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Using Building Information Modelling (BIM) by studying building orientation during design to achieve more sustainable buildings

Jamal Younes Omran, Moustafa Ali Wassouf
Tishreen University; Lattakia, Syria

ABSTRACT

Introduction. Energy is one of the most important issues that attract the attention of the whole world, and this in turn is reflected in the increase in energy consumption in residential and industrial buildings Therefore, the process of assessing the efficiency and quality of interior spaces is an important step from which the process of developing and upgrading these spaces begins to reach a sustainable model from an environmental, economic and social point of view.
Materials and methods. The research aims to study the distribution patterns of residential divisions and their reflection on the energy of a residential suburb consisting of twenty residential buildings in Tartous Governorate, through the development of a software tool using Dynamo, which is one of the visual programming methods used in (BIM) using a programming language (Python) with the addition of studying heating and air conditioning loads for current orientation with comparison with loads after directing the building at different angles in order to reduce consumption and benefit from solar radiation sources through Revit. An analytical approach was used, through the analysis and extrapolation of the literature and references related to the study, in addition to the deductive approach by deducing problems in the current situation and providing suggestions for solutions that can be followed in the management and analysis of energy.
Results. The BIM approach contributed to the study of the building orientation and its reflection on thermal loads, taking into account all the factors causing this load, which can be adjusted according to any requirements or code.
Conclusions. Studying the building orientation during the design stage contributes to reducing the total annual heat load by more than 20 %, and this percentage varies according to the way buildings are assembled.

KEYWORDS: Building Information Modelling, Visual programming, building orientation, design phase, sustainability, shadow study, the building envelope, building orientation

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Corresponding author: Moustafa Ali Wassouf, mosstafa11@gmail.com.

Использование информационного моделирования строительных объектов (BIM) с целью изучения ориентации здания при проектировании для достижения их большей устойчивости

Джамал Юнис Омран, Мустафа Али Вассуф
Университет Тишрин; г. Латакия, Сирия

АННОТАЦИЯ

Введение. Энергетика — один из наиболее актуальных вопросов. В связи с увеличением потребления энергии в жилых и промышленных зданиях оценка эффективности и качества внутренних помещений является важным шагом, с которого начинается процесс разработки и внедрения новых технологий. Модернизация данных пространств приводит к созданию устойчивой модели с экологической, экономической и социальной точек зрения.
Материалы и методы. Цель исследования — изучение закономерностей распределения жилых кварталов и их отражение на энергетике жилого пригорода, состоящего из двадцати жилых зданий в провинции Тартус, благодаря разработке программного инструмента с использованием программы Dynamo, который служит одним из методов визуального программирования, используемых в BIM, с применением языка программирования Python. Исследованы нагрузки на отопление и кондиционирование воздуха для данной ориентации в сравнении с нагрузками после проектирования здания под разными углами, чтобы снизить потребление и извлечь выгоду из источников солнечного света с помощью Revit. Использованы аналитический подход, основанный на анализе и экстраполяции литературы, связанной с исследованием; дедуктивный подход путем определения проблем и предоставления предложений по решениям, которым можно следовать при управлении и анализе энергии.
Результаты. BIM-подход способствовал изучению ориентации здания и ее отражения на тепловых нагрузках с уче-

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том всех факторов, вызывающих эту нагрузку, которые могут быть скорректированы в соответствии с требованиями или нормами.

Выводы. Исследование ориентации здания на стадии проектирования способствует снижению общей годовой тепловой нагрузки более чем на 20 %, этот процент варьируется в зависимости от способа сборки зданий.

КЛЮЧЕВЫЕ СЛОВА: информационное моделирование строительных объектов, визуальное программирование, ориентация здания, этап проектирования, устойчивость, изучение расположения тени, ограждающая конструкция здания

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Автор, ответственный за переписку: Мустафа Али Вассуф, mosstafa11@gmail.com.

INTRODUCTION

Modifying existing buildings offers great opportunities to reduce energy consumption and carbon emissions because buildings consume the most energy [1]. The research methodology based on Building Information Modelling (BIM) technology is considered one of the new technologies for retrofitting buildings to achieve low energy housing and reduce environmental impact [2]. The construction trend in sustainable design is defined as the way a building is placed on its position relative to the path of the sun and how the building handles the sun and how the glass openings are identified can have a significant impact on the energy efficiency of the building's systems and the comfort of the residents. Because the right orientation prepares the building to optimize passive solar-based and sometimes wind-based strategies, it naturally creates less energy solutions for lighting, heating and cooling [3]. Building Information Modelling (BIM) has the potential to help designers evaluate different design alternatives and select bioenergy strategies and systems at the design stage of proposed projects [4]. Linking the energy analysis tool to the BIM model helps speed up the energy analysis process, provide more detailed and accurate results, as well as provide energy-efficient buildings [5]. This research attempts to shed light on the issue of energy cost savings in construction projects during the design phase within the BIM environment with the aim of reaching sustainable energy-efficient buildings that benefit from sunlight and reduce fossil energy consumption, especially in residential buildings, which rank second in consumption [6]. Building energy use is expected to increase by 32 % by 2040 [7]. Where the most effective decisions regarding the sustainable design of a building can only be made at the design and pre-construction stages [8].

Many researchers have studied the effects of using BIM in examining project performance in terms of sustainability, and some research has focused on studying the possibility of BIM in supporting the design team to make the right design decisions early in the design phase and providing a model for a working mechanism to integrate building performance simulation for energy in the design phase [9]. In addition to correlation analysis of factors affecting cooling energy demand in residential units, energy use for heating, ventilation and air conditioning is often the main contributor to operational energy demand, which ranges between 50–70 % in most developed countries [10]. Some research has conducted energy analysis of residential buildings and various facilities at the end of the design phase, and once the building components and elements are selected from the orientation, shape, height, type and thickness of walls, type of glass, and thickness of ceilings and floors, however, the analysis of the energy consumption of these components at the conceptual design stage is very useful for designers to make decisions regarding the selection of the most appropriate design alternative that will lead to an energy-efficient construction [4]. Research has shown that design decisions have a significant impact on energy consumption in residential buildings, as the results showed a significant decrease in the energy consumed as a result of changing the orientation of the building, the area of windows and the addition of insulation layers to the external walls. The results also showed that the penetration of direct sunlight into the voids is the main source of heat and the first responsible for the high energy consumption in this sector of buildings. It showed that this source is responsible for 55 % of energy consumption followed by thermal conductivity through the building's outer sheath materials [11]. After reviewing the results of previous studies, the research localizes a global technology and shows the strong features of BIM in the field of building energy analysis and studying the impact of changing building distribution patterns and methods of assembly and direction on the total energy consumption costs.

Purpose of the study

Propose a methodology that allows the designer to study the percentage of utilization of natural solar radiation (during winter) or protection from it (during summer), in order to predict the thermal performance of the building, through an additional tool developed using visual programming, as well as calculate the necessary thermal loads (for heating and air conditioning). With the reorientation of the building at different angles in order to study the impact of the orientation of the building on energy consumption costs, up to the proposal of suitable materials for the building envelope that provide good thermal insulation, and thus contribute to reducing the annual thermal load. To achieve this, the following steps were followed:

- building a 3D model using Revit that represents the case studied (residential buildings);
- designing a tool to predict the rates of utilization of solar radiation by nature (during the winter season) or protection from it (during the summer season) and using it on the studied situation;
- calculation of the loads necessary for heating and air conditioning of the studied residential buildings in the case of real orientation with recalculation of this load after changing the orientation by 5 and 10 degrees counterclockwise from the current situation;
- proposing and designing an additional tool by Dynamo and Python to achieve the building envelope for the design requirements of the thermal insulation code in order to reduce thermal leakage, because the materials used in this envelope have high thermal transfer coefficients.

MATERIALS AND METHODS

Collection of research data

All the data and plans necessary for the research were collected from the residential suburb project (Sheikh Saad node), consisting of twenty buildings, located in Tartous Governorate, and each building consists of a ground floor and sixteen repeated floors with a total height of (55.7 m). The floor area is (745 m^2). Each floor consists of eight apartments with a floor area per apartment (70 m^2). The following is the projection of the general location of the studied residential suburb Fig. 1.

Data analysis

The study tools were used, namely.

The use of BIM helps reduce the cost of sustainable buildings [12], where Software developers have integrated the visual programming language into BIM programmes [13], and it is important to develop energy simulation methods at the early design stage and this is done using the latest tools, the newly developed VP (Visual Programming) (Dynamo) along with the Autodesk Revit design tool [8]:

- where Dynamo is used within Revit to automatically extract asset management data from the form and export the data to a special format required by the facility owner [14];
- Autodesk Revit 2020: BIM application tool helps to 3D modelling and simulation of the building energy modelling (BEM) in addition to calculating thermal loads for heating and air conditioning;
- Dynamo 2020 Autodesk: A visual programming tool integrated into the Revit programme, which was used to facilitate the energy analysis process;
- Python language: It is a programming language that was used in visual modelling as it is compatible with Dynamo;
- Insight 360: which is an addition within the Revit programme was used to calculate the amount of solar radiation falling on the facades of buildings for the studied case. Linking the energy analysis tool to the BIM model helps speed up the energy analysis process, provide more detailed and accurate results, as well as provide energy-efficient buildings [8].

Analytical Study of the Project in the Environment (BIM)

Based on the data collected, the following figure shows the results of modelling the residential suburb in the Revit programme (Fig. 2).

