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Energy Simulation and Management of the Main Building Component Materials Using Comparative Analysis in a Mild Climate Zone

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P A P E R I N F O

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A B S T R A C T

Must limited energy resources and the need for energy saving make the design of buildings more efficient in terms of energy consumption. For this reason, proper orientation of buildings, use of sunlight, natural ventilation, application of consumable materials are factors that help reduce heat and cooling loads. The objective of this study is to evaluate the energy efficiency of residential buildings using natural energy and optimizing the choice of materials for heat and cold saving with the Ecotect simulation software. According to analysis and simulation, it was found that the optimum materials of the main building components in a mild climate zone of Rasht city include (a) the Brick Conc block Plaster for a wall with the total radiation incident of 340 W/m^2 and a radiation absorption of 240 W/m^2, (b) Double Glazed-Low E for windows with the total radiation incident of 340 W/m^2 and a radiation absorption of 100 W/m^2, (c) Foam Core Ply Wood for door with the total radiation incident of 340 W/m^2 and a radiation absorption of 200 W/m^2, (d) ConcSlab-OnGround for floor with the total radiation incident of 340 W/m^2 and a radiation absorption of 220 W/m^2, and (e) Conc Roof Asphalt for roof with the total radiation incident of 340 W/m^2 and a radiation absorption of 300 W/m^2. According to an hourly temperature analysis of all stories of the building on two hot and cold days of the year and as observed by the design and material selection requirements, the building will be conditioned in an almost thermal comfort zone (below 30 degrees) in the warm season.

1. INTRODUCTION

The issue of energy and access of the developed countries to low-cost energy sources has always been subject to many challenges [1]. This is one of the most important and common topics in today's world. These days, worldwide environmental changes have put human civilization in jeopardy [2]. An effective indoor condition relies upon a better comprehension of ecological components including building structure and setting. Indoor climatic conditions play a critical role in the sustainability of building construction [3]. The building sector is responsible for 40 % of energy consumption and 38 % of the CO_2 emissions in the U.S. [4]. About 27 % of the CO_2 emissions in the UK are attributed to buildings (heat loss at homes). Thermal analysis has the most important role in dealing with building energy consumption and is one of the key points of investigation [5, 6]. One of the main topics in the debate on the sustainable building plan is the balance between energy storage and distributed renewable energy consumption (solar and wind energies) [7]. A sustainable building is developed using environment-friendly materials and low energy consumption during the whole lifecycle of a building [8]. Buildings and their corresponding energy requirements significantly impact the environment, which is presently a matter of concern among the related research community [9]. Since worldwide interests are aligned with energy efficiency in buildings under the current environmental changes, thermal comfort studies are received considerable attention nowadays [10]. In this respect, ensuring ecological energy saving and constructing green buildings in many countries have become exceptionally fascinating [1]. Increase in building energy consumption can affect the world in negative terms [11]. The negative climatic effects on developing countries and their buildings result from the high intensity of solar radiation and high daily air temperature [12].

Limited energy resources and energy saving requirements make the design of buildings more efficient in terms of energy consumption [13]. For this reason, proper orientation of buildings, use of sunlight, natural ventilation, and the choice of consumable materials to reduce heat and cooling loads and prevent energy loss are important. A number of factors are conducive to the increase and decrease rates of energy consumption of buildings. Factors such as form, materials, pop-ups, and orientation of the building to sunlight and wind are the most important ones, among which the shape and orientation of the building usually receive more emphasis. Many studies have been done on the design of building materials, Phase Change Material (PCM), and simulation and optimization of heating and cooling system in order to achieve energy efficiency [14-30]; however, in terms of designing an optimum thermal form with favorable performance, studies have rather underestimated the parameter of using proper materials. The objective of this study is to evaluate the energy efficiency of residential buildings using natural energy and optimizing the choice of materials for heat and cold saving with the Ecotect simulation software. For this purpose, the design phase along with the choice of optimum materials can play a notable role in the energy management of a building. In this study, modeling is performed with Ecotect software according to the climate data (mean annual temperature) of the area, building orientations, sunlight angle, available natural ventilation, and optimum material selection analysis.

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Based on comparative results, the best conditions will be obtained for energy conservation in the early stages of design.

Autodesk Ecotect is a very powerful environmental design software product that examines the basic 3D model of solar, heat, lighting, acoustics, and cost [31]. As a result, based on the climatic conditions, initial architectural design can be done [32, 33]. Ecotect analysis offers a wide scope of simulation and building energy analysis, which can develop the performance of existing buildings as well as new building plans [34]. Ecotect analyzes the design of building materials and the best material and component choices for energy conservation [5]. This analysis includes a broad range of simulation and analysis practices required to study how a building materials design will be operationalized and performed [35]. For these reasons, Ecotect was selected as the analysis software of this study.

2. RESEARCH METHODOLOGY

The residential building of Mehr in Rasht, Iran is selected as a case study to estimate the impact of architectural design and building materials used on the amount of heating and cooling energy required. The amount of heat and cooling energy required is calculated through modeling in Ecotect software. In the case study, all the details used will be computed for the walls, roof (ceiling), floor, door, and window. Figure 1 illustrates the steps of the study method in the following flowchart format.

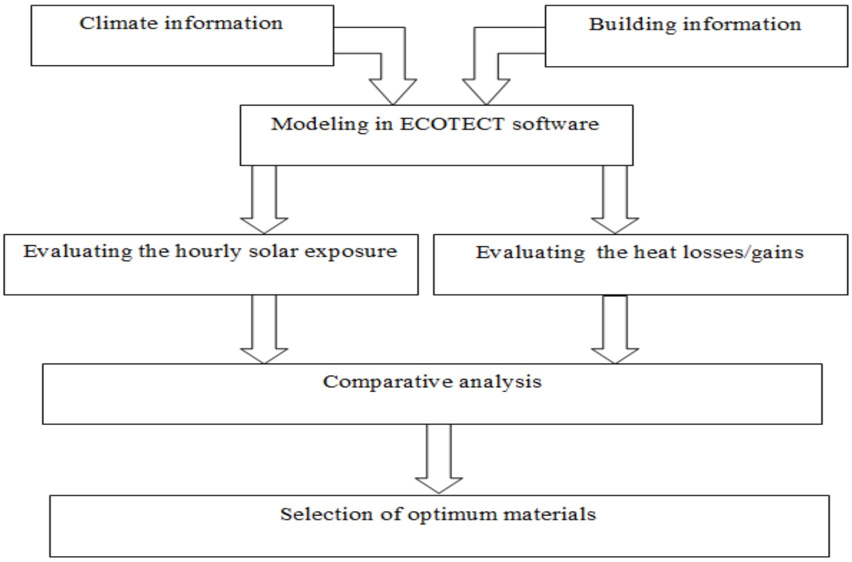


Figure 1. Research method flowchart.

2.1. Weather data

All The average annual temperature in Rasht, the capital of Guilan province, Iran, is 15.9 °C. The average annual maximum and minimum temperatures are 20.6 °C and 11.3 °C. The difference between the maximum and minimum annual temperatures is 9.3 degrees. The average temperature is 6.8 °C in the coldest month of winter (January) and 25.2 °C in the hottest month of summer (July). The mean seasonal temperatures are 18.8 °C in the spring, 24 °C in summer, 13 °C in autumn, and 7.6 °C in winter [36]. Figure 2 shows the maximum and minimum air temperatures according to the Climate Consultant software 6.0 output. Two months of the year (January and February) require the use of a heating system (the maximum temperature diagram is below the thermal comfort range). However, it takes about six months of the year (May to October) to use a cooling system to provide thermal comfort. Figure 3 depicts the solar radiation diagram for determining the warm and cold periods in Rasht.

