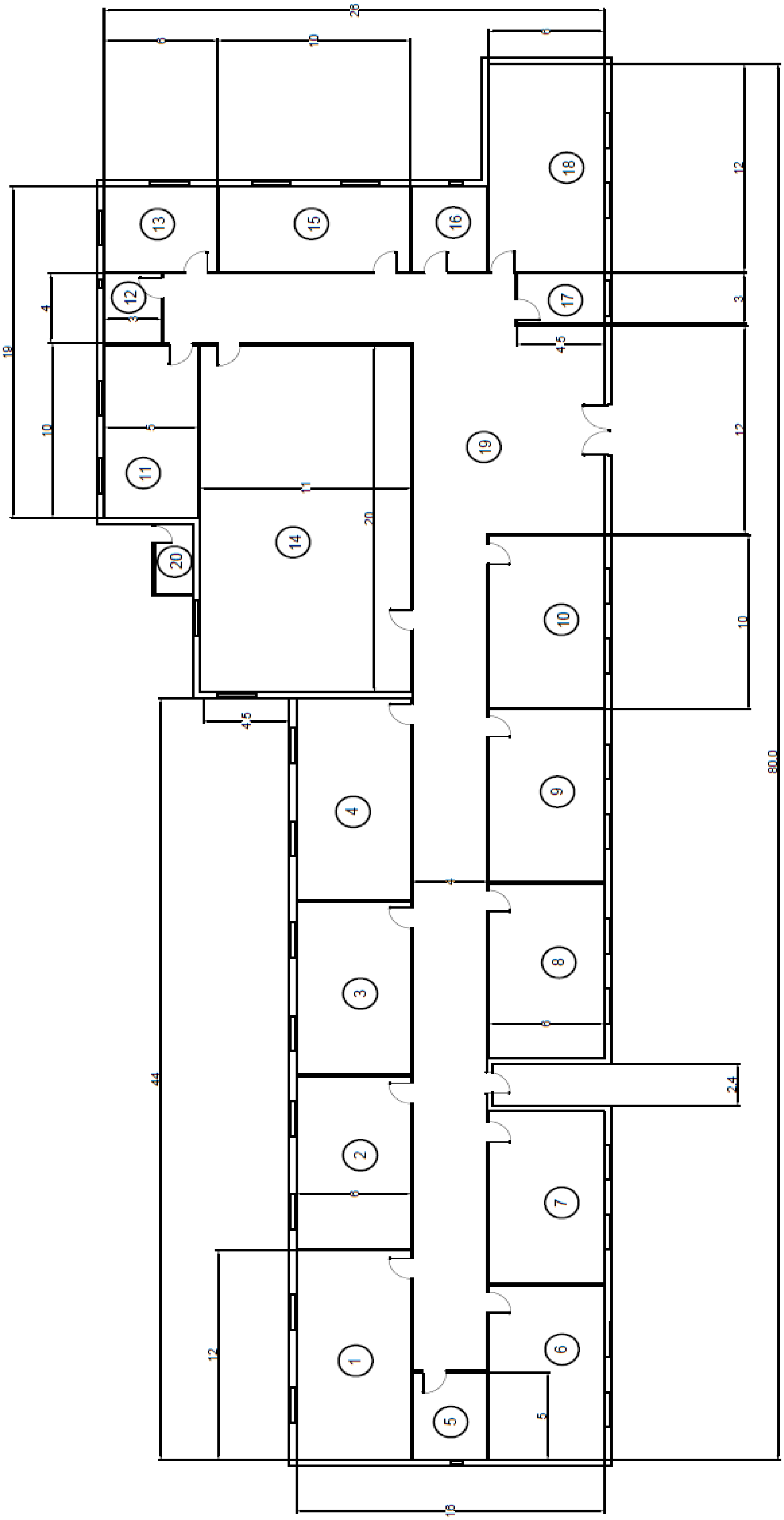
Different studies conclude that the temperature in places where sedentary activities are performed should be between 17 and 27 ℃. Failures in follow this rule can lead to headaches, drowsiness and difficulty concentrating. According to this idea and respecting the European standards most used in air conditioning, I establish a temperature of 20 ℃ in classes, offices, canteen and library, 24℃ in the different bathrooms and 16℃ in the corridor that communicates all of them

A fundamental factor in this project is that the building complies with the current legislation in relation to thermal insulation. For buildings with the inside temperature over 16ºC the values are (year 2017):

Barrier	Maximum heat transfer coefficient U (W/m2K)
External walls	0,23
Roofs	0,18
Windows	1,1
External doors	1,5

With all these global considerations and another's which will be detailed in the *Design of the building* part, I establish the construction plans.

Construction plans



1. - Music class (72 m^2)

2. - Classroom 1 (60 m^2)

3. - Classroom 2 (60 m^2)

4. - Classroom 3 (72 m^2)

5. - Girls WC (20 m^2)

6. - Classroom 4 (60 m^2)

7. - Classroom 5 (60 m^2)

8. - Classroom 6 (60 m^2)

9. - Classroom 7 (60 m^2)

10. - Classroom 8 (60 m^2)

11. - Director´s office (45 m^2)

12. - Teachers WC (13,5 m^2)

13. - Teachers office (30 m^2)

14. – Auditorium (220 m^2)

15. - Canteen (72 m^2)

16. - Boys WC (20 m^2)

17. – Superintendent´s office (13,5 m^2)

18. – Library (72 m^2)

19. – Corridor (380 m^2)

20. – Boiler (72 m^2)

Design of the building

The building has one floor, which is distributed in two main parts: The classes' zone and the administrative zone, on both sides of the main door. The objective of that design is to separate the part of the building where the classes are being developed with the "social" part of the school, where could be found for example the director office or the teachers room.

Between the classes 5 and 6 I introduce a separation, with two objectives: I try to avoid the fact that five classes are all followed together and also to add in this part of the corridor and emergency exit door. In a privileged place just at the entrance of the school I have added a large common room where the acts that affect to the entire educational community take place, a room that due to its dimensions I will have to pay special attention when dealing with its temperature control. It is also the only room to which I have added two access doors.

Behind this common room I put the boiler room, trying that the situation of this room is such that the length of pipes used to connect the radiators to the boiler is minimal

In the detailed plan of the next pages is detailed the desire temperature in each room of the house. Furthermore it has an architecture designed for more or less one hundred students and twenty staff people. There are 8 standard classes, an auditorium and a music class. In addition the building contains three bathrooms, one for students, another for students and a third for teachers. There are also other auxiliary services such as canteen, auditorium or library.