"Shadow Study" results

The following figure shows the nodes of the tool used to study the formed shadows and their effect

Fig. 1. Description of the general site with the placement of buildings (organizational scheme)

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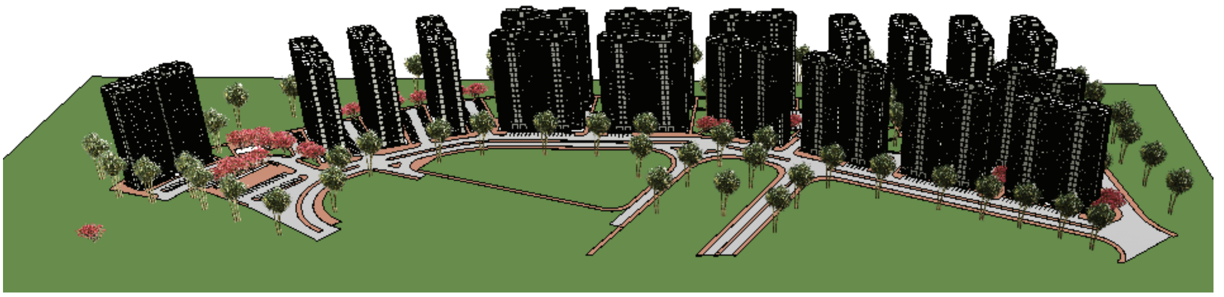

Fig. 2. Revit modelling results

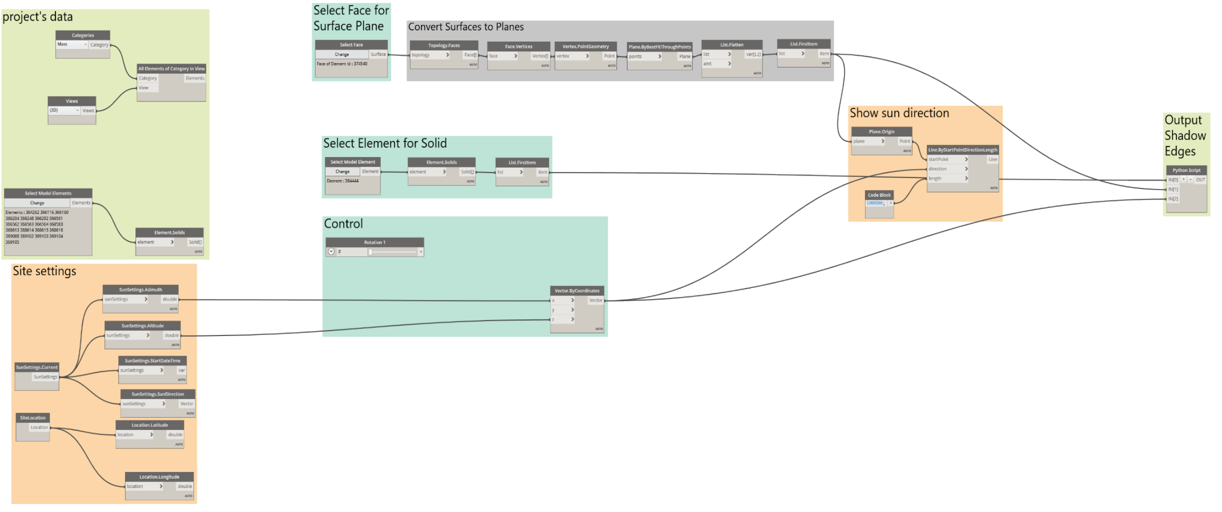

Fig. 3. Shadow Study node components in Dynamo software

on neighboring buildings every hour of the year for each type of denominator (continuous and alternating) of the studied case (Fig. 3).

Continuous assembly of buildings

This method is characterized by peripheral aspects from all sides around the residential building, and

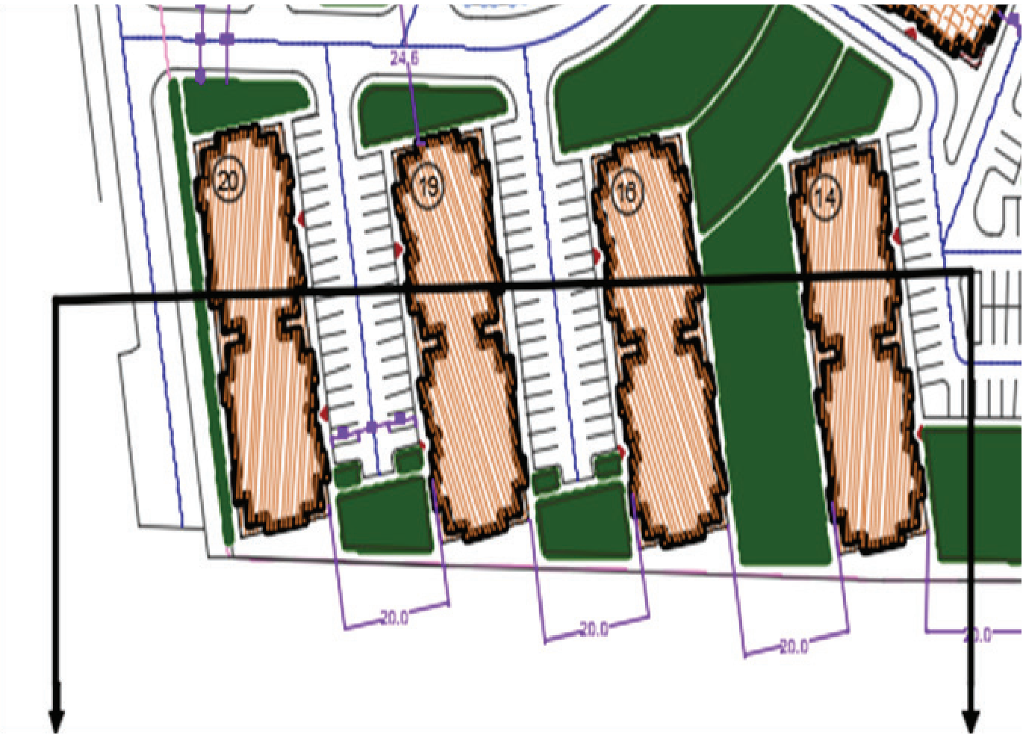

Fig. 4. North-South continuous assembly axis

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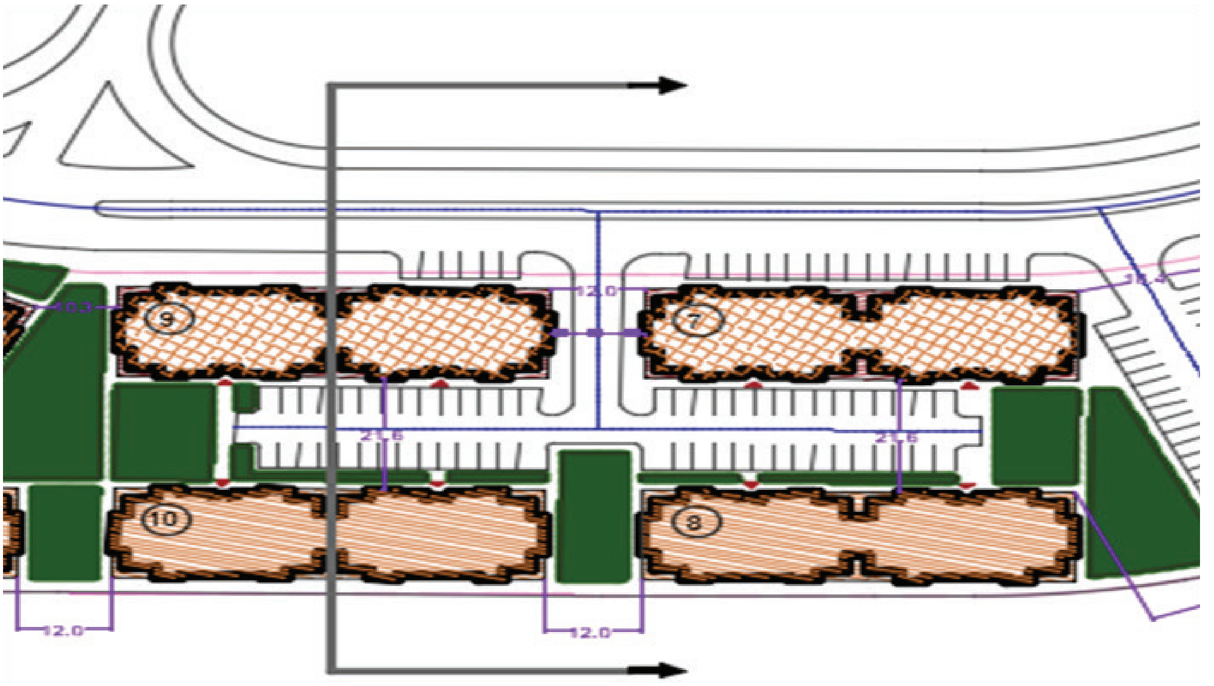

Fig. 5. East-West continuous assembly axis

the residential sections are adjacent from two or three sides, and this grouping affects the buildings that will be built within these sections through.

When the longitudinal direction of this grouping, as in Fig. 4 is north-south, it will lead to the fact that the buildings located within the partitions that are located on the southern side, which will benefit from the winter sun, are few in number because the percentage of buildings located in the shadow area will be large.

When the longitudinal orientation of the assembly method is towards east-west Fig. 5 the buildings located within the residential complex, which are reached

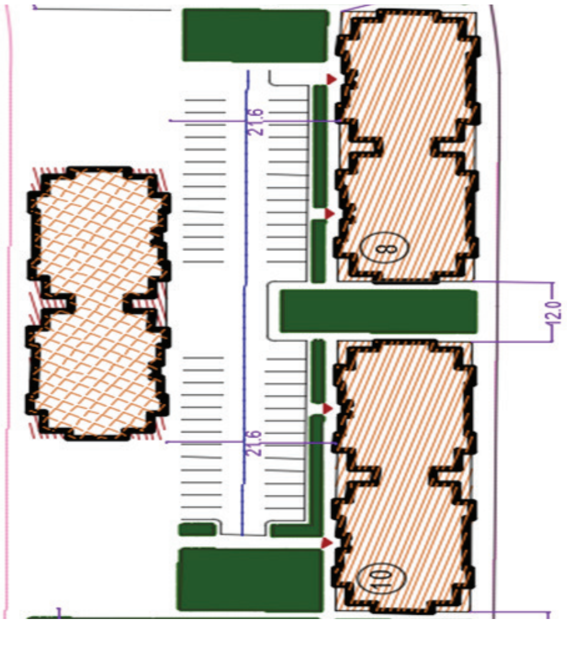

Fig. 6. East-west alternating assembly axis

by the sun's rays in winter on the southern side, will be half of the buildings, since the buildings located on the northern side will be located in the shadow area thrown by the southern buildings.

Grouping of buildings alternately

This method is characterized by the fact that the front divider is displaced from the rear divider by half the length of the divider, and this displacement helps in the arrival of the sun's favoured rays from the southern side when the longitudinal direction of the assembly is east-west to the rear buildings through the distances between the front buildings as in Fig. 6.

When the longitudinal direction of the alternating assembly is towards the north-south, the buildings located within the front sections of the southern side are exposed to the winter sun, while the buildings located on the northern side are not exposed in the southern facade to sunlight in the winter because of the shadow of the building on it, as in Fig. 7.

RESULTS

Calculation of heat loads for heating and air conditioning using Revit

We will calculate the heat load for each type of divider in its current state and then we will redirect these blocks at certain angles provided that the rotation angle does not exceed 10 degrees [3] because this will affect the system of partitions adopted in the division. The direction of the building should be seriously considered, especially in the equatorial zone according to the interaction of the building envelope with solar radiation as well as the direction of the wind [15].