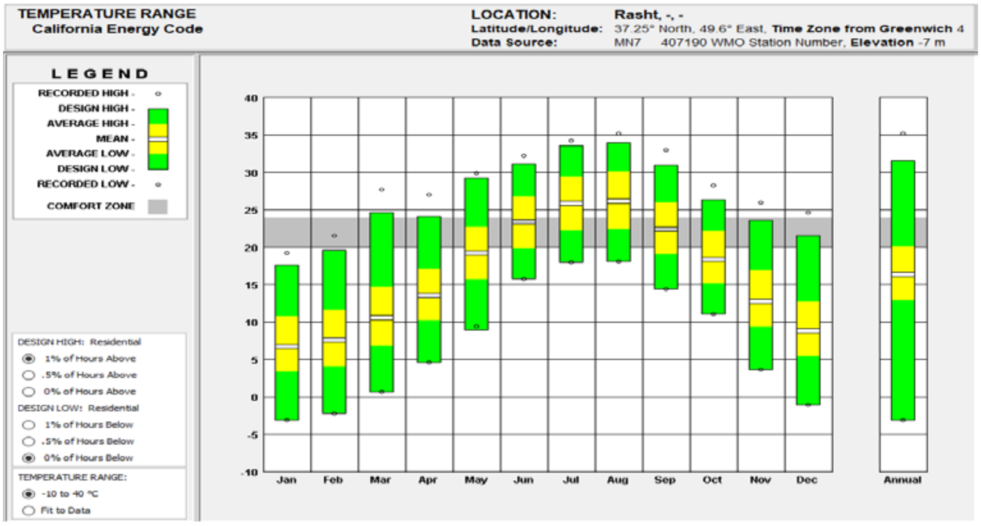


Figure 2. The maximum and minimum air temperatures in Rasht city [37].

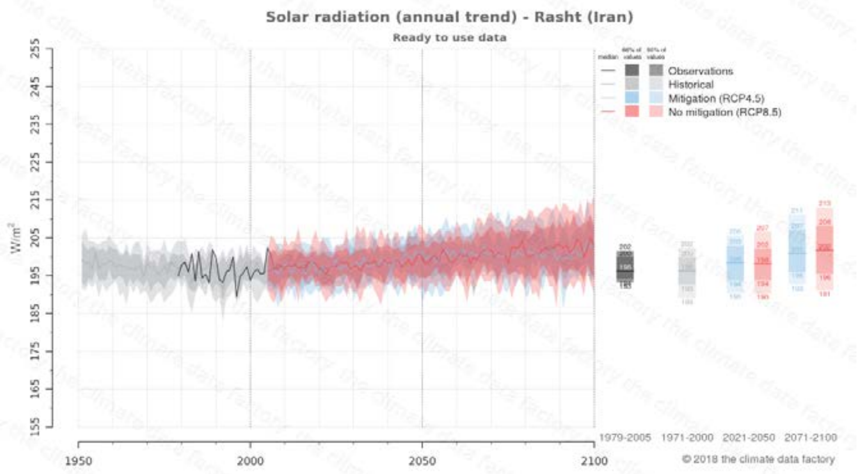


Figure 3. Solar radiation diagram for determining the warm and cold months in Rasht, Iran [38].

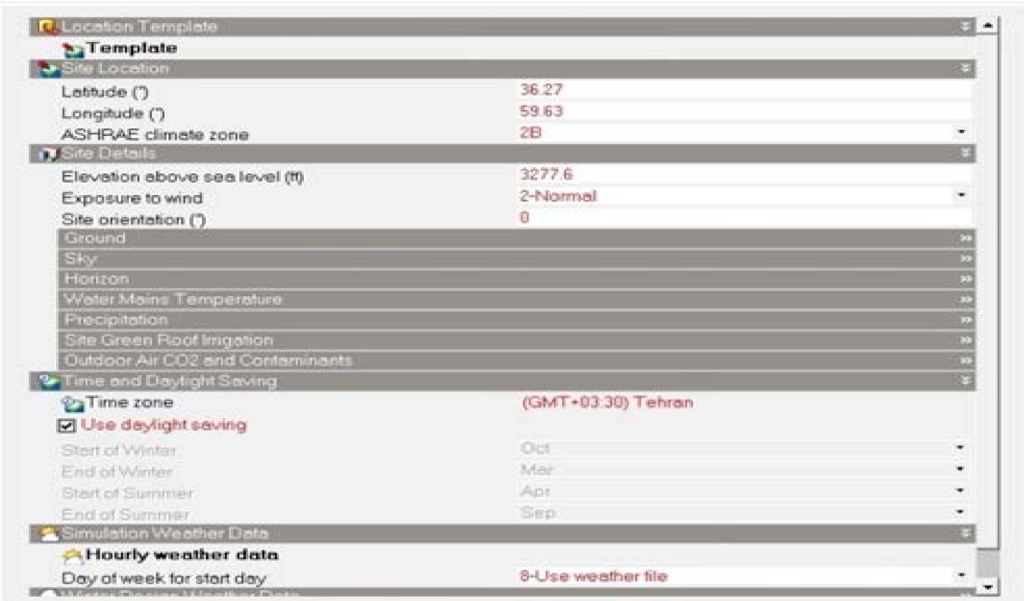


Figure 4. Weather data input in Ecotect.

2.2. Building description

This study analyzed a residential building that covers an area of 150 m^2 (each story) and a length of 3 m, two north and south windows with an area of 1.5 m^2, and the door with an area of 1.8 m^2 on the east side. Table 1 shows the technical specifications of the building.

Table 1. Technical specifications of the building.

Area	900 (m^2) (5 storey) (150 m^2 in each storey)
Construction	Structural concrete frame
Floor sizes	15×10 (m^2)
Floor heights	3 (m)
Window dimensions	1.5 m^2 (10 windows in each storey)
Door dimensions	1.8 m^2

Based on the residential consumption rate of each story, a number of 4 to 6 people were considered full time working all days of the year and each story enjoys natural lighting for all available space in the building which translates into profitability. Figure 5 shows the simulation of the proposed scheme in Ecotect software.

Table 2 presents the required materials for analysis and comparison.

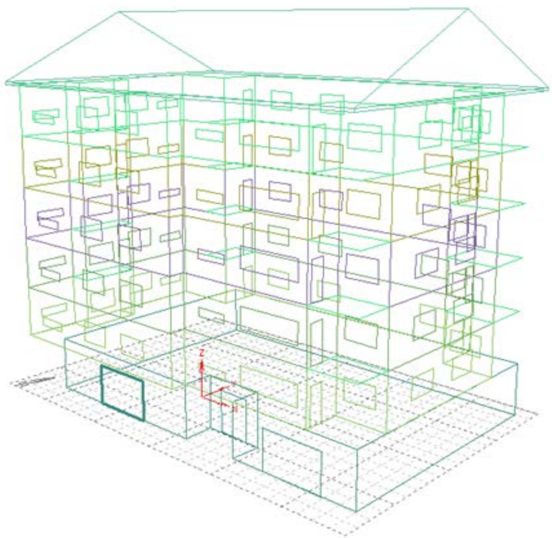


Figure 5. Building simulation design with Ecotect software.

Table 2. Building materials for modeling and simulation.

Five types of materials of the main building components for modeling and simulation																								
Wall					**Floor**					**Roof**					**Door**					**Window**				
Brick Cavity Conc Block Plaster	Brick Conc Block Plaster	Brick Timber Frame	Double Brick Solid Plaster	Timber Clad Masonery	ConcSlab-OnGround	ConcFlr-Carpeted-Suspended	ConcFlr-timber-Suspended	ConcFlr-tiles-Suspended	ConcSlab-tiles-OnGround	Clay-TiledRoof	Clay-TiledRoof-Ref_Foil_Gyproc	Concrete Roof_Asphalt	Plaster-Foil-Heat Retention-Ceramic tile	MetalDeck_Insulated	FoamCore_Plywood	GlassSliding_Door	HollowCore_Ply wood	Solid Core_Oaktimber	Solid Core_Pine timber	Double Glazed-LowE-AlumeFrame	Double Glazed-LowE-AlumeFrame	Double Glazed-LowE-AlumeFrame	Single Glazed-TimberFrame	Translucent_Sky light

The best orientation is a 15-degree rotation towards the east of the southern front for maximum use of natural light (Figure 6).

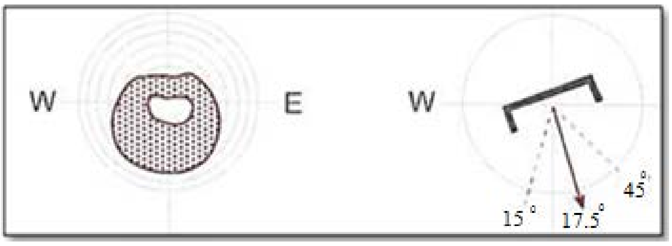


Figure 6. Building rotation in a mild climate area.