The height of the walls is the same for all the building: 2.5 m, with the roof of 0,7 m of height. These walls are 36 cm thick for the external walls and 10 cm the internal. The materials used to make them are:

External wall	
Material	Thickness (m)
Cement plaster	0,02
Hollow brick K065-2W	0,12
Polyurethane foam	0,14
Hollow brick K065-2W	0,07
Estrich gypsum	0,01

Internal wall	
Material	Thickness (m)
Cement plaster	0,015
Hollow brick K065-2W	0,07
Cement plaster	0,015

When choosing the components of the roof and the floor of the school must be taken into account again that they must comply with current legislation in Poland in relation to the U factor, in addition to trying to make its price as low as possible. Finally my decision is:

Roof	
Material	Thickness (m)
Ceramic tiles	0,15
Cement plaster	0,06
Hollow brick K065-2W	0,04
PS-E FS 20 foamed polystyrene.	0,22
Cavity concrete of crushed stone.	0,22
Cement plaster	0,01

For the floor, and given the special climatic conditions of the area where the school is located, I have added a sheet of polystyrene that separates the ground from the foundation of the building. This fact will be included also in the program and taken into account in the calculations. With this in mind:

Floor	
Material	Thickness (m)
Polysterene sheet	0,02
Cavity concrete of crushed stone	0,45
PS-E FS 20 foamed polystyrene.	0,25
Cement plaster	0,1
Ceramic floor tiles	0,015

When choosing the doors for the school I again distinguish between those that will give directly to the exterior and those that serve to connect interior rooms. In the case of the latter the same type of door is used for the whole school. The dimensions of the interior doors are 1 m wide and 2 m high:

Internal doors	
Material	Thickness (m)
Beech wood across fibre	0,2

For the external door (dimensions 2,5 m wide and 2 m high):

External doors	
Material	Thickness (m)
Beech wood across fibre	0,35

As for windows I have tried to maximize the surface of these to try to squeeze the natural light as much as possible. The material and thickness chosen have been:

Windows	
Material	Thickness (m)
Window glass	0,017
Unventilated air layer	0,08
Window glass	0,017

Looking for the greatest possible uniformity all the windows of the building are 1m high and are 80 cm above ground level. Depending on the room the width change:

Room	Number of windows	Width (each one, m)
Music class	2	3
Classes 1,3,4,5,7 and 8	2	2
Class 3	2	3
Bathrooms	1	2
Auditorium	2	2,5
Director office, teachers room and canteen	2	2
Library	2	3
Superintendent´s office	1	1,5

Calculation and results with Audytor OZC 6.1

After all the design considerations, I use the Audytor OZC 6.1 tool to perform calculations related to heat flows and losses in the building. In this section I do not go into the details of the program's operation and I am going to focus on its results, but in *Annex 1* I explained in depth the process followed to introduce the particularities of the building in the program.

After introducing the basic building data and the thermal bridges, I introduce in the program the materials and thicknesses used in the different components and check that they comply with the Polish legislation in relation to the U coefficient.

Barrier	Internal heat transfer resistance	External heat transfer resistance	Heat transfer coefficient U (W/m2K)
External walls	0,13	0,04	0,209
Internal walls	0,13	0,13	0,855
Roof	0,1	0,04	0,147
Floor	*	*	0,081
Windows	0,13	0,04	0,971
Internal doors	0,13	0,04	0,927
External doors	0,1	0,04	0,568

*Equivalent thermal resistance of the ground=4,826 m2K/W

All of the barriers in the building comply with current legislation and I try to respect the idea of minimum cost.

In this moment I introduce in the program all of the details of the rooms, including area, height of the walls and all of the thermal bridges designed. More details of this process are in the *Annex 1*. The final results in terms of heat loads of the rooms:

Room	ϕHL (heat load, W)
Music class	7334
Classroom 1	6376
Classroom 2	6376
Classroom 3	7848
Classroom 4	6623
Classroom 5	6822
Classroom 6	6843
Classroom 7	6376
Classroom 8	6056
WC Girls	1585
Auditorium	18468
WC Teachers	891
Teachers office	3017
Canteen	1816
WC Boys	1142
Library	2901
Superintendent´s office	806
Corridor	17912
Director`s office	2636
Boiler room	140

Selection of equipment and system design

Once I have determined the heat requirement of the building is the time to decide how it will be generated all that heat. After carrying out a study of the different options (including pellets or biomass) I have decided to place two condensing boilers.

The reason for this choice is that condensation is the technology with major yields and lower gas consumption, and therefore, the one that most respects the environment. It ability to take advantage of part of the heat that is lost in the form of steam of water in the combustion smoke generates extra performance which allows to consume between 15 and 30% less gas according to the type and use of installation. Condensation boilers are suitable for any type of installation. In fact, the greater the heating, more cost effective is its use. Its efficiency is maximized when the installation works at a lower temperature. In combination with thermostats I get not only does the supply the demand for heat at all times, and therefore, guarantee the greater comfort, but also minimize energy expenditure even more and the gas bill. This reduction in gas consumption translates into in a lower emission of CO_2 to the atmosphere also minimize emissions of NO_x, oxides of nitrogen whose excess causes acid rain.

The equipment that is installed in the school is of the company Baxi, concretely the model Power HT Plus. As already mentioned, I have decided to install two equipments, which will give rise to two independent heating circuits in the building. I reject the idea of a one-cable system because in the last radiator will be a great loss of temperature. There are two different boilers according to the power necessary in each part of the building. The first one needs 84648 W and I choose the model Power HT Plus 90 F
The main characteristics of this type of boiler according to the catalog of the company are:

Power (KW)	Supply temperature (°C)	Temperature drop (°C)	Efficiency	Weight (kg)	Price (€)
85	80	20	A	104	4465

For the second part (24105 W) I choose the model Power HT Plus 50 F:

Power (KW)	Supply temperature (°C)	Temperature drop (°C)	Efficiency	Weight (kg)	Price (€)
35	80	20	A	40	3195

With the chosen heat supply system it is time to choose the type of pipes that will connect the boiler to the radiators. I have decided to place pipes of polyethylene crosslinked, with a coating of polyethylene foam. The reasons for this decision are: the flexibility, price, resistance to abrasion, chemicals and temperature changes and the durability of crosslinked polyethylene.