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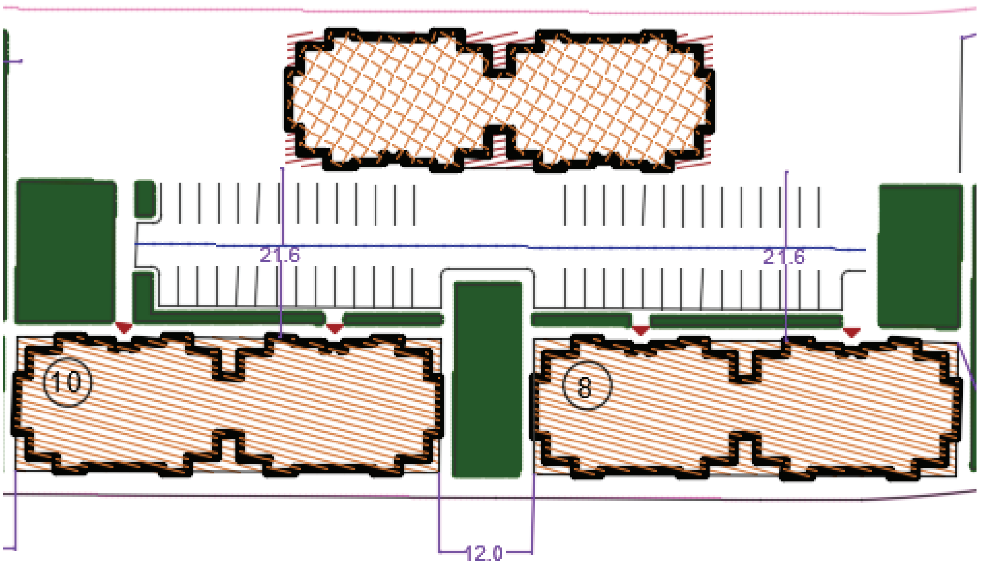

Fig. 7. North-south alternating assembly axis

After completing the modelling, we defined the spaces into rooms, which would be cooled and heated, and include living rooms and bedrooms, and then we defined the vertical zones, which is the group of space located in one plane, where all the data and special parameters necessary to calculate the heat load were entered in the Revit programme, shown in Table 1.

After defining all the parameters of the building, we will define the properties of the space for each room as shown in Fig. 8. Most of the previous properties and parameters are calculated by the Revit when determining the type of space, such as the space allocated per person, the number of people, the heat emitted from them, the thermal energy from electrical appliances, the rate of ventilation and the required lighting, as these values have been modified according to the Syrian thermal insulation code, in addition to developing room occupancy plans, which greatly affects the heat load, so the presence of the person within the room means the need to achieve comfort for him, i.e. the operation of air conditioning or heating systems, and the following are the occupancy plans for the rooms (Fig. 9, 10).

After completing the definition of the properties of all spaces, the last step is to define the properties and parameters of the zone (Fig. 11).

Table 1. Parameters of calculating the heat load on the Revit programme

Parameter	Value	Explanation
Building Type	Multi Family	It is important to determine the type of building for which the load is to be calculated because this affects its occupancy rate and the number of operating hours
Location	Tartous (34.9–35.9)	When you select the location, the programme imports weather data from the daily temperature and the degree of clarity of the atmosphere
Ground Plane	Level 1	The programme takes into account the floors adjacent to the soil when determining the ground floor level
Sliver Space Tolerance	12 m	The programme asks for special tolerance limits between buildings, i.e. whether there are buildings adjacent to the studied building
Building Envelope	Split System(s) with Natural Ventilation	Type of air conditioning and heating system to be installed
Schematic Types	<Building>	The type of building structure, is it resistant to heat transfer due to insulation or not because this will affect the heat transfer with the external medium
Building Infiltration Class	Medium	The degree of immunity of the building and takes three values (heavy, medium, low) if the type of building is heavy and the peak hour is one in the afternoon, the building will need time to transfer heat (it will trap the maximum external temperature) and the peak hour inside the building is at three o’clock in the afternoon and this factor relates to the type of structure and the degree of insulation

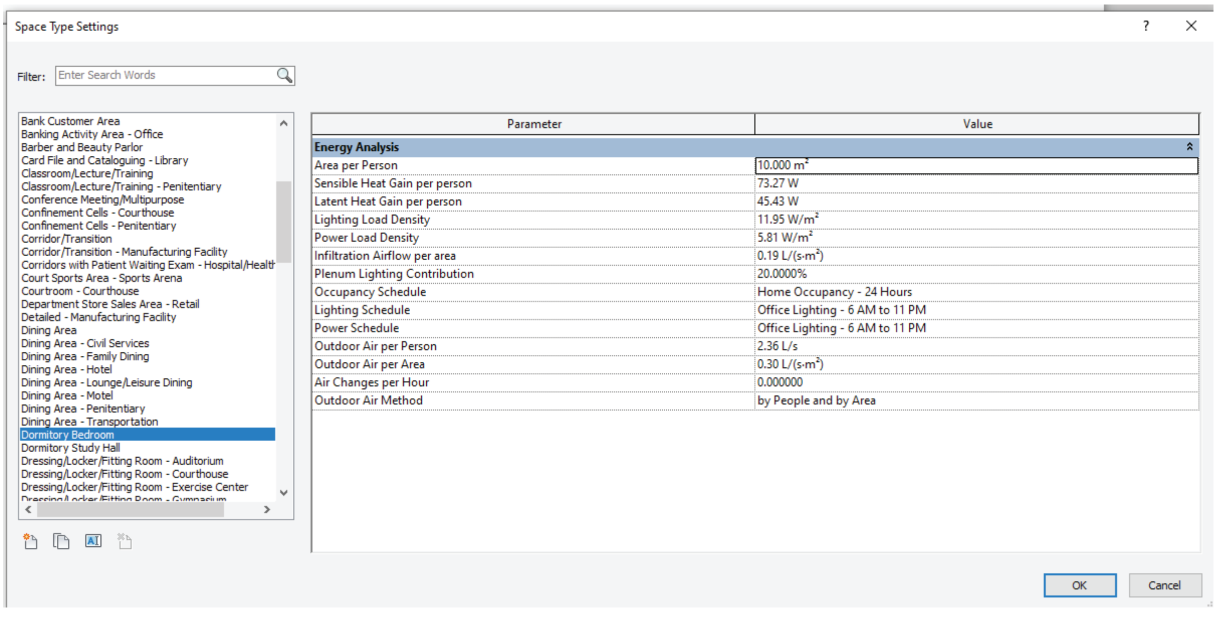

Fig. 8. Properties of Space

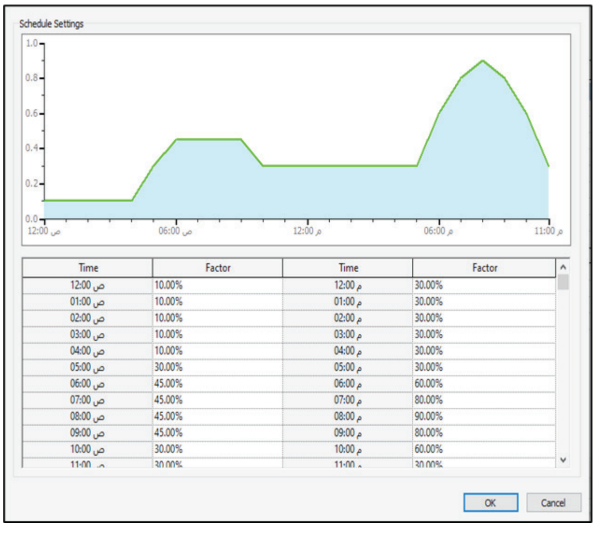

Fig. 9. 24-hour space occupancy chart for bedroom

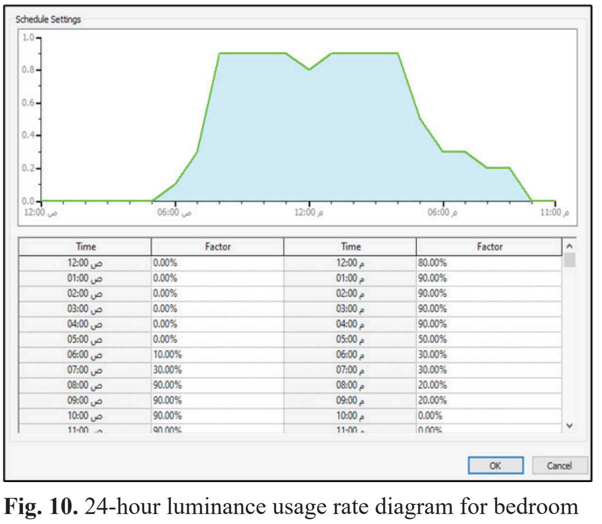

Fig. 10. 24-hour luminance usage rate diagram for bedroom

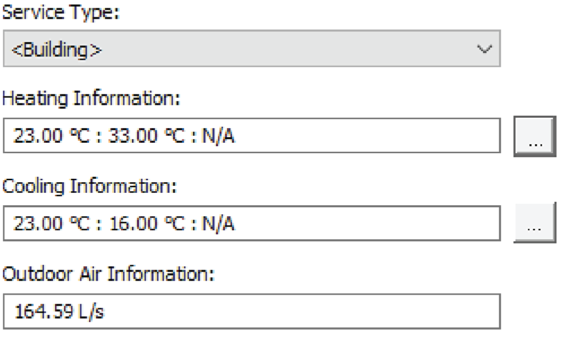

Fig. 11. Properties and parameters of the zone

Here we will specify the information on heating and air conditioning devices, which are Table 2.