3. RESULTS

3.1. Simulation of the hourly solar exposure

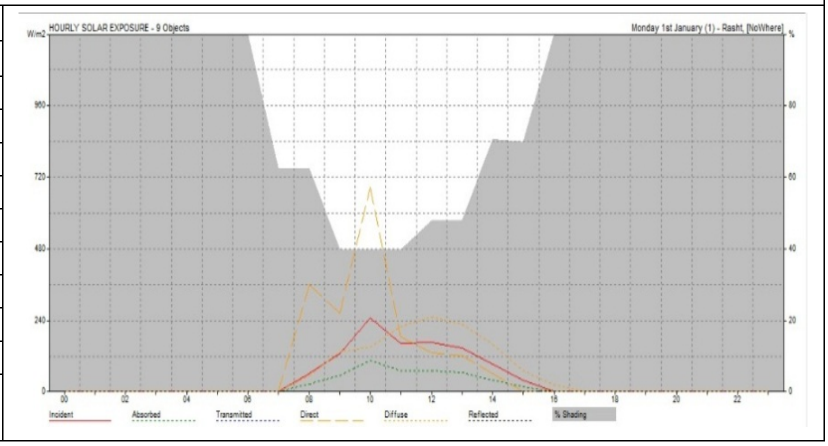
The simulation of Ecotect software shows the output of hourly solar exposure of 5 groups of materials used in the residential building. The analysis was performed from 7 AM to 4 PM. The graphs show the amount of solar radiation in a single day zone per hour. The red curve shows the total amount of the radiation incident; the green curve shows the total amount of the radiation absorbed; the yellow curve shows the maximum intensity of indirect radiation. The numbers on the right, left, and down sections show the indicator percentage of the shading, the indicator values in W/m^2, and the working times/hours, respectively. Figures 7 to 11 show the results of the simulation analysis with five different types of materials used for each group of the main building components including walls, floors, roofs (ceilings), doors, and windows.

3.2. Simulation of the fabric gains

Figures 12 to 16 show the graph of heat losses and gains. In this graph, the numbers on the left and right show the working times and the values of heat losses and gains in Watts, respectively. Yellow and blue curves demonstrate absorption and thermal waste indicators, respectively. Comparisons are made through the fabric gains diagram between the highest absorption of radiative energy and the amount of shading on each of the selected materials in the building components. Finally, optimum materials are selected from the solar energy absorption and transmission, daytime shading in hot and cold seasons, and the best thermal comfort temperature for building occupants. The building's south-facing facade with a 15-degree turn to the east allows for maximum energy absorption only once in the morning. Therefore, the choice of high-thickness materials can delay the transfer of heat from the exterior wall to the interior wall and, over time, the sun angle changes and shadow will reduce the amount of energy absorbed. This subject can provide good thermal comfort and makes heating systems more efficient in winter due to reduced energy absorption. To this end, to minimize gas consumption, materials must be selected to maximize energy absorption (thickness and weight) resulting in savings in winter gas consumption. For all of the materials used in the main building components, the energy absorption of the various materials in each section is compared; finally, the best materials with the highest absorption rate are selected. Figures 12 to 16 show the results of the comparison of selected materials through the fabric gains diagram.

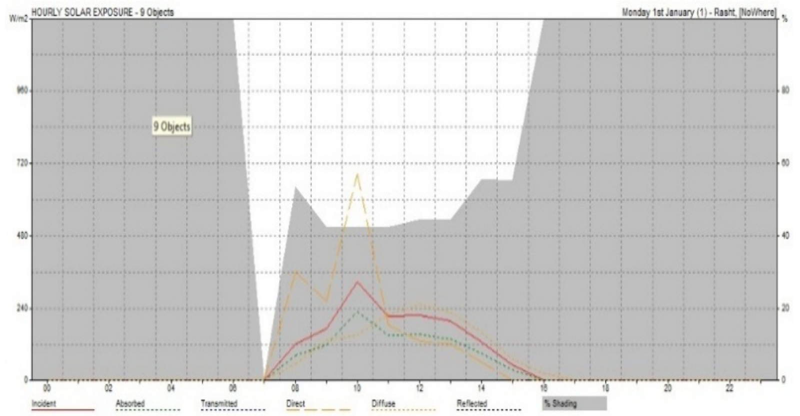
Wall_1

Brick Cavity Conc Block Plaster	
U-value (W/m^2.K)	1/720
Admittance (W/m^2.K)	4/220
Solar absorption (0-1)	0/428
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/41
Thermal lag (hrs)	7/8
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	280
Weight (Kg)	408/565



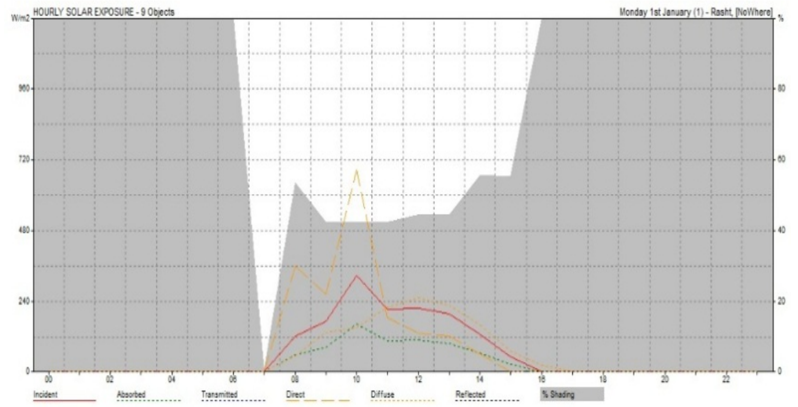
Wall_2

Brick Conc Block Plaster	
U-value (W/m^2.K)	1/88
Admittance (W/m^2.K)	4/4
Solar absorption (0-1)	0/7
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/44
Thermal lag (hrs)	7/7
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	340
Weight (Kg)	584/5



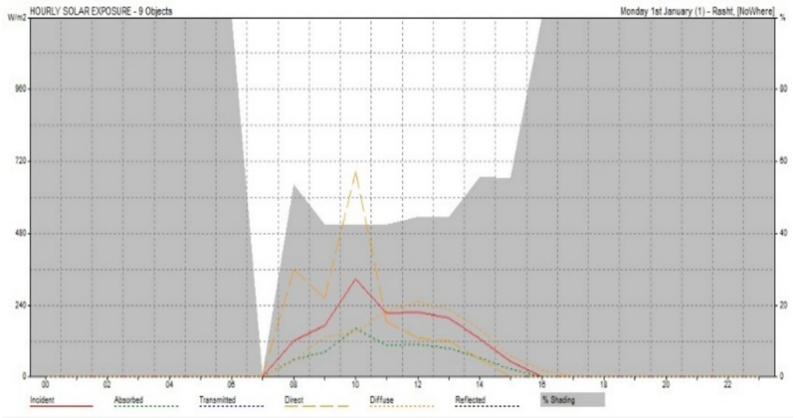
Wall_3

Brick Timber Frame	
U-value (W/m^2.K)	1/77
Admittance (W/m^2.K)	2/2
Solar absorption (0-1)	0/495
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/77
Thermal lag (hrs)	4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	195
Weight (Kg)	232/598



Wall_4

Double Brick Solid Plaster	
U-value (W/m^2.K)	1/95
Admittance (W/m^2.K)	4/55
Solar absorption (0-1)	0/495
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/39
Thermal lag (hrs)	7/8
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	230
Weight (Kg)	452/5



Wall_5

Timber Clad Masonry	
U-value (W/m^2.K)	0/3
Admittance (W/m^2.K)	4/96
Solar absorption (0-1)	0/531
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/35
Thermal lag (hrs)	5
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	210
Weight (Kg)	240/848