Specifically I use the type HKS1 of the manufacturer Purmo. The main characteristics of this type of pipe are:

ρ (kg/m3)	λ (W/mK)	k (mm)	Tmax(°C)	Pmax (Mpa)	Efficiency (%)
950	0,45	0,01	90	1	70

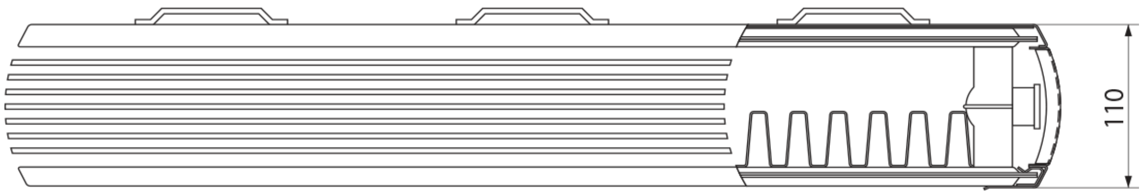
The radiators of the building are also from the manufacturer Purmo, specifically the model PURMO Ventil Compact Kos H. I try to adjust the height of the radiators in 600 mm, changing the width in order to get the necessary power in each case.

In relation to the position of the radiators is important that all of them are in the same height: 15 cm above the floor. Furthermore if it is possible the radiators are going to be under the windows in order to improve the convection of the air in the room. Depending on the room I am going to put different number of radiators to satisfy the heat demand. For the corridor I have decided that there are four radiators, each with a quarter of the required calorific power. Having all of this in mind I go to the catalog of Purmo and I choose the necessary equipment for each room:

Room	ϕHL (heat load, W)	Number of radiators	Radiator details	Power (W)
Music class	7334	2	Type 33 600 x 1650	8066
Classroom 1	6376	2	Type 33 600 x 1350	6598
Classroom 2	6376	2	Type 33 600 x 1350	6598
Classroom 3	7848	2	Type 33 600 x 1650	8066
Classroom 4	6623	2	Type 33 600 x 1500	7332
Classroom 5	6822	2	Type 33 600 x 1500	7332
Classroom 6	6843	2	Type 33 600 x 1500	7332
Classroom 7	6376	2	Type 33 600 x 1350	6598
Classroom 8	6056	2	Type 33 600 x 1350	6598
WC Girls	1585	1	Type 21 600 x 1200	1604
Auditorium	18468	4	Type 33 600 x 1950	19064
WC Teachers	891	1	Type 21 600 x 750	1003
Teachers office	3017	1	Type 33 600 x 1350	3299
Canteen	1816	1	Type 33 600 x 900	2200
WC Boys	1142	1	Type 21 600 x 900	1203
Library	2901	1	Type 33 600 x 1350	3299
Superintendent´s office	806	1	Type 21 600 x 750	1003
Corridor	17912	4	Type 33 600 x 1950	19064
Director`s office	2636	1	Type 33 600 x 1050	2566
Boiler room	140	-	-	-

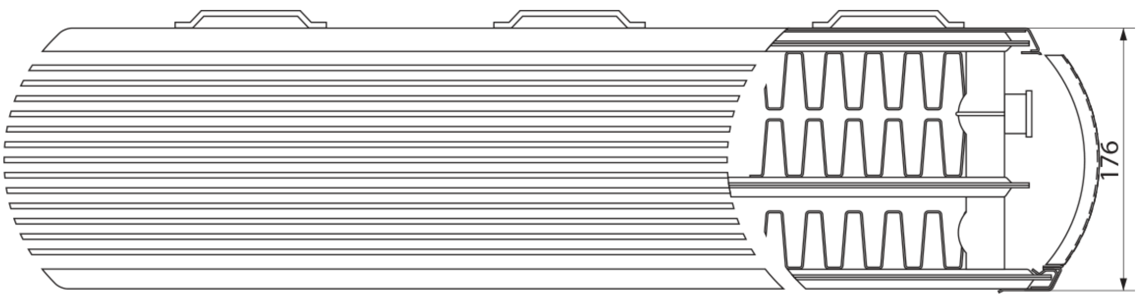
Due to the extreme external temperature considered in this project (-22℃) I have chosen the power always a little bigger of the power data given by the program in the design of the radiators.

For radiators Type 21, chosen for the bathrooms and the superintendent´s office, the basic data is:



And for the 600 mm of height model, the volume is 7,50 l/m and the weight 32,3 kg/m

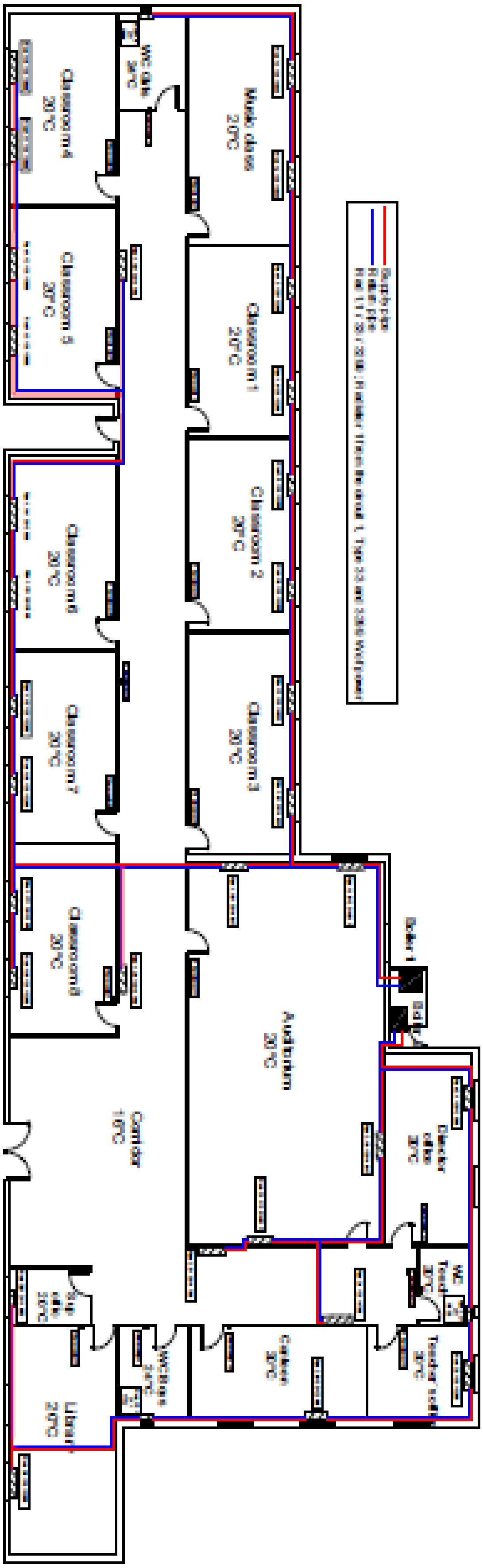
For radiators Type 33, chosen for the rest of the rooms:



Also for the 600 mm of height model, the volume is 10,86 l/m and the weight 54,19 kg/m

It is also important to dimension and design the piping system. For design I choose a system based on two independent circuits powered by two condensing boilers. In addition to the flexibility provided by this system I also try that in case of failure of one of the two boilers none of the two main rooms (corridor and auditorium) is without heat input

For the process of dimension, the Audytor CO 6.0 program is proposed, in which, following a process similar to that detailed in *Annex 1*, the final dimensions of the pipes can be obtained as a final result of the program, introducing as design parameters the characteristics of the rooms, the boiler parameters, the length and material of the pipes and the type of radiators used. Another input parameter will be the one obtained with the program Audytor OZC 6.1, the heat flows of each room. By introducing in schematic form the components of the circuit the dimensions of the pipes will be obtained


Supply pipe
Return pipe
Music class
20°C
Classroom 1
20°C
Classroom 2
20°C
Classroom 3
20°C
Classroom 4
20°C
Classroom 5
20°C
Classroom 6
20°C
Classroom 7
20°C
Classroom 8
20°C
Auditorium
20°C
Corridor
16°C
Library
20°C

Alternative possibilities

As an alternative to the one developed in this project I explore the possibility of installing radiating floor in the school.

Radiant is called the heating system that uses one of the walls of a place as a heat emitter. The emitter can be any of the walls of the premises to be heated (floor, walls or ceiling), but the most common is to use the floor.

Due to the surface extension of the emitter, low temperatures are used because the emission depends on the difference in temperature between the emitter and the environment and the surface of the emitter (the larger the emission surface, the lower the temperature difference). Some regulations limit this temperature to 28 or 29 ° C

There are two main types of installations: those that get the heat of hot water circulating through the pipes and those that get it from electricity with a system of metallic electrical resistances or carbon fiber wires as resistors.

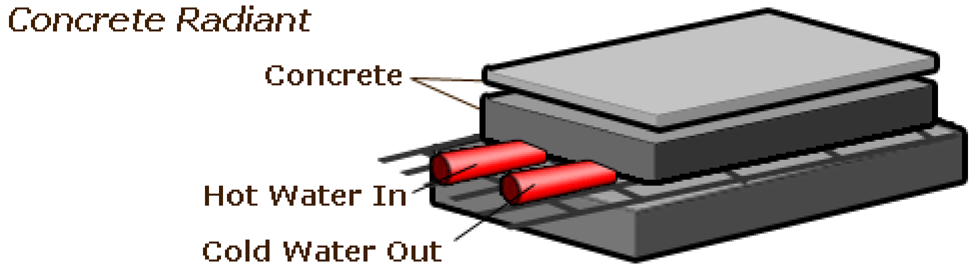
For the first type (hydronic radiant floor systems) water pumped from a boiler circulates through pipes under the floor which normally form "s" structure.The temperature in each room is controlled by regulating the flow of hot water through each tubing loop via a system of zoning valves or pumps and thermostats.

And for the second (electric radiant floor) in the case of the electric resistances these are distributed on the floor by interposing a thermal insulation to avoid that the heat dissipates towards the bottom plant. A layer of cement mortar and sand is placed on the resistances. For the carbon fiber system, a kind of weave of these fibers, which act as resistors, is used in bands of a certain length, which carry two electric conductors to the sides and wrapped in a flexible plastic material electrical insulation).

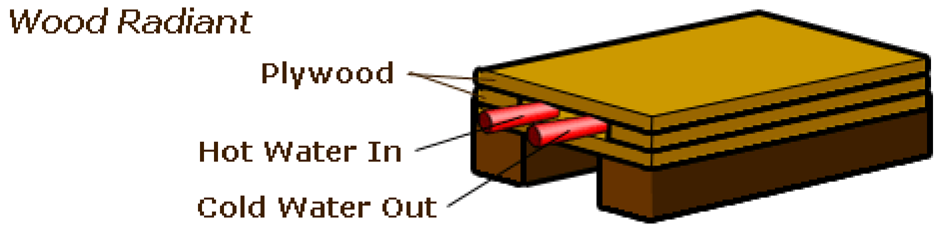
If I had to propose a radiant floor system for the school I would choose one that would use the electricity-based system. The reason is that I could use a system that will take advantage of the hours when the building is not in use to "load" the floor and keep it warm during school hours. This system could save enough money compared to a water-based system for the location and particularities of the building studied.

All two types of radiant floor heat can be further subdivided by the type of installation:

- Those that use a large thermal mass of a concrete slab floor or lightweight concrete over a wooden subfloor (these are called "wet installations")



- Those in which the installer "sandwiches" the radiant floor tubing between two layers of plywood or attaches the tubing under the finished floor or subfloor ("dry installations")



It could be great to make the floor radiant useful in cooling in summer, but the possibility that, by increasing the relative humidity of the air, the dew point could be reached on the floor and formed puddles, has paralyzed the investigations.

At present, it has been concluded that, although no real cooling can be achieved, it is possible to refresh the room in a small way.

The advantages of installing this type of technology in the school instead of the detailed system of convection radiators are, for example, that this system allows heating throughout the whole floor, not just in localized spots. Therefore radiant floor heating also eliminates the draft, dust, and allergen problems associated with forced-air heating systems. It is also very important that in these types of systems the water supply temperature is around 35/40 ℃ , well below the 80 ℃ raised in the previously designed system. We also achieve greater comfort since the temperature of the air near the ground will be slightly higher than the temperature of the air at the height of the head.