Table 2. Information of heating and air conditioning devices

Heating Information		
Heating Set Point	23 °C	The room temperature at which the heating device will stop working
Heating Air Temperature	33 °C	The temperature of the air coming out of the heating device
Cooling Information		
Cooling Set Point	23 °C	The room temperature at which the air conditioner will stop working
Cooling Air Temperature	16 °C	The temperature of the air coming out of the air conditioner

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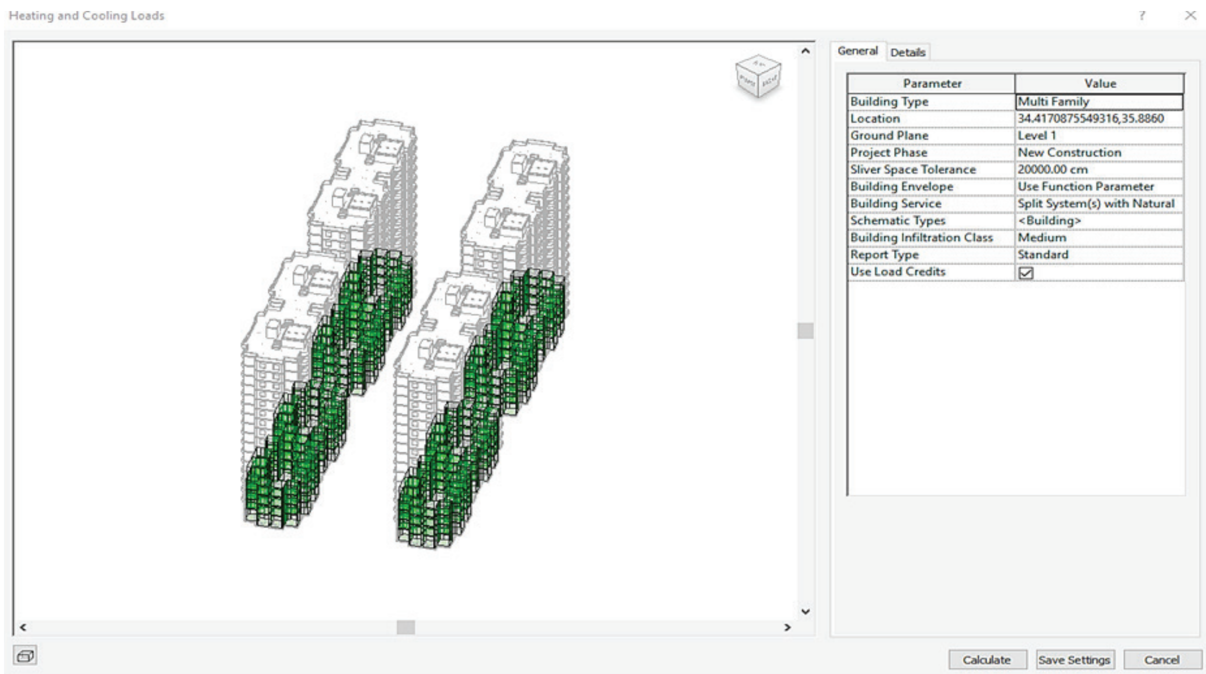

Fig. 12. Continuous assembly in real mode

Results of the loads for the continuous assembly method of buildings

Continuous assembly with East-West axis

The loads of each method of assembling buildings were studied in three orientation positions, the first in the real current situation (Fig. 12), the second when rotating at an angle of 5 degrees, and the third when rotating at an angle of 10 degrees, and we will compare the results with each other to reach the best orientation.

After calculating the load in the previous real situation, these buildings were rotated by 5 degrees (the second case) (Fig. 13) and 10 degrees (the third case) (Fig. 14) counterclockwise so that the longitudinal axis (east-west) and this in turn will increase the area of the facades exposed to sunlight [16].

We note that the air conditioning loads of the ground floors decreased when directing the buildings at an angle of 5 degrees counterclockwise, where the availability in the load reached (26.8 kW), while when steering by 10 degrees, the availability reached (15 kW) and the third block in which the loads increased significantly as a result of the exposure of the bulk of its outer cover to sunlight (Fig. 15).

We note that the heating loads of the ground floors decreased when directing the buildings at an angle of 5 degrees counterclockwise, where the savings

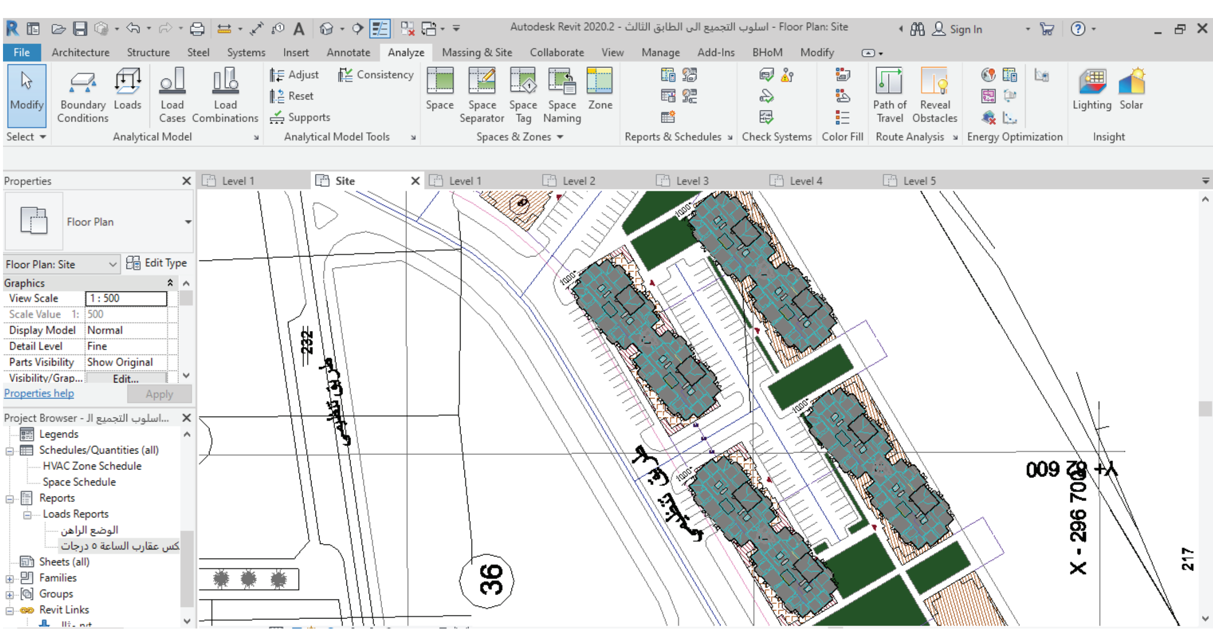

Fig. 13. Continuous assembly after steering 5 degrees counterclockwise

Fig. 14. Continuous assembly after steering 10 degrees counterclockwise

in load reached (49.73 kW), while when steering by 10 degrees, the savings reached (46.36 kW) (Fig. 16).

The savings in the total heat load when directing the four buildings by 5 degrees counterclockwise (778.41 kW) and compared with the availability resulting from directing the buildings 10 degrees counterclockwise, which amounted to (957.85 kW) (Fig. 17) with attention to the difference in savings on each floor of the building and the reason for this difference is due to the effect of height as a result of changing the intensity of radiation falling on the building with the change in height (Fig. 18, 19) where this was concluded by calculating the intensity of radiation falling on the building using the Insight programme, which is an addition to the Revit programme.

Continuous assembly with a north-south axis

The loads were studied in three orientation modes: the first in the real current situation (Fig. 20, *a*), the second when rotating 5 degrees clockwise (Fig. 20, *b*), and the third when rotating 10 degrees clockwise (Fig. 20, *c*) and we will compare the results with each other to reach the best orientation.

The percentage of savings in the total heat load when directing the four buildings by 5 degrees clockwise (16.4 %) and compared with the percentage of savings resulting from directing buildings 10 deg-rees with the clock, which amounted to (20.2 %) The reason for this is that the rotation will allow an increase in the solar radiation falling on the southern facades so that the long axis of each block becomes east-west

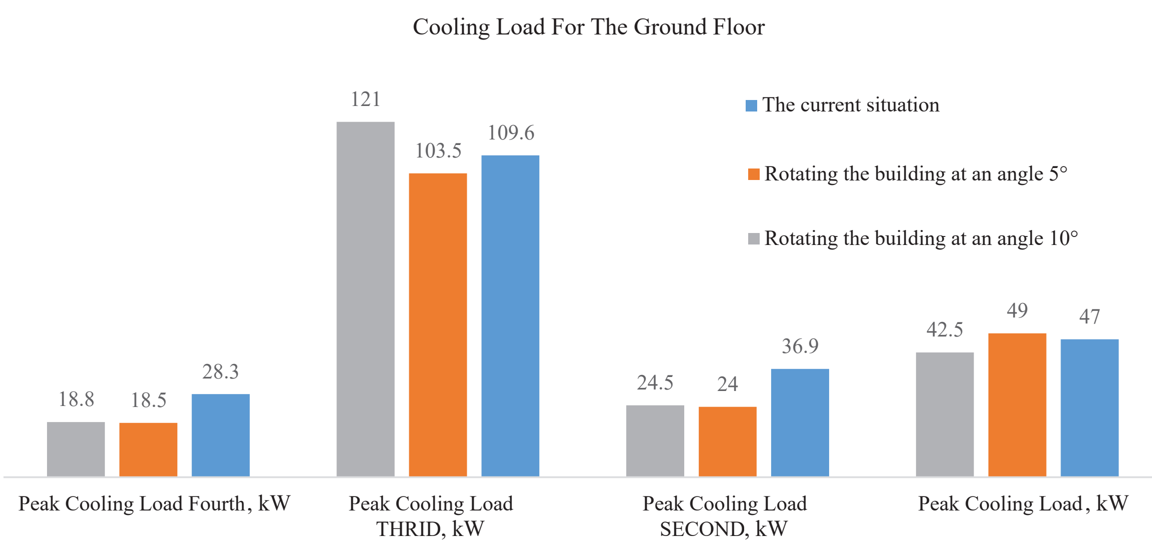

Fig. 15. Cooling load of ground floors in each block with three steering positions

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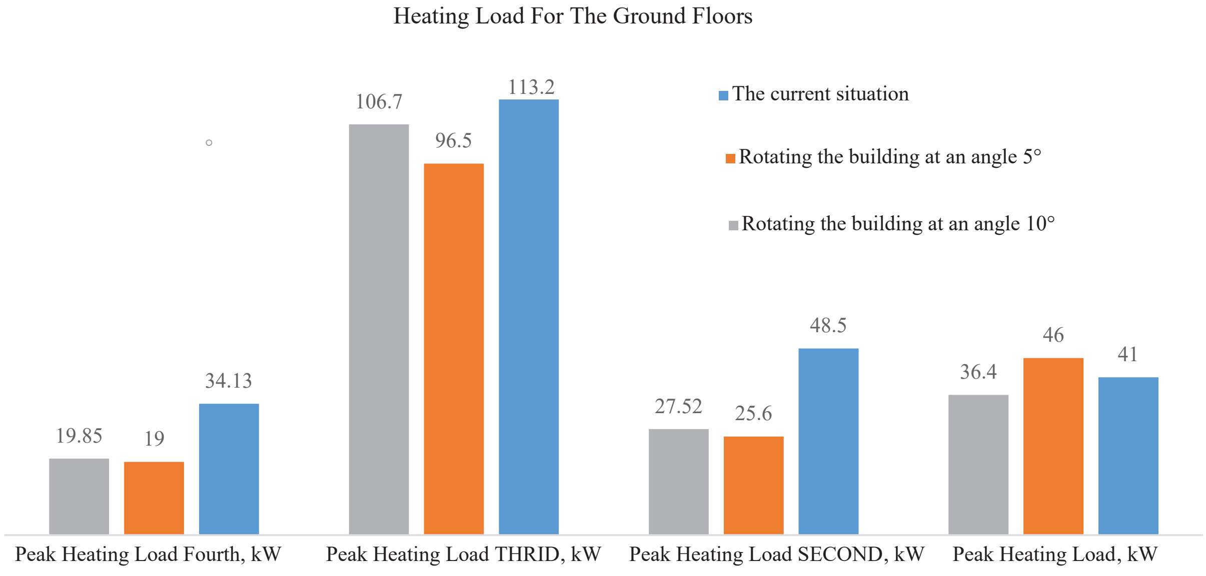


Fig. 16. Heating load of ground floors in each block with three steering positions

direction. Below is a table showing the heat load for each floor in the four blocks in the three positions (Table 3).