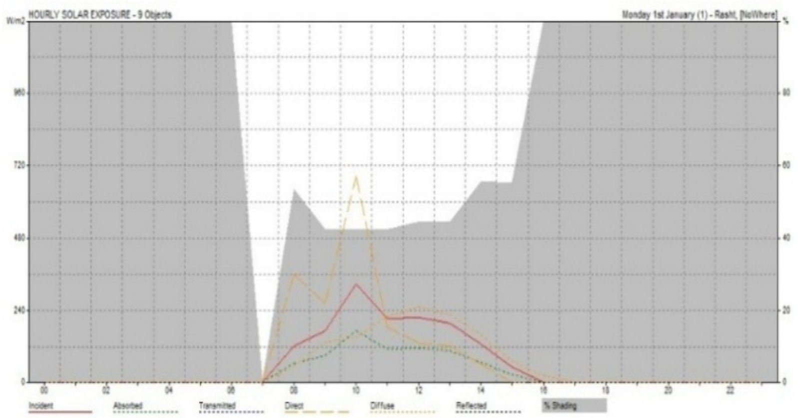
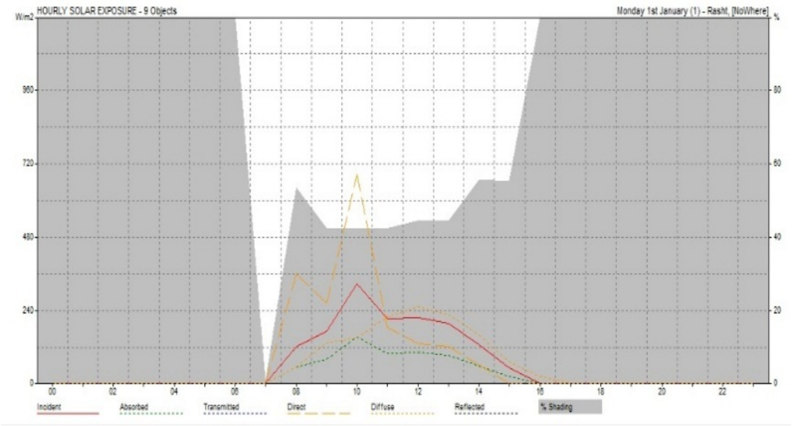


Figure 7. Hourly solar exposure of 5 groups of different materials used in the wall.

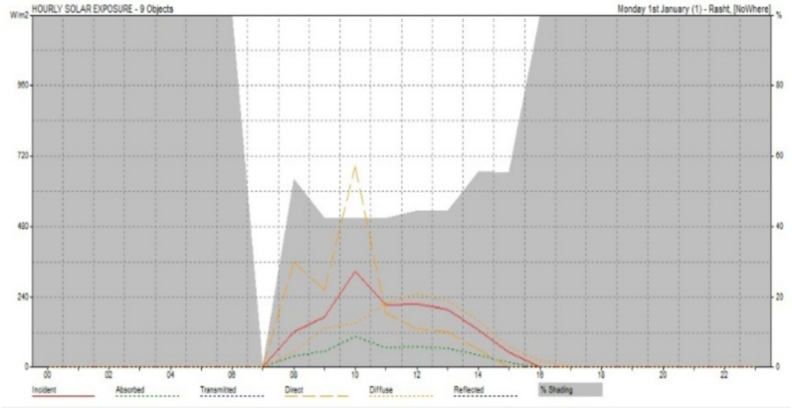
Floor_1

CocSlab-OnGround	
U-value (W/m².K)	0/88
Admittance (W/m².K)	6
Solar absorption (0-1)	0/467
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/3
Thermal lag (hrs)	4/6
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



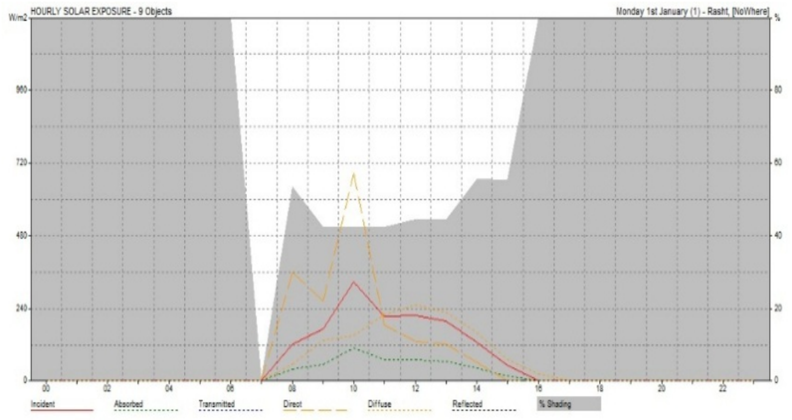
Floor_2

ConcFlr-Carpeted-Suspended	
U-value (W/m².K)	2/560
Admittance (W/m².K)	4/2
Solar absorption (0-1)	0/3244
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/7
Thermal lag (hrs)	4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



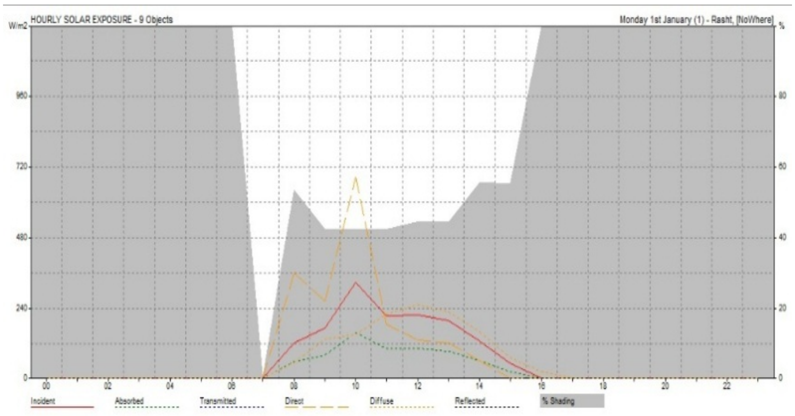
Floor_3

ConcFlr-timber-Suspended	
U-value (W/m².K)	2/160
Admittance (W/m².K)	2
Solar absorption (0-1)	0/333165
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/97
Thermal lag (hrs)	0/7
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



Floor_4

ConcFlr-tiles-Suspended	
U-value (W/m².K)	2/9
Admittance (W/m².K)	5/2
Solar absorption (0-1)	0/475208
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/69
Thermal lag (hrs)	4/1
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



Floor_5

ConcSlab-tiles-OnGround	
U-value (W/m^2.K)	3/418
Admittance (W/m^2.K)	5/8
Solar absorption (0-1)	0/642
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/02
Thermal lag (hrs)	9
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0

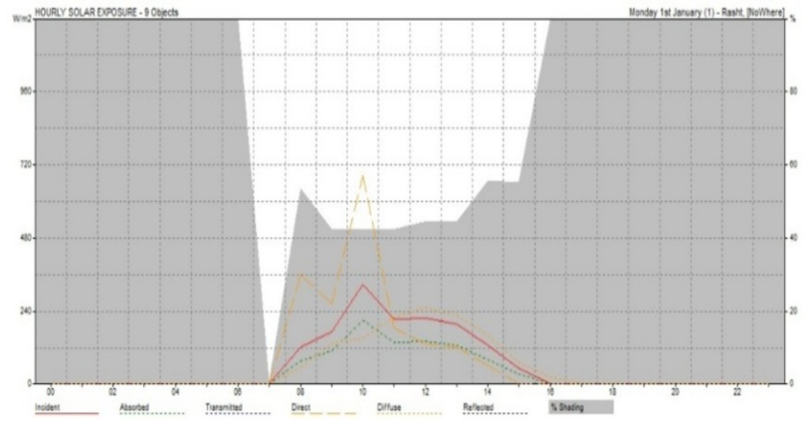
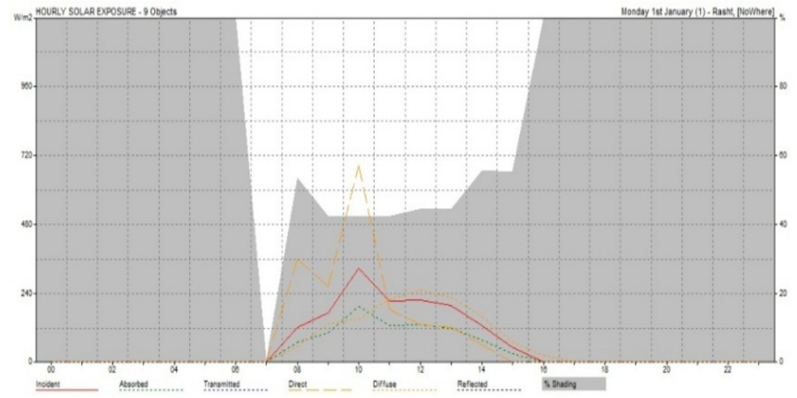


Figure 8. Hourly solar exposure of 5 groups of different materials used in the floor.