The disadvantages or problems that can arise when using this type of systems should be considered. It does not respond quickly to temperature settings and also it is relatively expensive to install, a fact that should be considered very seriously especially in large buildings such as the one being studied in this project

Alternatives can also be assessed in the way the required heat in the building is generated. In particular it is possible to propose the replacement of the condensing boiler chosen by another based on biomass, specifically one that works by burning pellets.

The pellets are small cylinders made by wood debris such as sawdust, wood chips or splinters from agriculture or industrial waste that are conglomerated at high pressure. Its main peculiarity is the high calorific power that they have.

It is important to consider that the price of biomass is more stable over time in addition to being lower if you buy it in great quantity. It is a cheaper energy since it is generated from local resources. Biomass is the fuel with the most competitive price for the user, and, therefore, a biomass boiler brings profitability and economic comfort.

Is a renewable energy, clean and inexhaustible. The extraction of forest biomass helps to clean the forests (preventing fires). They also have a low CO2 emission fact that helps to reduce emissions of greenhouse gases and also acid rain.

The disadvantages of such systems are the large space they occupy, that it is necessary a good ventilation to install a system of this type and that are created residues as hollin or ash.

Conclusion

In this project I have tried to apply the knowledge acquired in the subject of Heating Systems and in all my formation like engineer in order to calculate a good approximation to the heat losses in a single house and also make a proper design of the barriers, the materials of the construction, the heat source, the pipes and the radiators.

I try to adjust the materials and the design to the current legislation in Poland, trying to not oversize the barriers and expend the less money as possible. I also think in preserve the environment, using a clean material for the pipes and modern technology for the boiler. I explore also the possibility of a pellets boiler for a cleaner energy or what would be the differences between the previously designed system and one based on floor heating technology.

I also have tried not only to perform a work of analysis of a heating system, but also an integral process taking into account also many parameters of design of the building, looking for that with the minimum possible expenditure the school reaches the best possible conditions in terms of comfort, isolation or care of the environment.

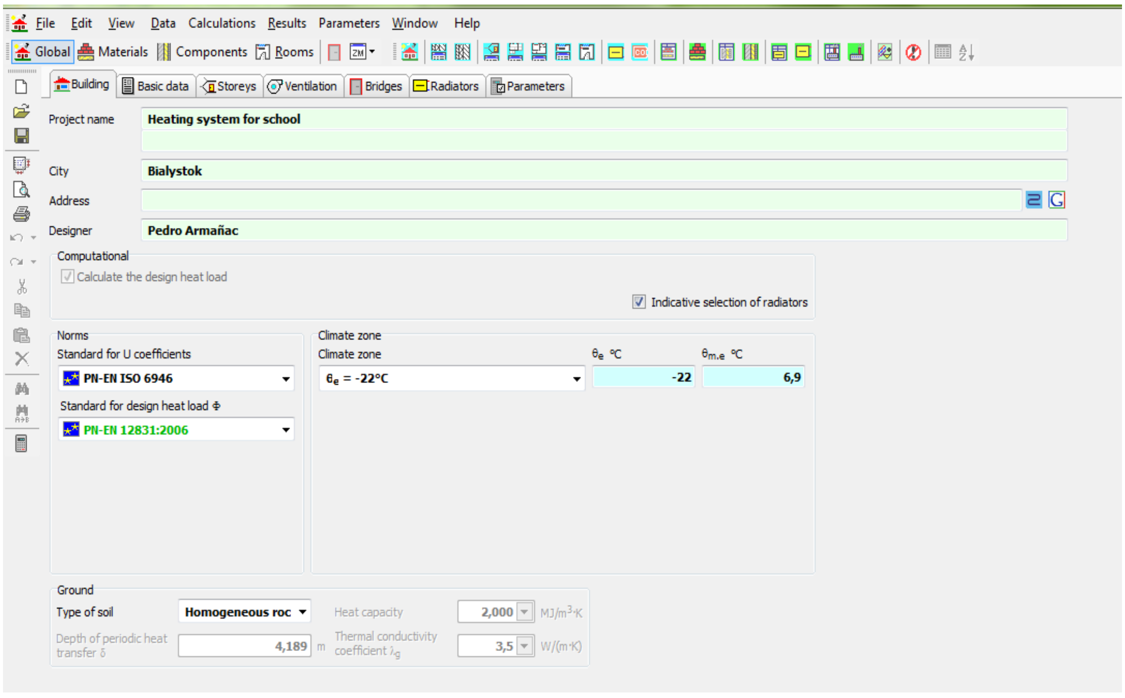
After this process I tried to design the heating system as efficiently as possible, trying to maximize the effect of the usual actions of energetic saving (such as placing radiators under windows or away from interior doors). The introduction of two independent heating circuits also provides many alternatives and flexibility to the building's heat supply system.

Finally, and to sum up, I have discovered a lot of information and knowledge doing this project and I really think that it is going to help me in my future professional performance.

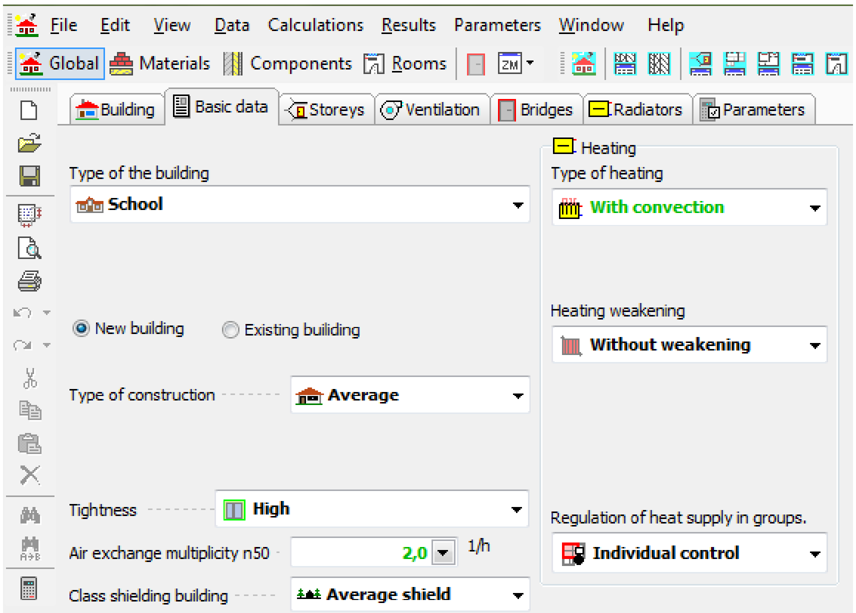
Annex 1, Audytor OZC 6.1

In this last part of the work I detail the process followed to perform the calculations in the computer program used.