Proposing an additional tool by Dynamo to achieve the building envelope to the design requirements of the Syrian thermal insulation code

The study of thermal loads by the Revit indicated that the heat load in all types of distribution of partitions is directly affected by the outer shell of the building from external walls, floors, ceilings, windows and even the glass used in it, where The building envelope can save energy and adapt to the surroundings and the external environment in order to provide internal comfort [17] and the table shows the components of the heat load for heating and adaptation and the contribution of each element to this load (Table 4).

We note from the previous two figures (Fig. 21, 22) that the ceilings contribute about 50 % of the air

Table 3. Total heat load per floor in the four blocks in kW

Floor	The current situation	Rotating the building at an angle 5°	Rotating the building at an angle 10°	Percentage of savings in the first case	Second case saving percentage
Ground floor	429.87	386.76	365.16	10.03	15.05
First floor	380.96	290.4	269.9	23.77	29.15
Second floor	328.3	230.92	221.6	29.66	32.50
Third floor	305.06	231.5	211.15	24.11	30.78
Fourth floor	354.86	299.38	292.75	15.63	17.50
Fifth floor	463.35	409.69	394.68	11.58	14.82
Sixth floor	460.3	408.46	385.07	11.26	16.34
Seventh floor	345.66	295.64	263.87	14.47	23.66
Eighth floor	465.7	417.5	405	10.35	13.03
Ninth floor	436	372.3	358.5	14.61	17.78
Tenth floor	388.67	321.77	296.97	17.21	23.59
Eleventh floor	341.34	290.54	257.64	14.88	24.52
Twelfth floor	366.8	291.9	300.8	20.42	17.99
Thirteenth floor	392.26	325.46	325.46	17.03	17.03
Fourteenth floor	440.65	381.95	373.05	13.32	15.34
Fifteenth floor	551.51	491.32	433.03	10.91	21.48
Sixteenth floor	451.81	325.81	352.55	27.89	21.97
Total	6,903.1	5,771.3	5,507.18	16.4	20.2

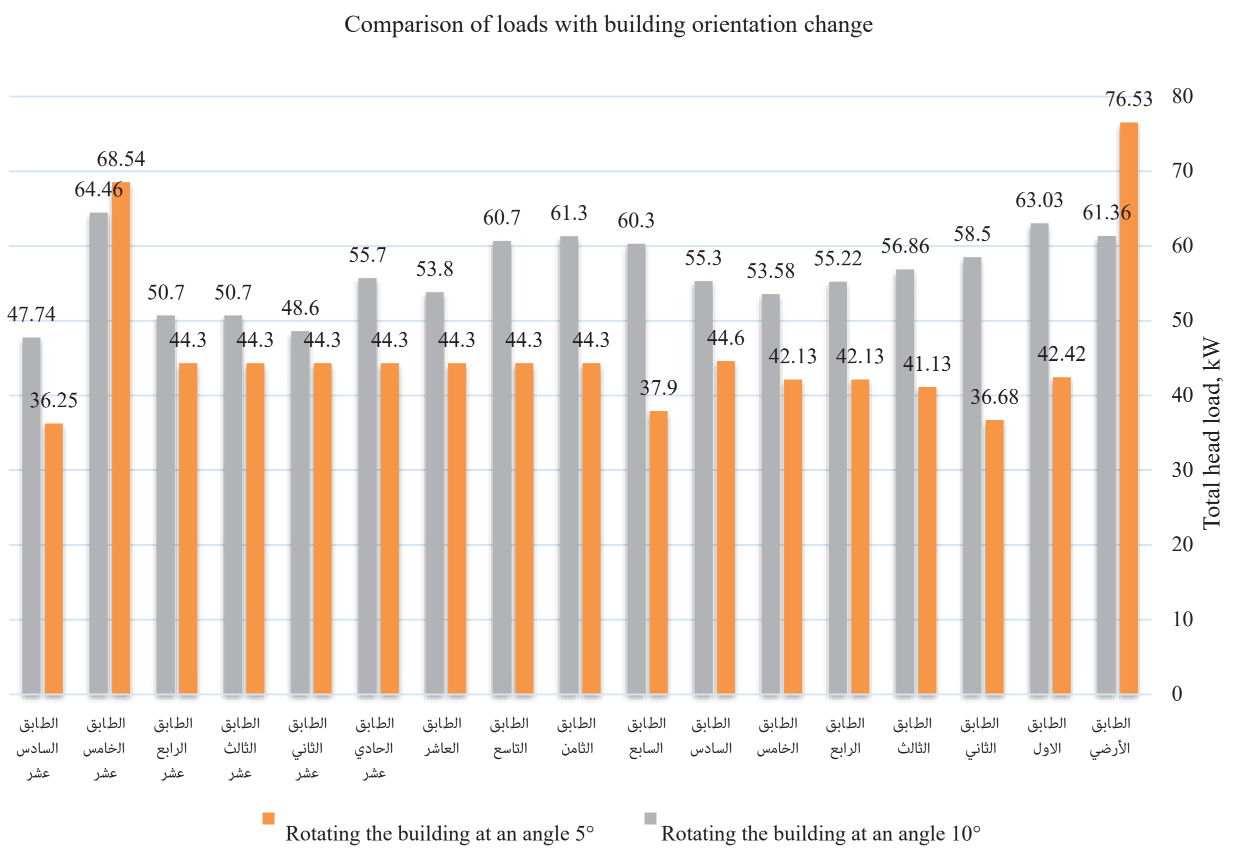


Fig. 17. Resulting savings per floor in the four blocks

Table 4. Components of convection with the contribution of building elements

Components	Cooling		Heating	
	Loads, W	Percentage of total, %	Loads, W	Percentage of total, %
Wall	13,018	20.65	34,955	48.70
Window	752	1.19	1,066	1.49
Door	751	1.19	1,812	2.53
Roof	31,438	49.88	15,820	22.04
Skylight	0	0.00	0	0.00
Partition	0	0.00	0	0.00
Infiltration	7,910	12.55	10,003	13.94
Ventilation	3,430	5.44	3,880	5.41
Lighting	2,054	3.26	–2,054	–2.86
Power	1,001	1.59	–1,001	–1.40
People	1,179	1.87	–1,179	–1.64
Plenum	0	0.00	0	0.00
Fan Heat	1,491	2.37	0	0.00

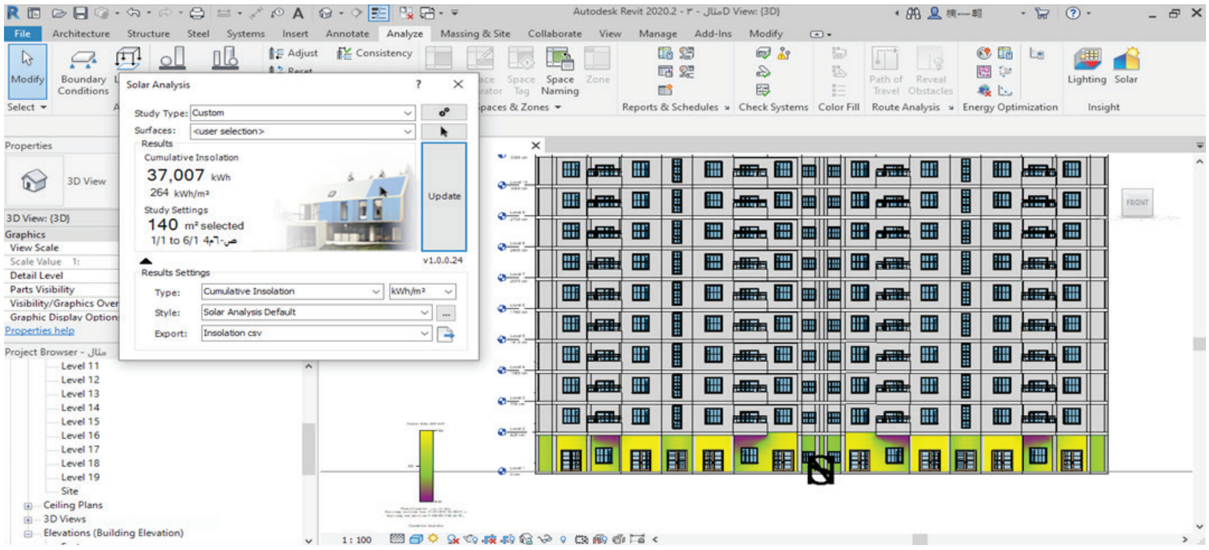
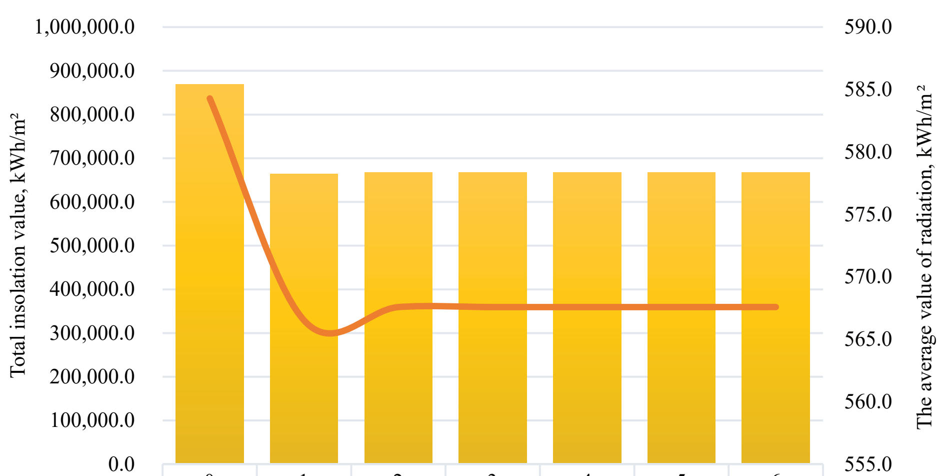


Fig. 18. A study of the solar radiation falling on the ground floor using Insight in Revit

conditioning loads and 22 % of the heating load, while the walls contribute about 50 % of the heating loads and 20 % of the air conditioning loads, and returning to the reason for this rise, we note that these elements are more interactive with the external environment as a result of the occurrence of heat exchange between the internal environment of the building with the heat of the air. As the total heat transfer coefficient of these elements is large and the value of the total heat transfer coefficient for building elements depends on several factors, including the properties of the material or materials that make up the elements, their thicknesses and the degree of exposure of their external surfaces to weather factors, and with the increase in the value of the total heat transfer coefficient for building elements, the amount of heat lost in winter and gained in summer increases. Thus, an increase in energy consumption necessary to heat and air conditioning and thermal insulation is one of the best long-term means to ensure energy savings, reduce utility bills and improve the indoor air quality of the building [18, 19]. The building Revit programme helps to calculate the values of the total thermal transfer coefficient for the elements of the building, once the materials are introduced with their thickness, the programme gives both the values of thermal resistance and the total transition coefficient of the modeled element and the following are the values of the thermal coefficients extracted