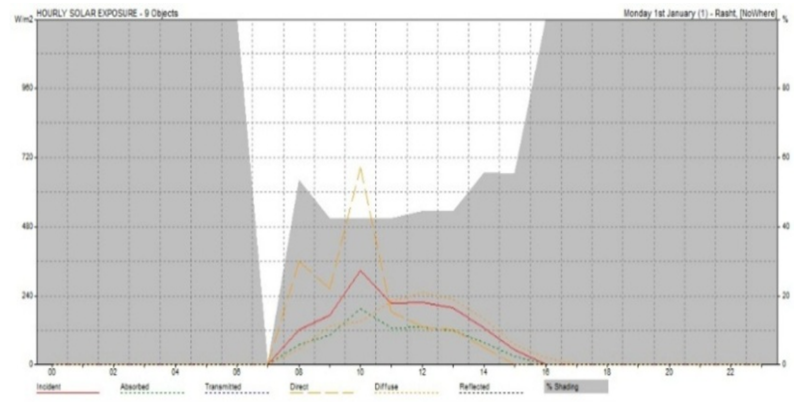
Roof_1

Clay-TiledRoof	
U-value (W/m^2.K)	0/896
Admittance (W/m^2.K)	2/3
Solar absorption (0-1)	0/9
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/58
Thermal lag (hrs)	7
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	175
Weight (Kg)	360/60



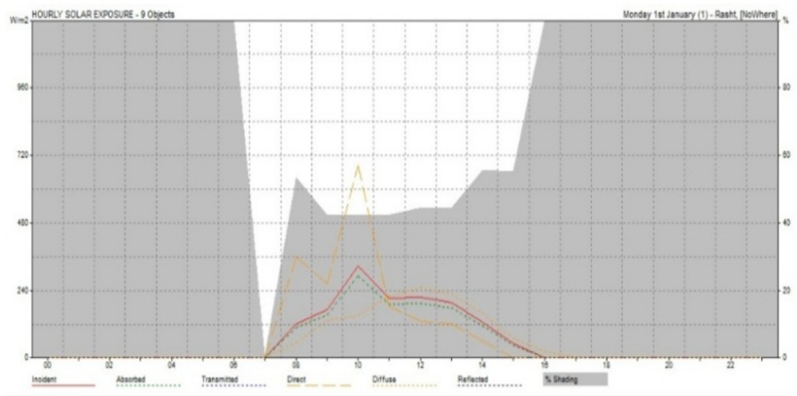
Roof_2

Clay-TiledRoof-Ref_Foil_Gyproc	
U-value (W/m^2.K)	1/82
Admittance (W/m^2.K)	2
Solar absorption (0-1)	0/6
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/95
Thermal lag (hrs)	0/5
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	132
Weight (Kg)	31/760



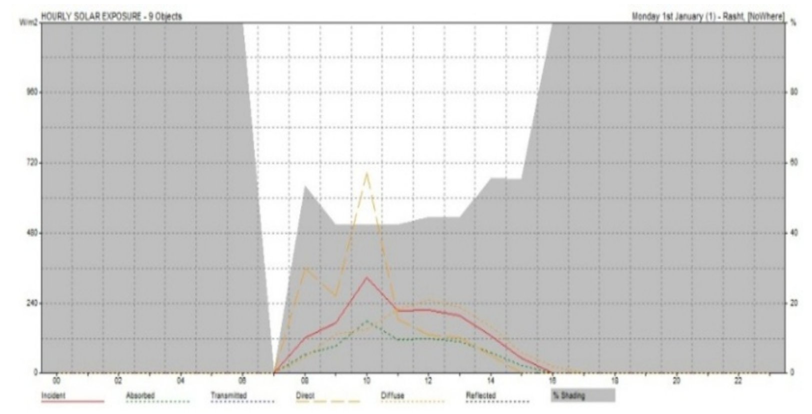
Roof_3

Concrete Roof_Asphalt	
U-value (W/m^2.K)	3/1
Admittance (W/m^2.K)	3/1
Solar absorption (0-1)	0/6
Visible transmittance (0-1)	0
Thermal decrement (0-1)	1
Thermal lag (hrs)	0/2
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	1/32
Weight (Kg)	31/760



Roof_4

Plaster-Foil-Heat Retention-Ceramic Tile	
U-value (W/m^2.K)	0/61
Admittance (W/m^2.K)	1
Solar absorption (0-1)	0/548235
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/9
Thermal lag (hrs)	1/5
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



Roof_5

MetalDeck_Insulated	
U-value (W/m^2.K)	0/55
Admittance (W/m^2.K)	1
Solar absorption (0-1)	0/5
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/96
Thermal lag (hrs)	0/7
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	75
Weight (Kg)	13

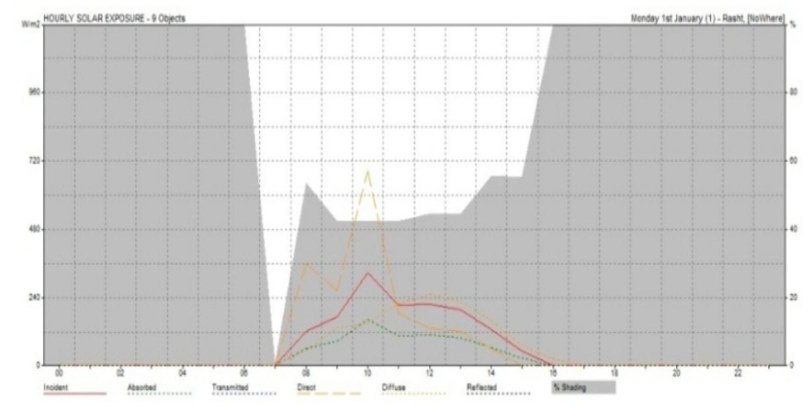
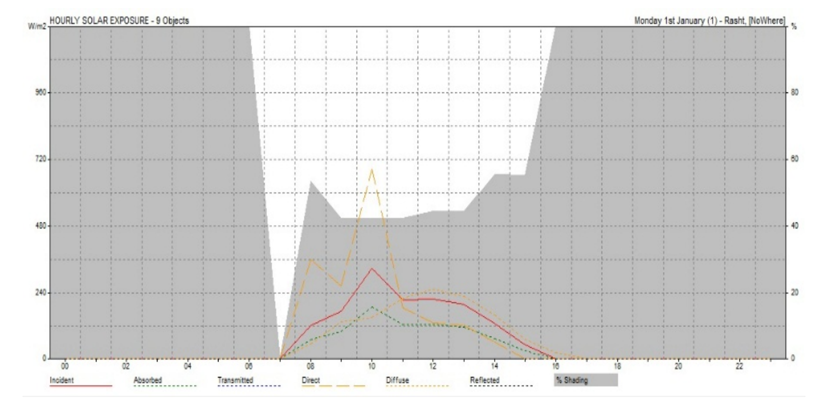


Figure 9. Hourly solar exposure of 5 groups of different materials used in the roof.

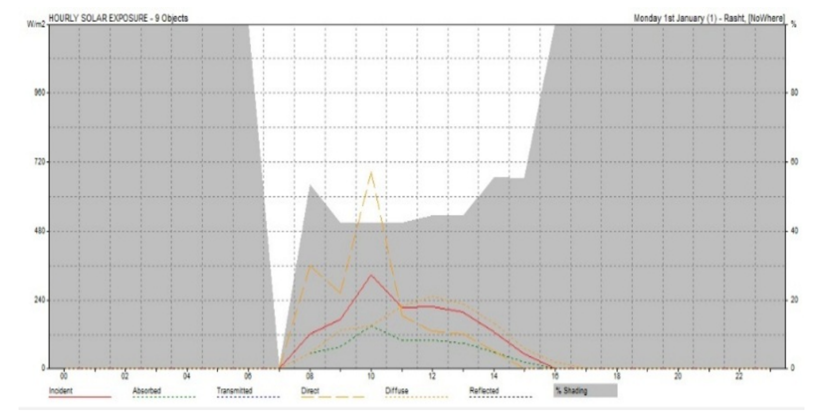
Door_1

FoamCore_Plywood	
U-value (W/m^2.K)	2/310
Admittance (W/m^2.K)	3/540
Solar absorption (0-1)	0/404
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/98
Thermal lag (hrs)	0/4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	40
Weight (Kg)	22