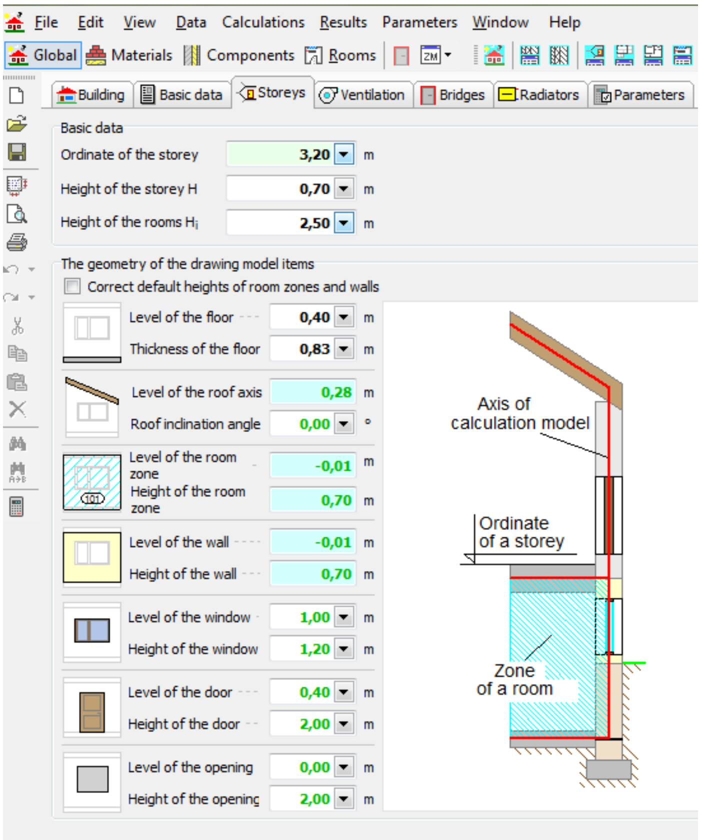
In the first program, Audytor OZC 6.1, I start by entering the general data of the building developed. The first screen looks like this:



For the basic data I choose:



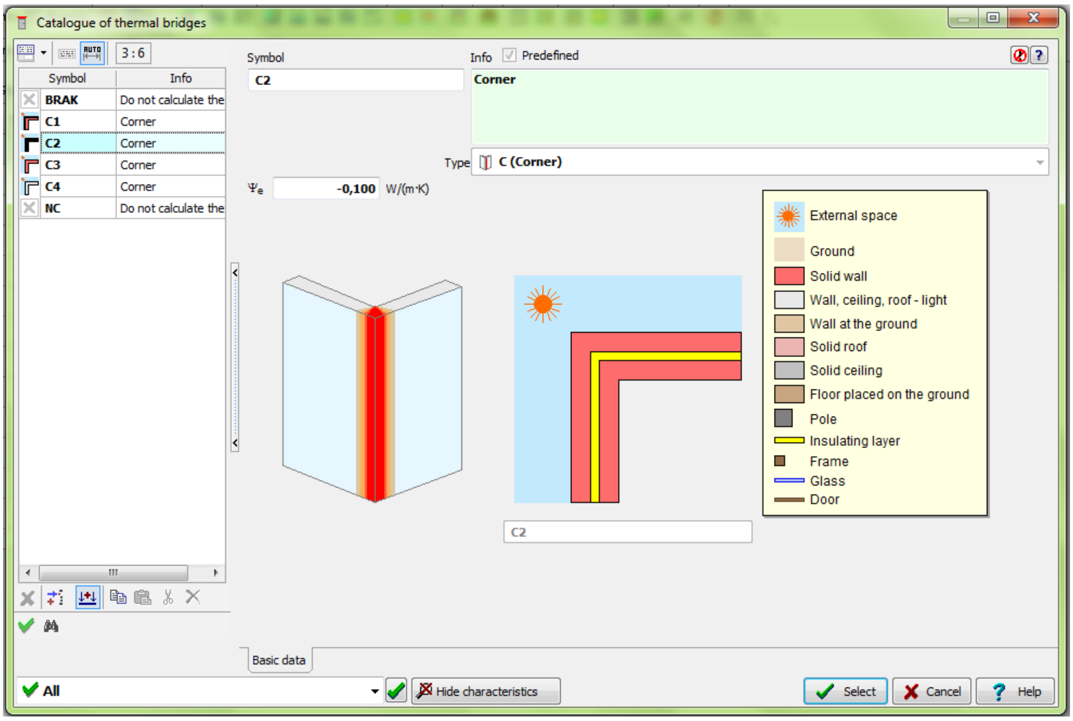
The same for the storey:



Important parameters in the correct isolation of the building are the thermal bridges. I choose all of them trying to get the minimum loss of heat, with the isolation layer in the middle of the barriers. For all of that:

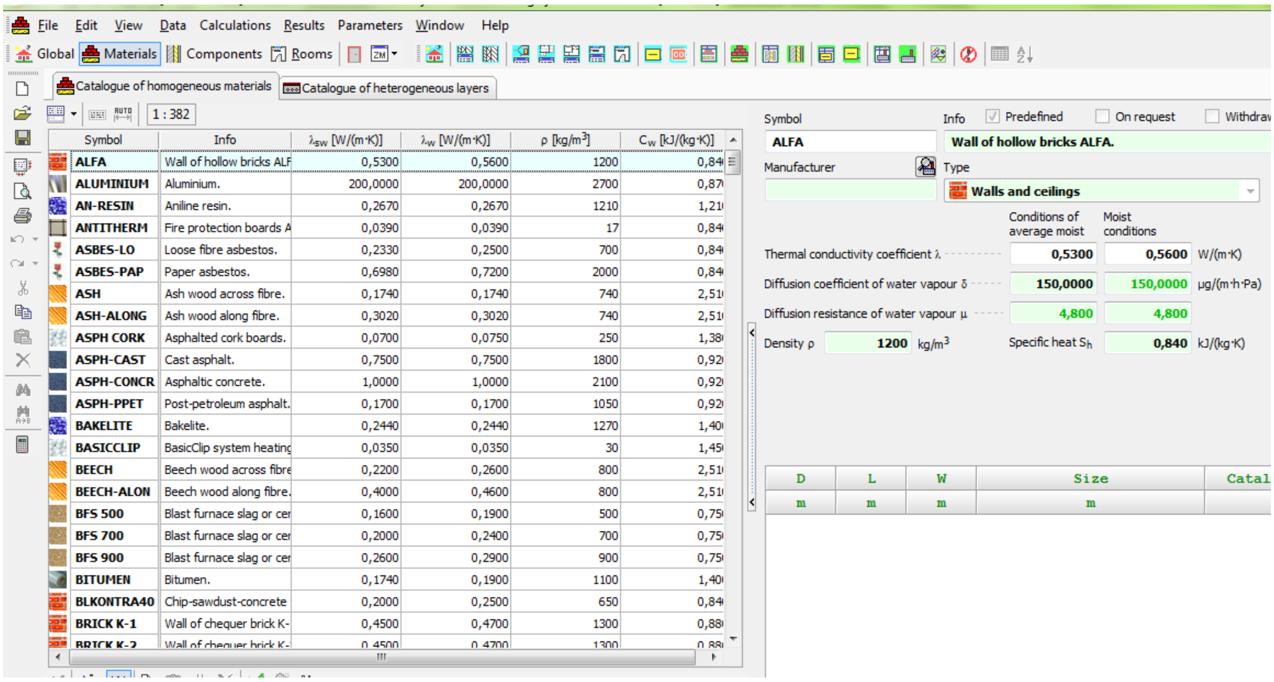
Type	Symbol	Ψ_1	Description
	C2	-0,100	Corner
	CC2	0,150	Concave corner
	IW5	0,000	Internal wall / External wall
	R2	0,500	External floor / Roof
	IWR1	0,000	External wall / Roof
	GF10	0,650	Suspended floor
	FE2	0,500	External ceiling / External wall
	IWFE1	0,000	Internal wall / External ceiling
	BRAK	0,000	Do not calculate the bridge for such a case.
	P2	1,200	Pole / External wall
	W11	0,000	Window opening / External wall
	D11	0,000	Door opening / External wall
	GF2	0,600	Floor placed on the ground / External wall

Entering in details in, for example, the first thermal bridge:



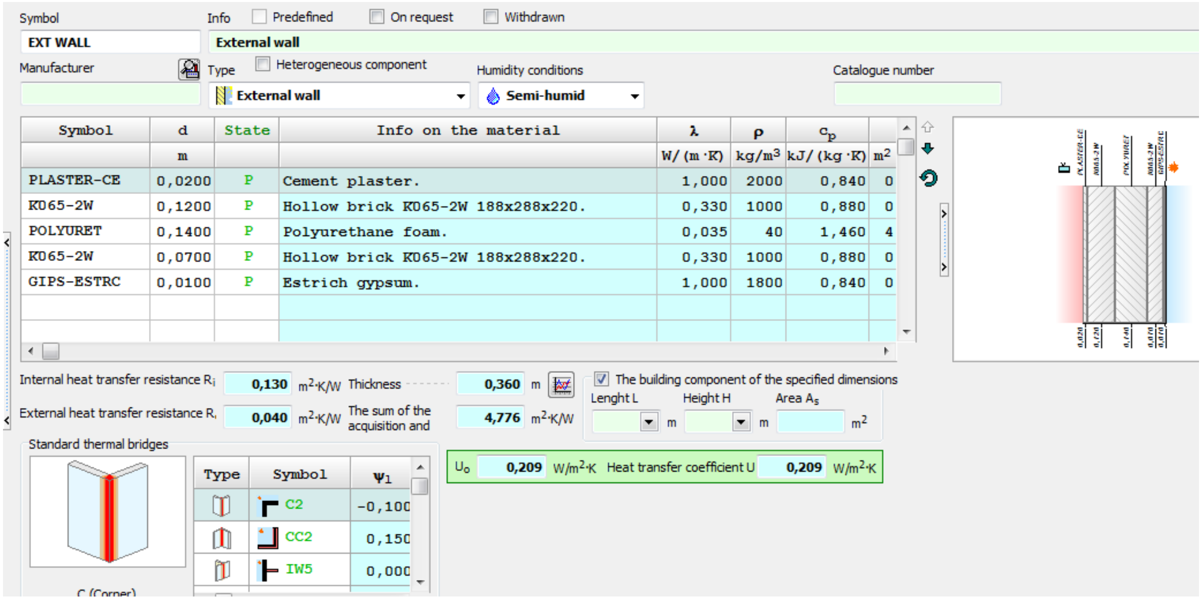
Once the desired thermal bridge type is chosen the program calculates its heat transfer coefficient by default (ψ1, W/mK), and these values are going to be used in the remaining calculations.

After these global considerations the next step is to choose the materials that will form the different components of the building. For this the program has an extensive catalog of materials of different quality and characteristics of which I will choose the ones that best fit the objectives and specifications of the project:



Is it also possible to introduce new materials in the catalog, and that is what I have done for windows. In them I did not get the value set in the coefficient U with the materials of the program, but I have introduced the characteristics of catalog of a glass of superior quality and I have achieved an optimal combination of glass thickness and insulation. The program also allows using heterogeneous layers.

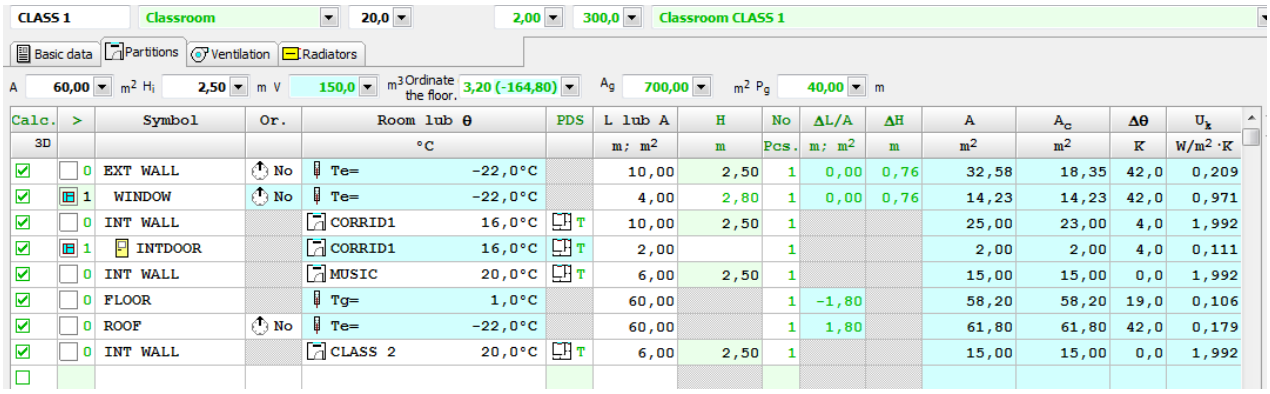
With these materials I introduce the structure of the different components of the school. For example, for the external wall:



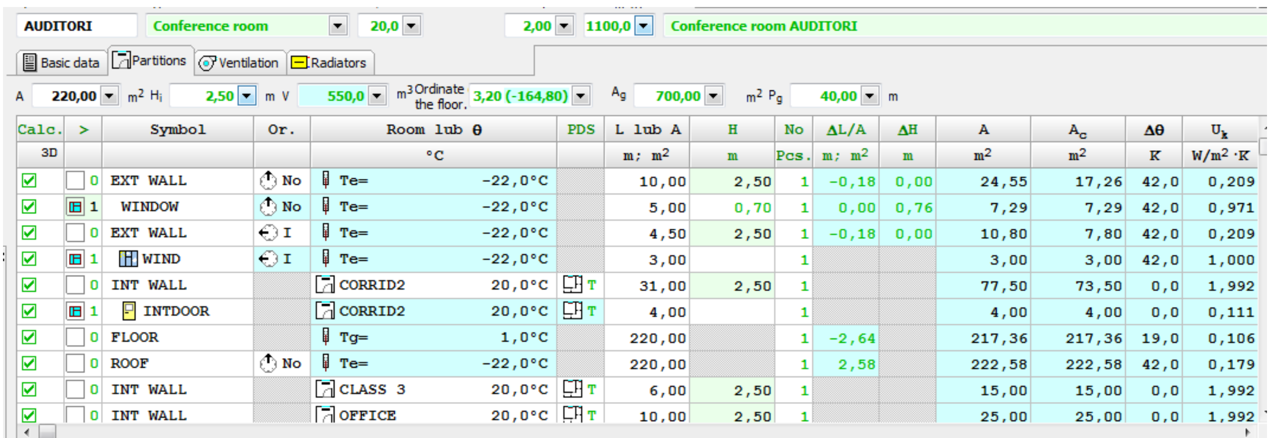
Symbol	d	State	Info on the material	λ	ρ	c_p	
	m			W/(m·K)	kg/m³	kJ/(kg·K)	m²
PLASTER-CE	0,0200	P	Cement plaster.	1,000	2000	0,840	0
K065-2W	0,1200	P	Hollow brick K065-2W 188x288x220.	0,330	1000	0,880	0
POLYURET	0,1400	P	Polyurethane foam.	0,035	40	1,460	4
K065-2W	0,0700	P	Hollow brick K065-2W 188x288x220.	0,330	1000	0,880	0
GIPS-ESTRC	0,0100	P	Estrich gypsum.	1,000	1800	0,840	0

Type	Symbol	ψ_1
	C2	-0,100
	CC2	0,150
	IW5	0,000

Once the process of the *Components* window is done the next step are the rooms. This section specifies the structure of the different partitions of the building, including the area of each wall. The final results obtained from the program are the heat fluxes, objective of all this analysis. Here I illustrate the process for, for example, classroom 1 and auditorium:



Calc.	>	Symbol	Or.	Room lub θ		PDS	L lub A	H	No	ΔL/A	ΔH	A	A_c	Δθ	U_k
3D					°C		m; m²	m	Pcs.	m; m²	m	m²	m²	K	W/m²·K
☑	0	EXT WALL	No	Te=	-22,0°C		10,00	2,50	1	0,00	0,76	32,58	18,35	42,0	0,209
☑	1	WINDOW	No	Te=	-22,0°C		4,00	2,80	1	0,00	0,76	14,23	14,23	42,0	0,971
☑	0	INT WALL		CORRID1	16,0°C	T	10,00	2,50	1			25,00	23,00	4,0	1,992
☑	1	INTDOOR		CORRID1	16,0°C	T	2,00		1			2,00	2,00	4,0	0,111
☑	0	INT WALL		MUSIC	20,0°C	T	6,00	2,50	1			15,00	15,00	0,0	1,992
☑	0	FLOOR		Tg=	1,0°C		60,00		1	-1,80		58,20	58,20	19,0	0,106
☑	0	ROOF	No	Te=	-22,0°C		60,00		1	1,80		61,80	61,80	42,0	0,179
☑	0	INT WALL		CLASS 2	20,0°C	T	6,00	2,50	1			15,00	15,00	0,0	1,992



Calc.	>	Symbol	Or.	Room lub θ		PDS	L lub A	H	No	ΔL/A	ΔH	A	A_c	Δθ	U_k
3D					°C		m; m²	m	Pcs.	m; m²	m	m²	m²	K	W/m²·K
☑	0	EXT WALL	No	Te=	-22,0°C		10,00	2,50	1	-0,18	0,00	24,55	17,26	42,0	0,209
☑	1	WINDOW	No	Te=	-22,0°C		5,00	0,70	1	0,00	0,76	7,29	7,29	42,0	0,971
☑	0	EXT WALL	I	Te=	-22,0°C		4,50	2,50	1	-0,18	0,00	10,80	7,80	42,0	0,209
☑	1	WIND	I	Te=	-22,0°C		3,00		1			3,00	3,00	42,0	1,000
☑	0	INT WALL		CORRID2	20,0°C	T	31,00	2,50	1			77,50	73,50	0,0	1,992
☑	1	INTDOOR		CORRID2	20,0°C	T	4,00		1			4,00	4,00	0,0	0,111
☑	0	FLOOR		Tg=	1,0°C		220,00		1	-2,64		217,36	217,36	19,0	0,106
☑	0	ROOF	No	Te=	-22,0°C		220,00		1	2,58		222,58	222,58	42,0	0,179
☑	0	INT WALL		CLASS 3	20,0°C	T	6,00	2,50	1			15,00	15,00	0,0	1,992
☑	0	INT WALL		OFFICE	20,0°C	T	10,00	2,50	1			25,00	25,00	0,0	1,992

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Boilers, Evaporators, and Condensers - Sadik Kakaç