	0	1	2	3	4	5	6
Total Surface Insolation Value	868,657.5	664,384.2	667,783.2	667,783.5	667,784.0	667,784.3	667,789.3
Average Surface Insolation Value	584.3	566.5	567.6	567.6	567.6	567.6	567.6

Floor

Total Surface Insolation Value   Average Surface Insolation Value

Fig. 19. The value of solar radiation on the first block of each floor

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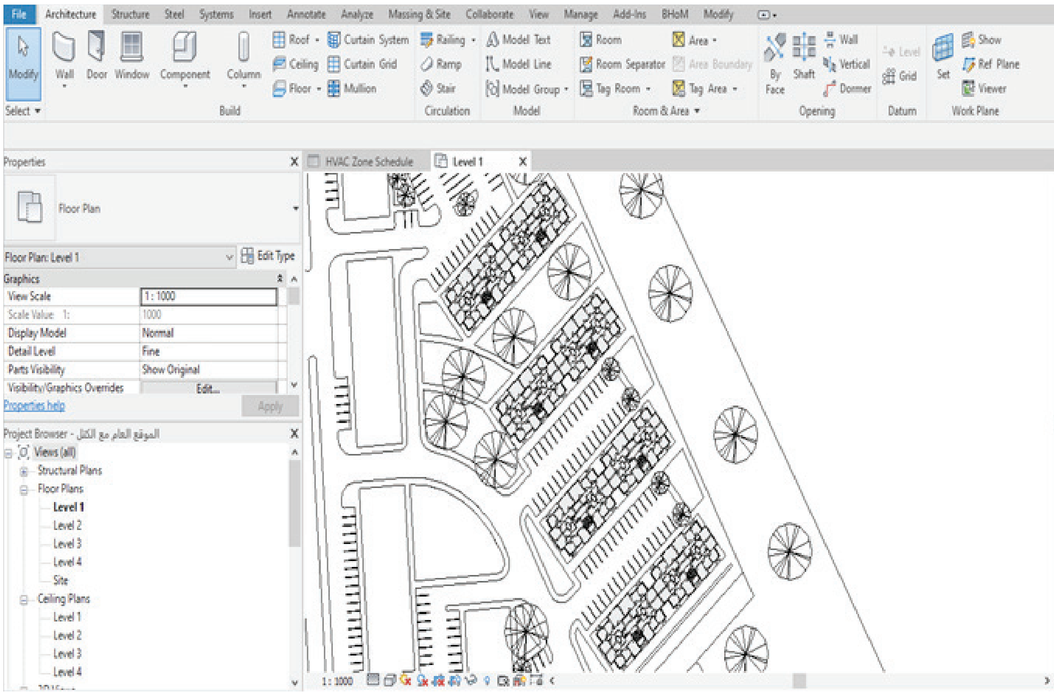
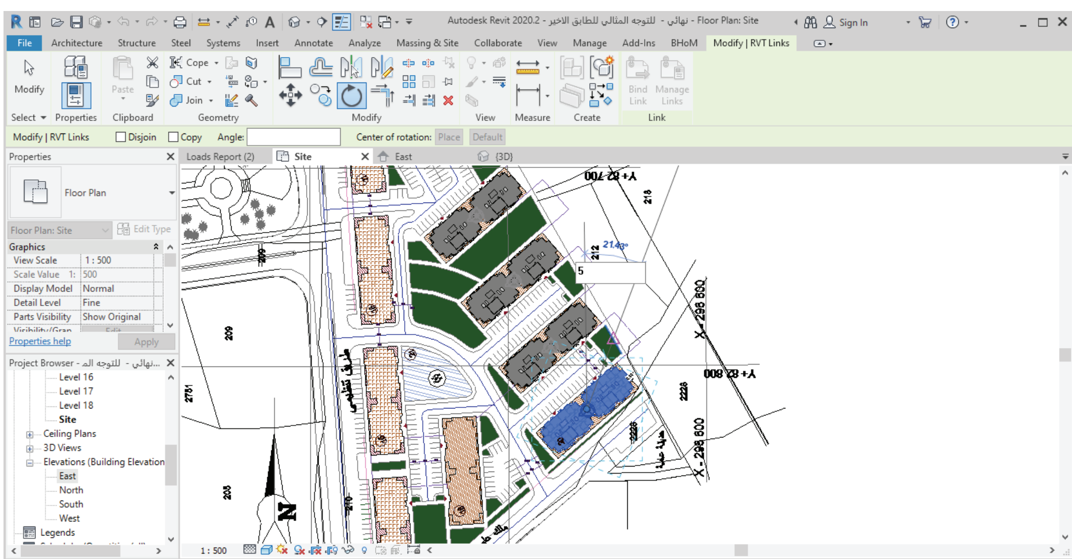
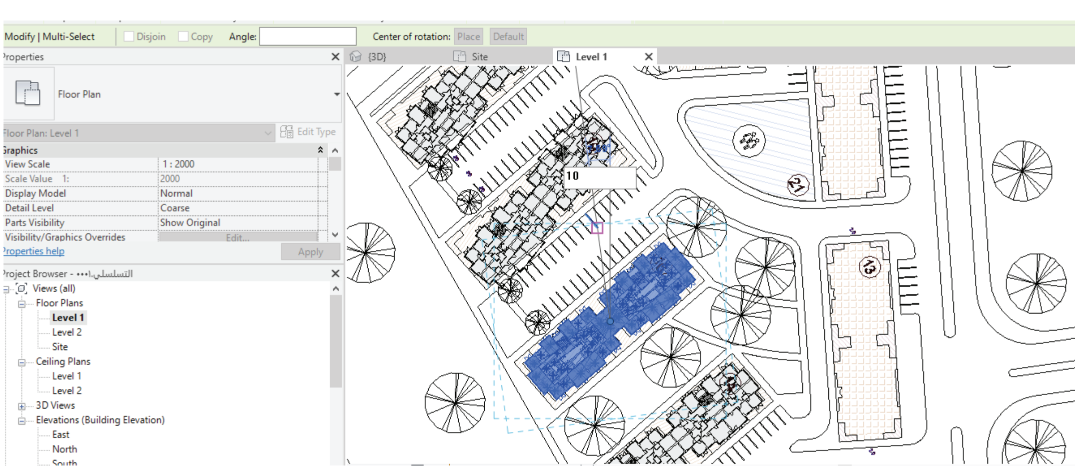


a



b



c

Fig. 20. North-South axis continuous assembly method

from the programme for the elements of the building (Fig. 23, 24).

The building elements must be designed so that the value of the total heat transfer coefficient is within the permissible limits according to the Syrian Arab code for insulation, and according to this code, the value of the total heat transfer coefficient for each building element must not exceed the values mentioned in Table 5.

The values of the total thermal transfer coefficient of the elements of the building envelope do not achieve the code, so an additional software tool was designed by Dynamo and the Python language (Fig. 25) to achieve the building envelope to the design requirements of the Syrian thermal insulation code in order to reach sustainable energy-saving buildings that benefit from sunlight and reduce fossil energy consumption.

Table 5. Maximum allowable values of the total heat transfer coefficient of building elements

Maximum total heat transfer coefficient, W/m²·K		Structural element
0.5	U_{roof}	The last ceiling
0.8	U_{ow}	Exterior walls without openings
5.2	U_{win}	Glass openings when they are:
		$A_{win} \leq 0.2$ A facade
		Glass openings when they are:
3.5	U_{win}	$A_{win} > 0.2$ A facade
1.5	U_{facade}	Exterior facades include all openings
1	U_G	Floors adjacent to the soil
1	U_F	Floors between floors
0.5	U_F	Exposed flooring
Awin: Window & Door Space		A_{facade}: Facade space