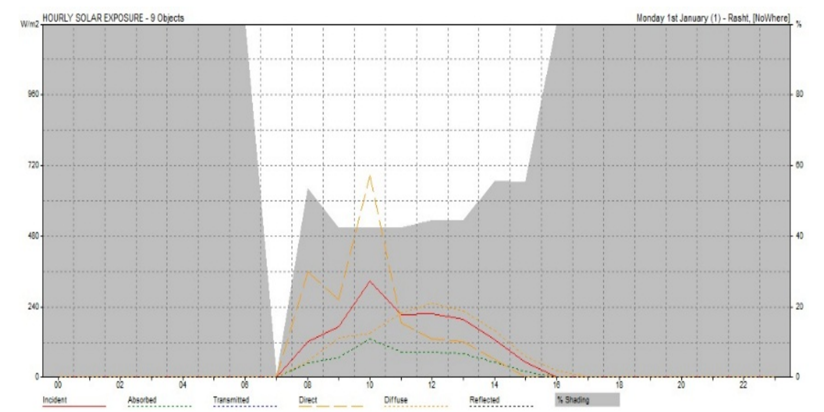
Door_2

GlassSliding_Door	
U-value (W/m^2.K)	5/356
Admittance (W/m^2.K)	5/360
Solar absorption (0-1)	0/1
Visible transmittance (0-1)	-1
Thermal decrement (0-1)	0/34
Thermal lag (hrs)	0/39
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	25/1



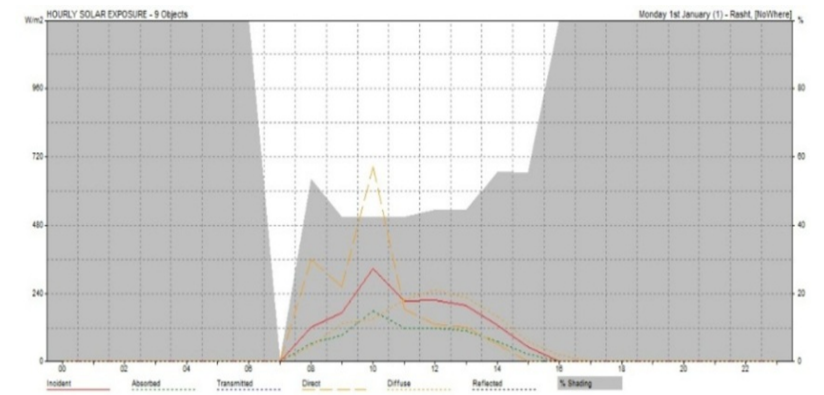
Door_3

HollowCore_Ply Wood	
U-value (W/m^2.K)	3/31
Admittance (W/m^2.K)	0/870
Solar absorption (0-1)	0/578628
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/98
Thermal lag (hrs)	0/4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	40
Weight (Kg)	4/744



Door_4

Solid Core_Oaktimber	
U-value (W/m^2.K)	2/260
Admittance (W/m^2.K)	3/190
Solar absorption (0-1)	0/46
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/95
Thermal lag (hrs)	0/4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	40
Weight (Kg)	33



Door_5

Solid Core_Pine Timber	
U-value (W/m^2.K)	2/980
Admittance (W/m^2.K)	0/650
Solar absorption (0-1)	0/55
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/98
Thermal lag (hrs)	0/4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	40
Weight (Kg)	3/224

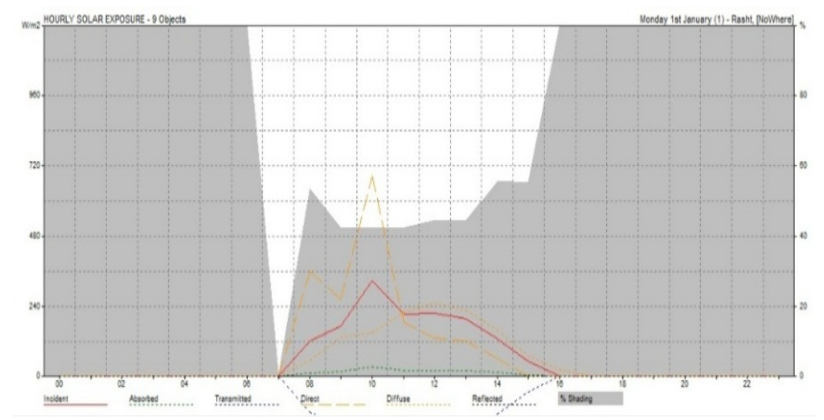
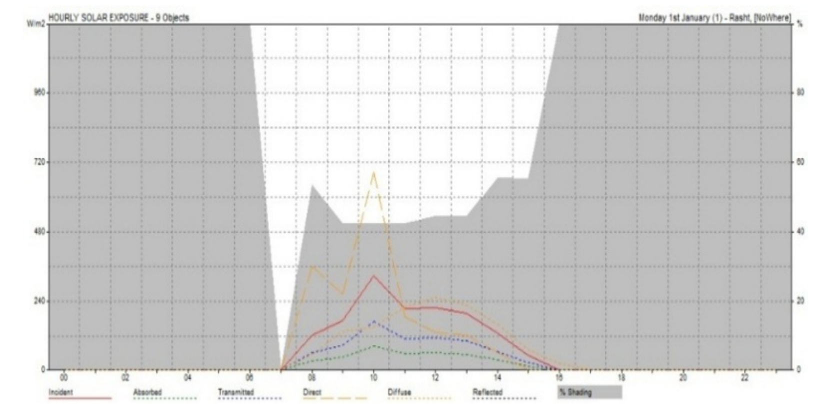


Figure 10. Hourly solar exposure of 5 groups of different materials used in the door.

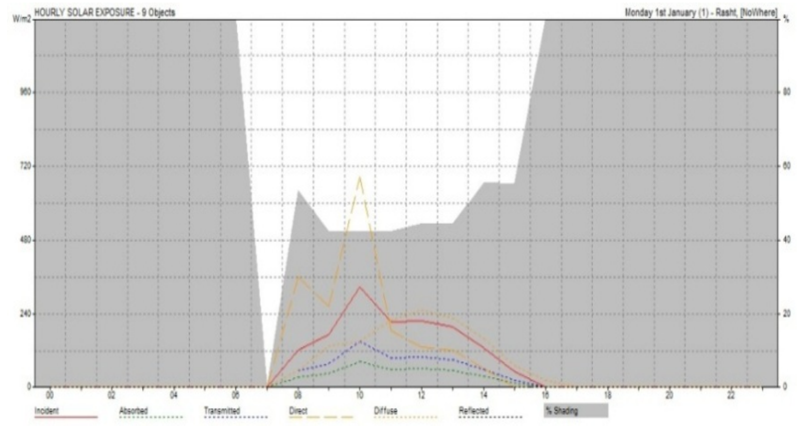
Window_1

Double Glazed-LowE-AlumeFrame	
U-value (W/m^2.K)	2/7
Admittance (W/m^2.K)	2/8
Solar absorption (0-1)	0/81
Visible transmittance (0-1)	0/639
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/42
(SBEM) CM1	0/56
(SBEM) CM2	-
Thickness (m)	0
Weight (Kg)	0



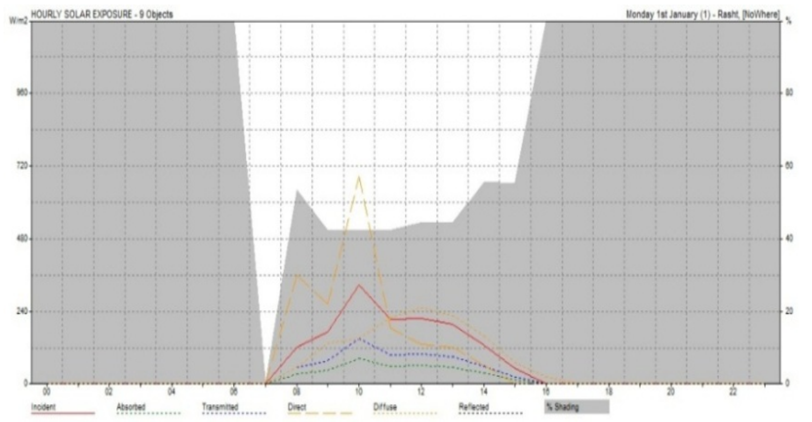
Window_2

Double Glazed-LowE-AlumeFrame	
U-value (W/m^2.K)	2/41
Admittance (W/m^2.K)	2/380
Solar absorption (0-1)	0/75
Visible transmittance (0-1)	0/611
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/21
(SBEM) CM1	0/29
(SBEM) CM2	-
Thickness (m)	0
Weight (Kg)	0