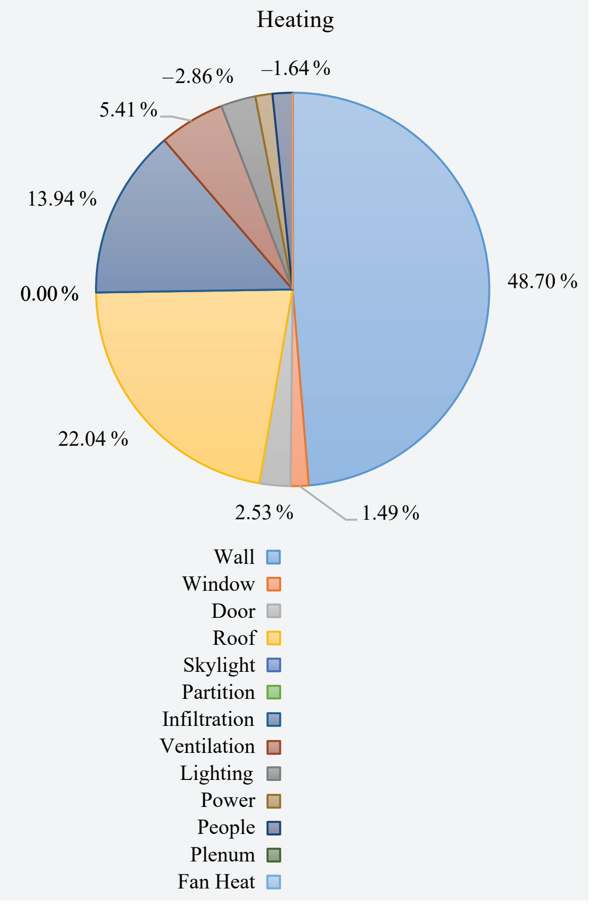


Fig. 21. Contribution of building elements to heating loads

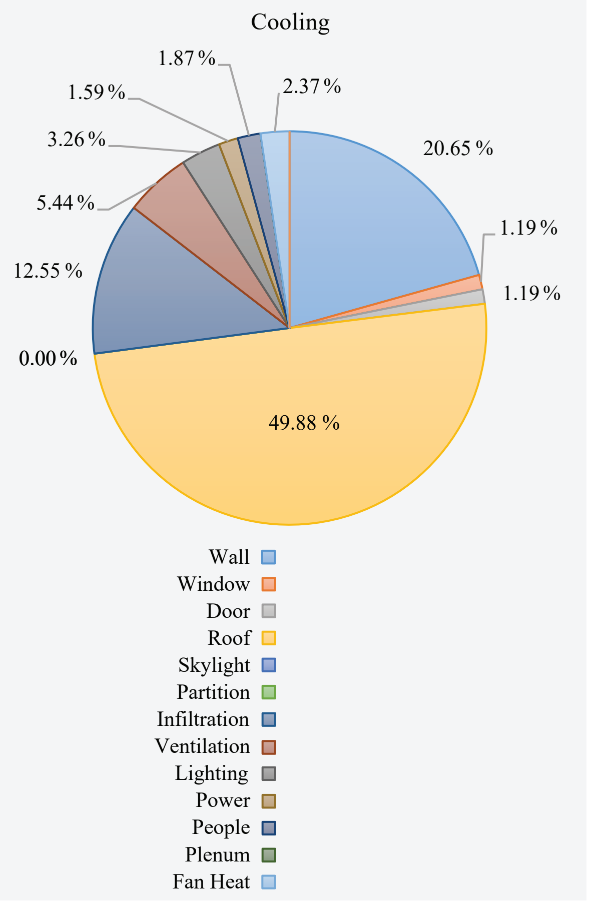


Fig. 22. Contribution of building elements to air conditioning loads

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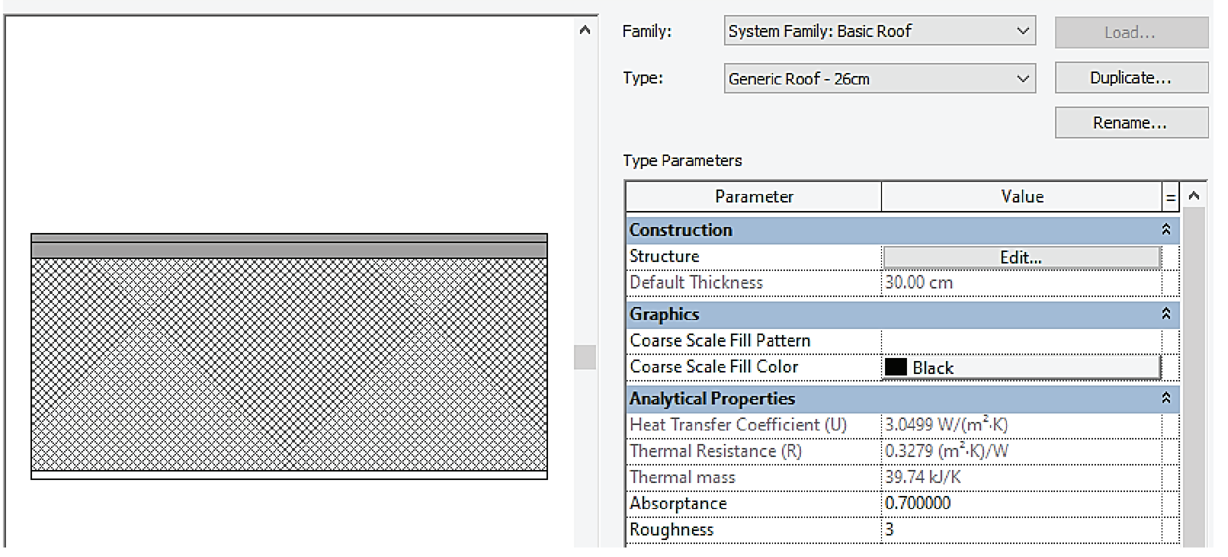

Fig. 23. Thermal properties of roofs extracted from Revit

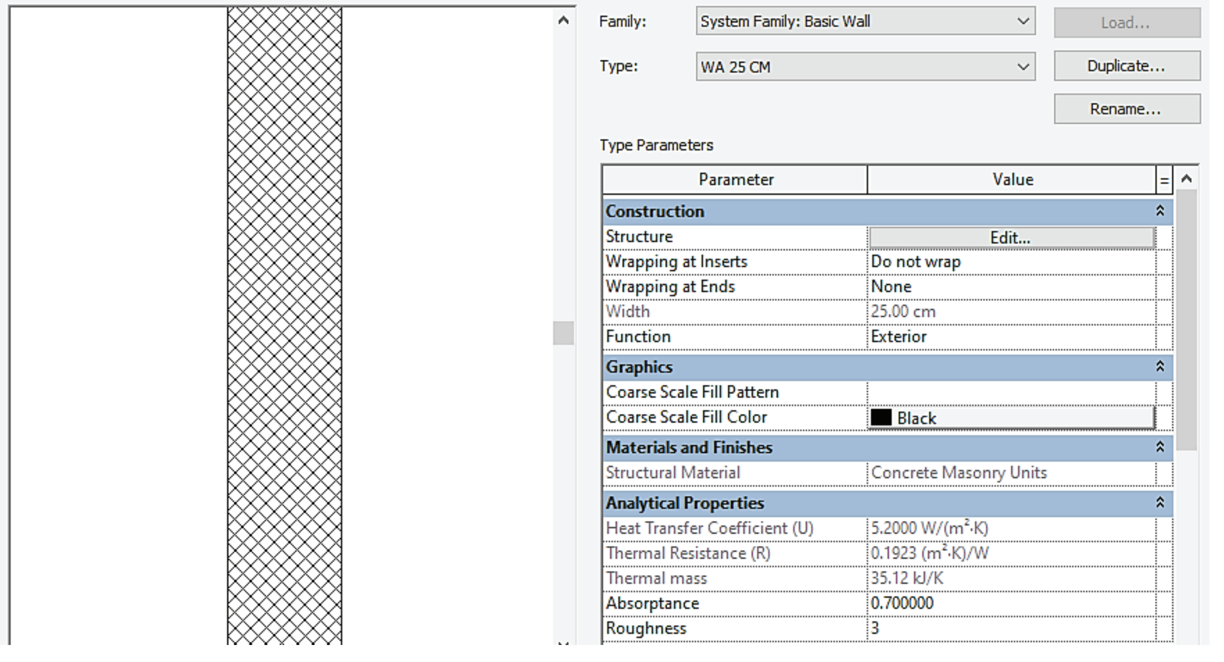

Fig. 24. Thermal properties of walls extracted from Revit

This tool first imports the elements of the outer shell of the studied building, which are (walls and floors adjacent to the soil, ceilings and floors between floors and windows) and then the thermal information integrated inside these elements, which is the total thermal transfer coefficient, thermal resistance and structural composition, is obtained in order to compare the transition coefficient resulting from modelling with what is allowed within the code and stipulated in (Table 5) using the Python language. If the results of the investigation node for the elements are not realized, the programme will add a new material (polystyrene) that increases thermal resistance [20] and decreases the total transition coefficient by a specific thickness that can be changed, and the following is a (Fig. 26) showing the mechanism of work of the node to introduce a new material to the building elements using the Python language.

The aim is to reach the elements of a building that meet one of the most important design requirements of the thermal insulation code, and after adding the new material, we notice a decrease in the thermal transfer coefficients so that they become within the acceptable limits stipulated in the code (Fig. 27, 28).

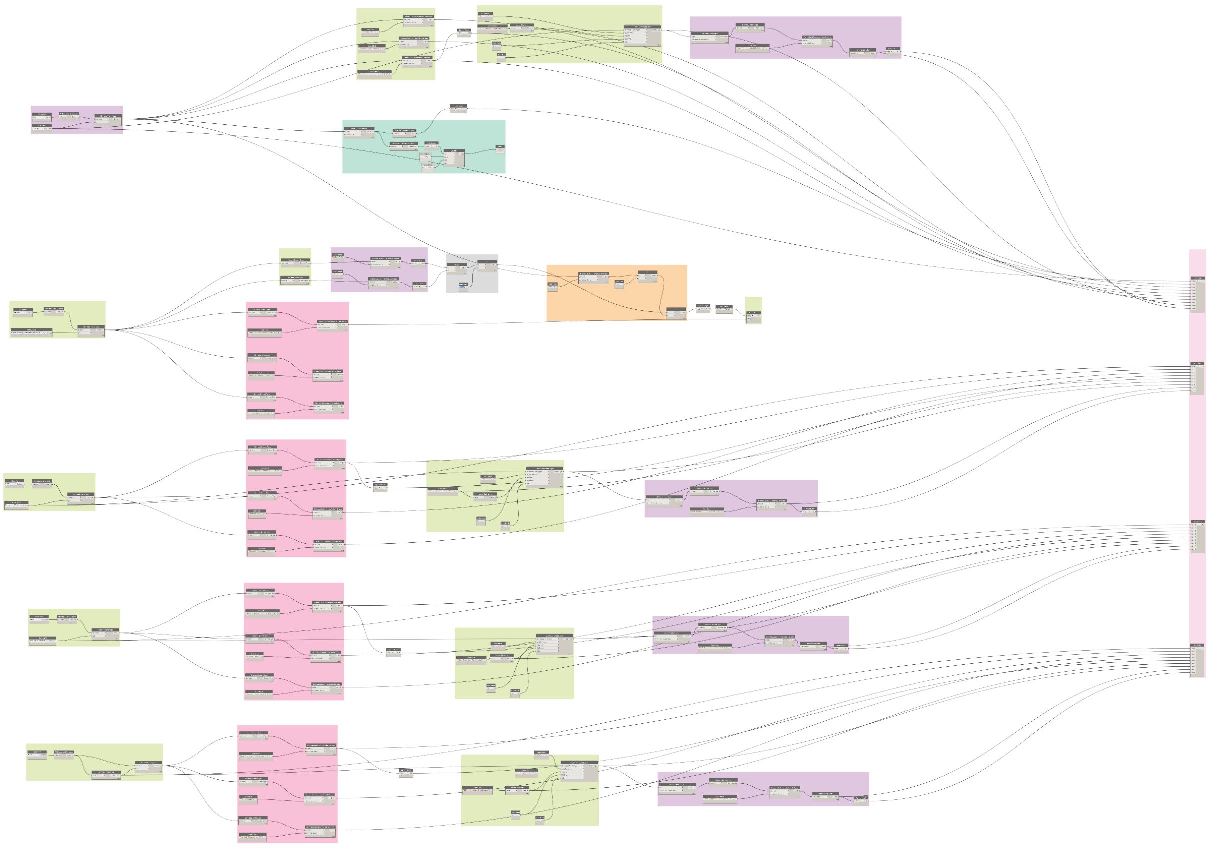

Fig. 25. Components of Dynamo nodes

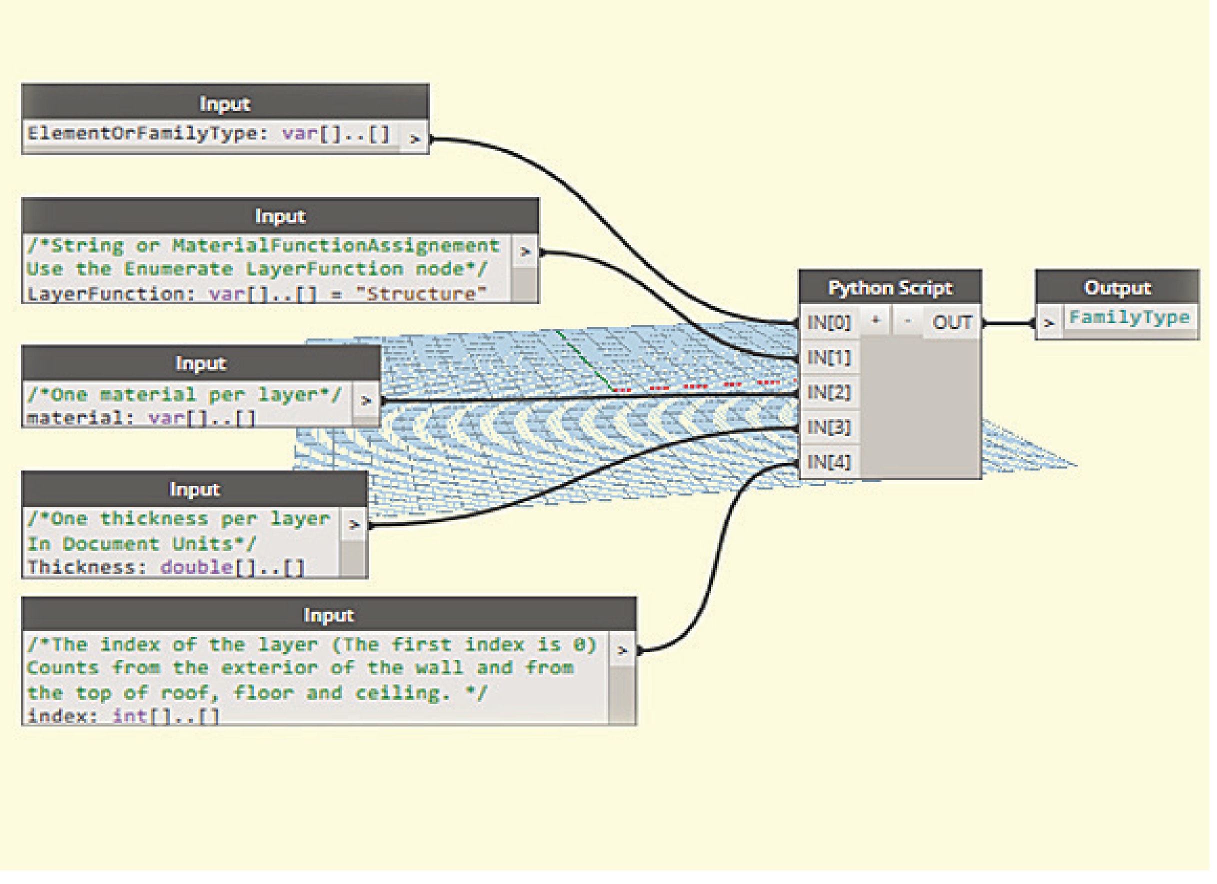

Fig. 26. Contract for introducing new material using Python

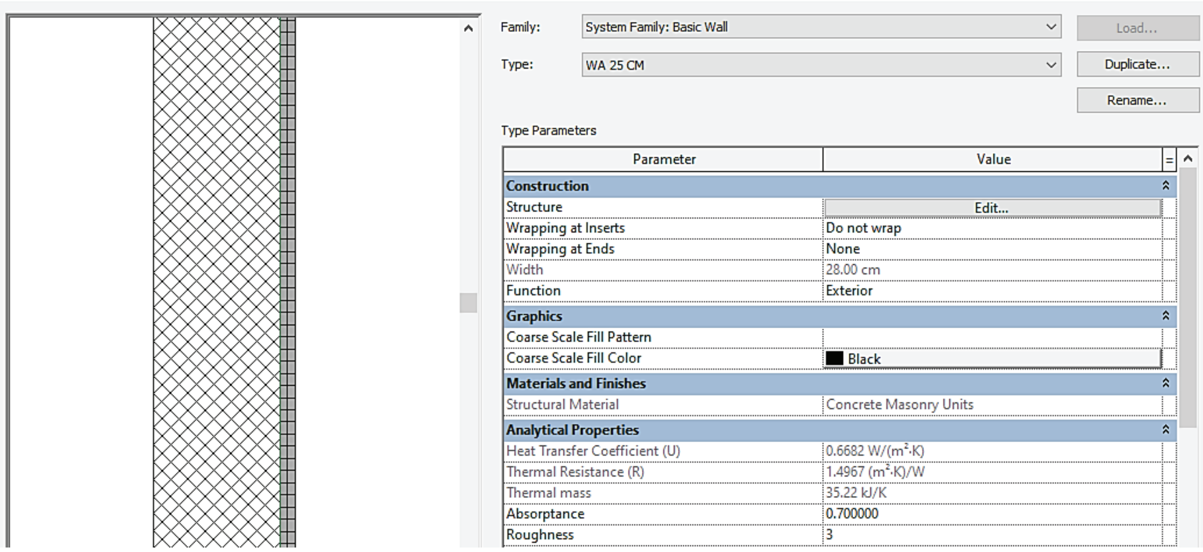

Fig. 27. Thermal properties of the walls of the building after adding the new material

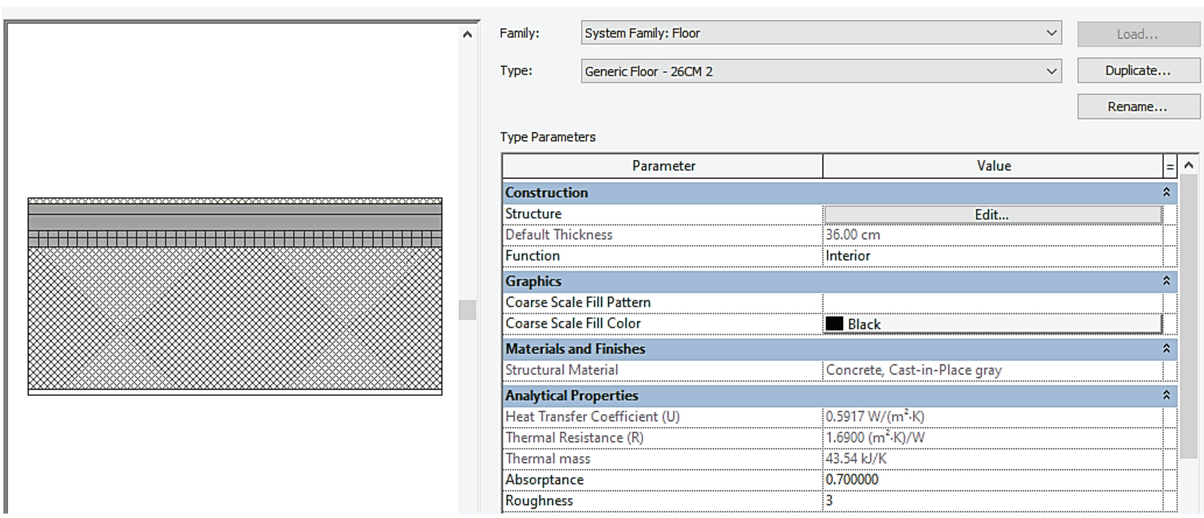

Fig. 28. Thermal properties of the floor of the building after adding the new material

CONCLUSION

The BIM methodology is an effective technology in the field of energy management in projects, which has many advantages that contribute to reducing annual energy consumption and reaching environmentally friendly buildings, and we conclude from this the following:

Building Information Modelling (BIM) contributes to predicting the amount of energy consumed annually and spent on heating and air conditioning through the tools that it provides easily and quickly, as building information is integrated into the building elements from heat transfer coefficient, thermal resistance, thermal mass and even climatic information of the site. They are taken from the nearest weather observatory without having to be collected or predicted by the site.

Studying the orientation of the building during the design stage contributes to reducing the total annual heat load by more than 20 %, and this percentage varies according to the method of assembling the partitions, as the orientation of the buildings in the continuous quadrilateral assembly method achieved a percentage of savings in consumption exceeding 24 %, while in the alternating assembly method it reached Savings 10 %.

Using the Shadow Study tool designed with the help of Dynamo within the work environment of the Revit contributed significantly to the study of the distribution of residential partitions in terms of the extent of benefit from natural solar radiation, which is a source of renewable energy, as the research indicated that the longitudinal axis of the method of distributing buildings towards east — west, when the building is in a rectangular shape because this allows the southern facades to benefit from sunlight.

The new addition, using the visual programming language, meets the design requirements of the building envelope from the Syrian thermal insulation code, as it contributed to reducing the thermal leakage resulting from the interaction of the outer shell of the building with the atmosphere, by returning the heat transfer coefficient of these elements from rejected values to acceptable values. Thus reducing the annual total convection.

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Bionotes: **Jamal Younis Omran** — PhD in Construction Project Management Engineering, Professor, Dean of Faculty of Civil Engineering; **Tishreen University**; Lattakia, Syria; Scopus: 57194594127, ResearcherID: ABF-2210-2021, ORCID: 0000-0002-8429-6210; president@tishreen.edu.sy, j-omran@tishreen.edu.sy;

Moustafa Ali Wassouf — civil engineer Department of Construction Management, engineer, graduate student with master's degree at the Faculty of Civil Engineering; **Tishreen University**; Lattakia, Syria; ResearcherID: HSF-7867-2023, ORCID: 0000-0002-3001-5030; president@tishreen.edu.sy, moustafa.wassouf@tishreen.edu.sy.

Contribution of the authors:
Jamal Eunice Omran — scientific guidance, concept of research and development of methodology, text review, final conclusions.
Moustafa Ali Wassouf — participate in the development and implementation of curricula, develop and implement a software tool, write code in (python.)
The authors declare that there is no conflict of interest.

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Об авторах: **Джамал Юнис Омран** — доктор наук в области инженерии управления строительными проектами, профессор, декан факультета гражданского строительства; **Университет Тишрин**; г. Латакия, Сирия; Scopus: 57194594127, ResearcherID: ABF-2210-2021, ORCID: 0000-0002-8429-6210; president@tishreen.edu.sy, j-omran@tishreen.edu.sy;

Мустафа Али Вассуф — инженер-строитель кафедры управления строительством, инженер, аспирант со степенью магистра факультета гражданского строительства; **Университет Тишрин**; г. Латакия, Сирия; ResearcherID: HSF-7867-2023, ORCID: 0000-0002-3001-5030; president@tishreen.edu.sy, moustafa.wassouf@tishreen.edu.sy.

Вклад авторов:
Джамал Юнис Омран — научное руководство, концепция исследования и разработки методологии, обзор текста, выводы.
Мустафа Али Вассуф — участие в разработке и внедрении учебных программ, разработка и внедрение программного инструмента, написание кода на Python.
Авторы заявляют об отсутствии конфликта интересов.