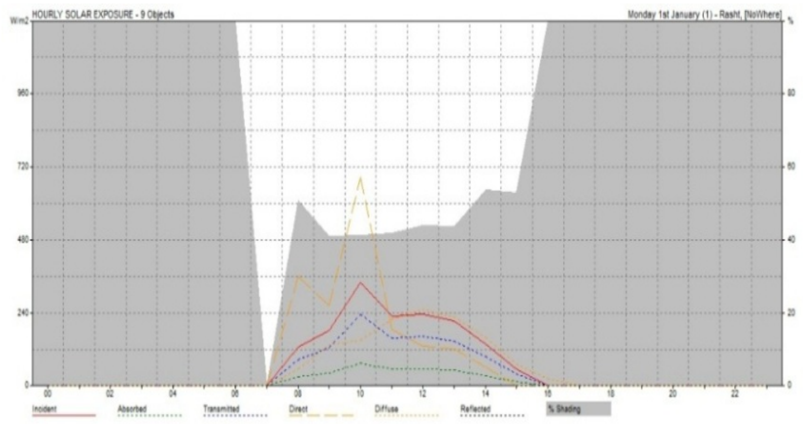
Window_3

Double Glazed-LowE-AlumeFrame	
U-value (W/m^2.K)	2/26
Admittance (W/m^2.K)	2/2
Solar absorption (0-1)	0/75
Visible transmittance (0-1)	0/639
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/21
(SBEM) CM1	0/29
(SBEM) CM2	-
Thickness (m)	0
Weight (Kg)	0



Window_4

Single Glazed-TimberFrame	
U-value (W/m^2.K)	5/1
Admittance (W/m^2.K)	5
Solar absorption (0-1)	0/94
Visible transmittance (0-1)	0/737
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/47
(SBEM) CM1	0/64
(SBEM) CM2	0
Thickness (m)	0
Weight (Kg)	0



Window_5

Translucent Sky Light	
U-value (W/m^2.K)	5
Admittance (W/m^2.K)	5
Solar absorption (0-1)	0/78
Visible transmittance (0-1)	0/658
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/38
(SBEM) CM1	0/47
(SBEM) CM2	-
Thickness (m)	0
Weight (Kg)	0

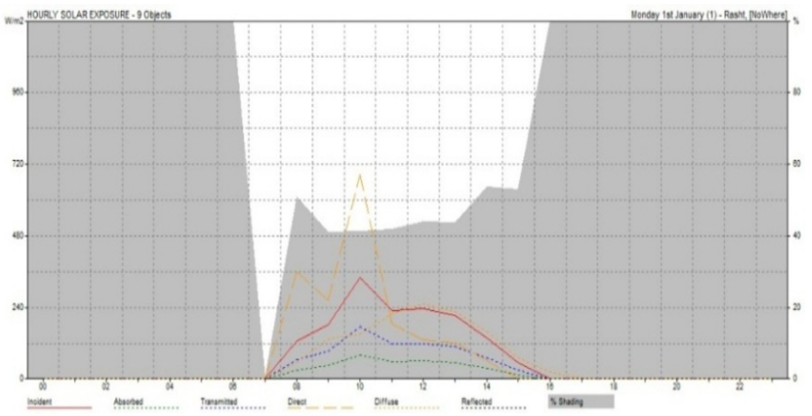


Figure 11. Hourly solar exposure of 5 groups of different materials used in the window.

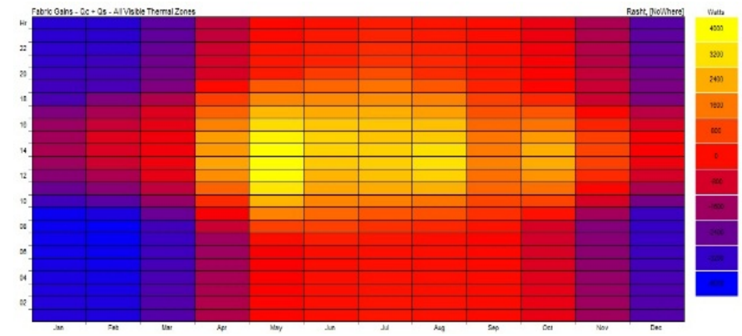
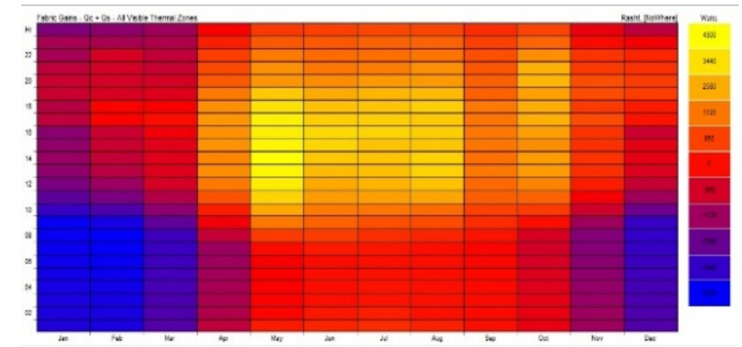
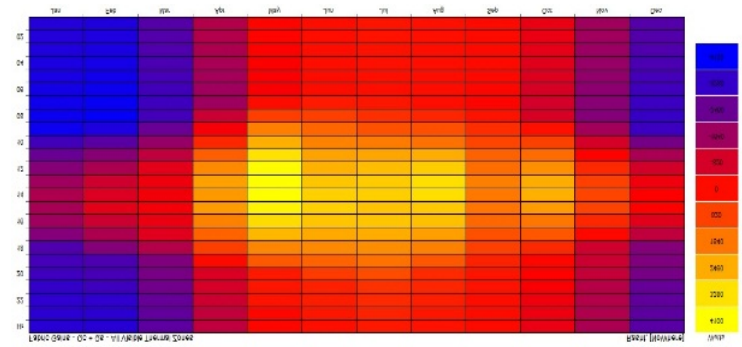
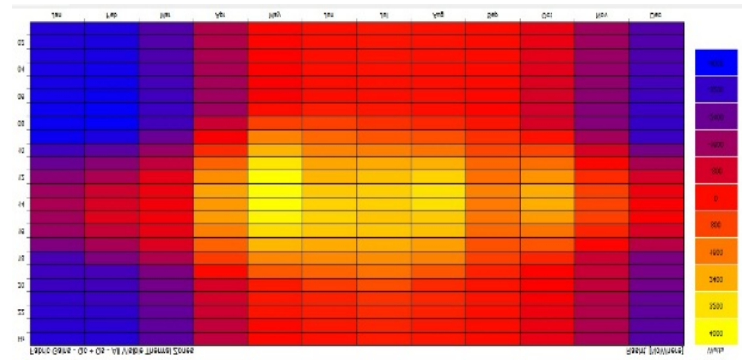
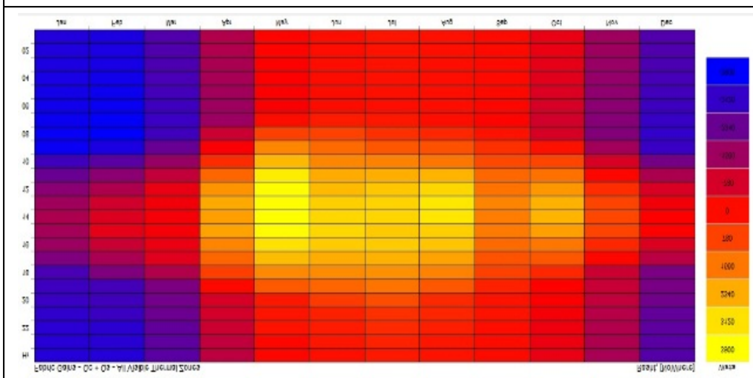
Fabric Gains (heat losses and gains)	Incident (w/m^2)	Absorbed (w/m^2)	Transmitted (w/m^2)	Wall material
	340	120	700	Brick Cavity Conc Block Plaster
	340	240	700	Brick Conc Block Plaster
	340	180	700	Brick Timber Frame
	340	180	700	Double Brick Solid Plaster
	340	190	700	Timber Clad Masonry

Figure 12. Fabric gains analysis of the selected wall materials.

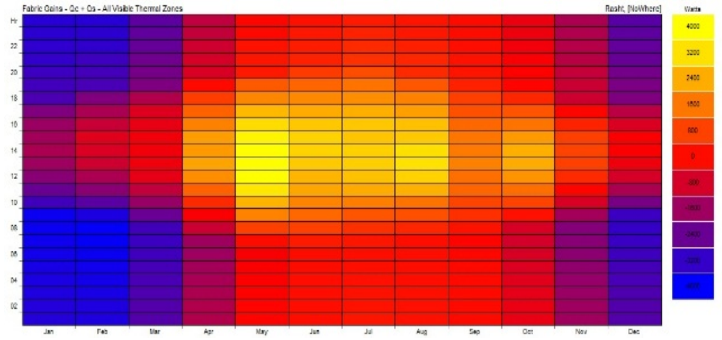
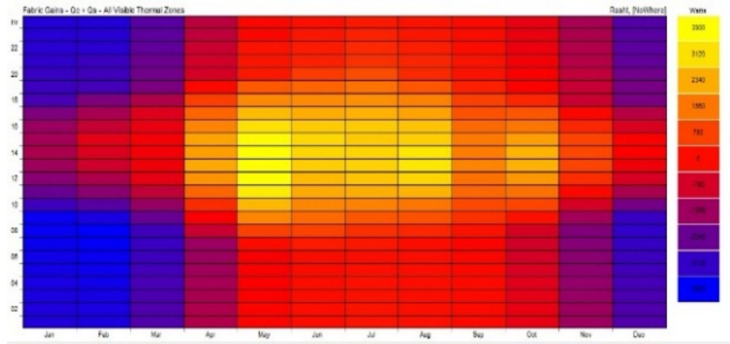
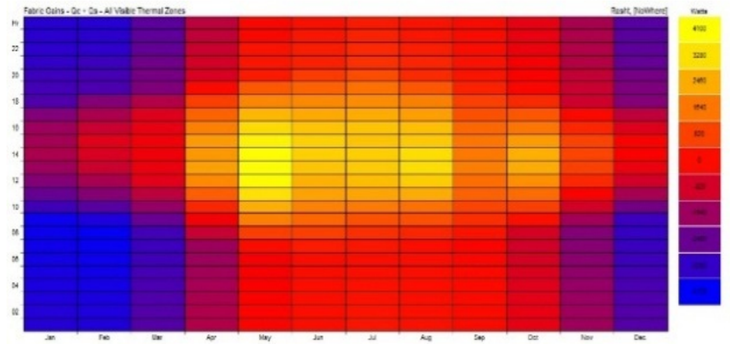
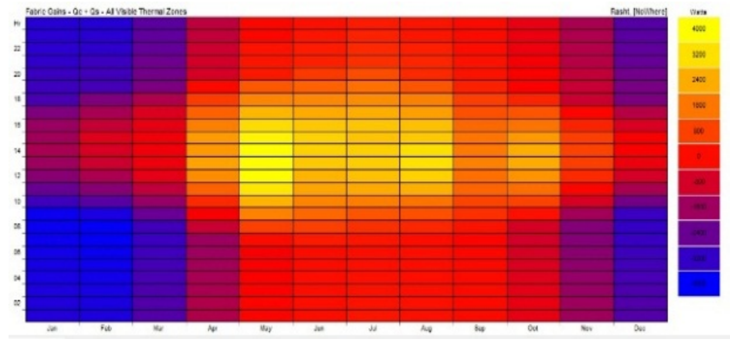
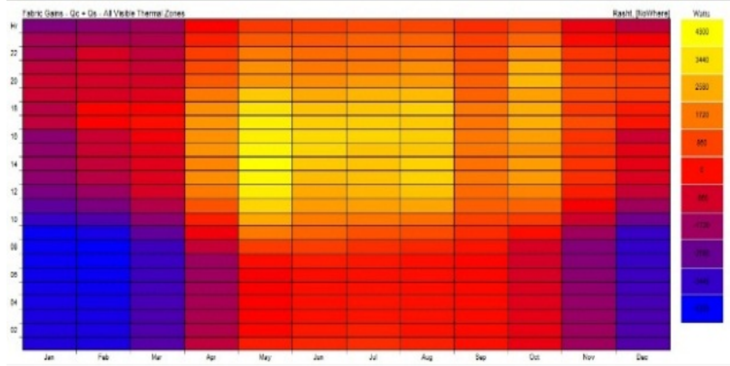
Fabric Gains (heat losses and gains)	Incident (w/m^2)	Absorbed (w/m^2)	Transmitted (w/m^2)	Floor material
	340	140	700	ConcSlab□OnGround
	340	110	700	ConcFlr-Carpeted-Suspended
	340	115	700	ConcFlr-timber-Suspended
	340	170	700	ConcFlr-tiles-Suspended
	340	220	700	ConcSlab-tiles-OnGround

Figure 13. Fabric gains analysis of the selected floor materials.

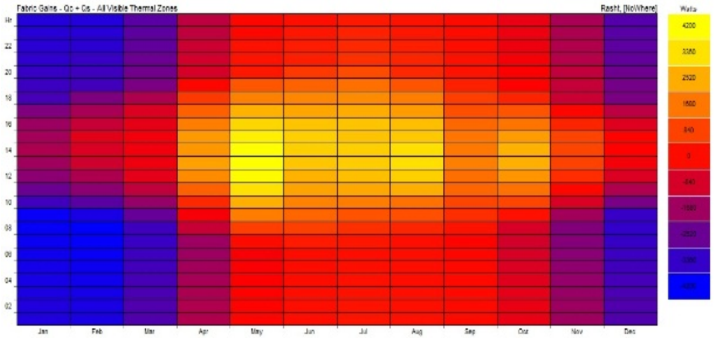
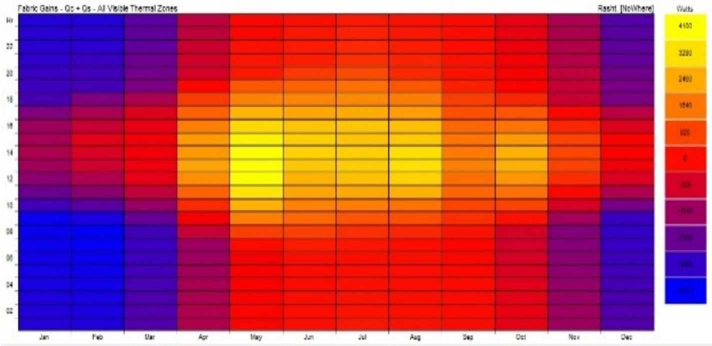
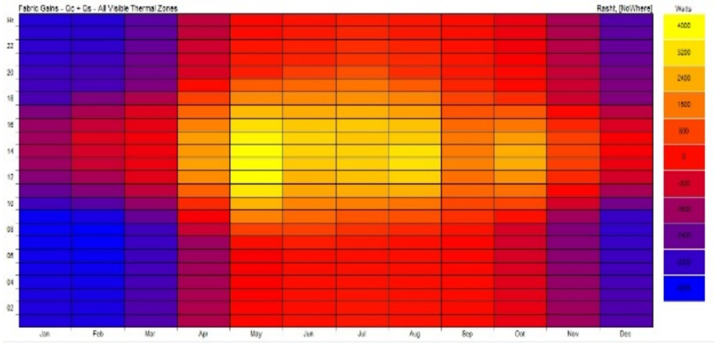
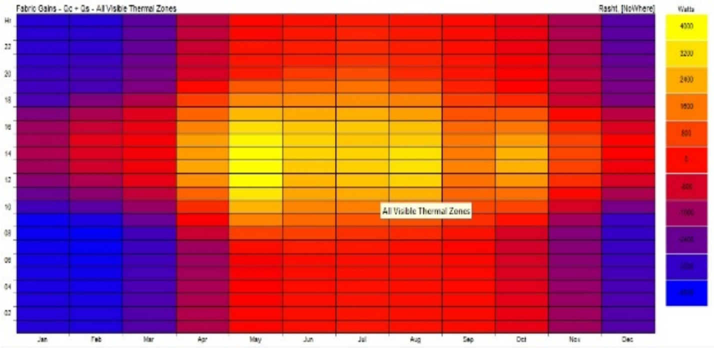
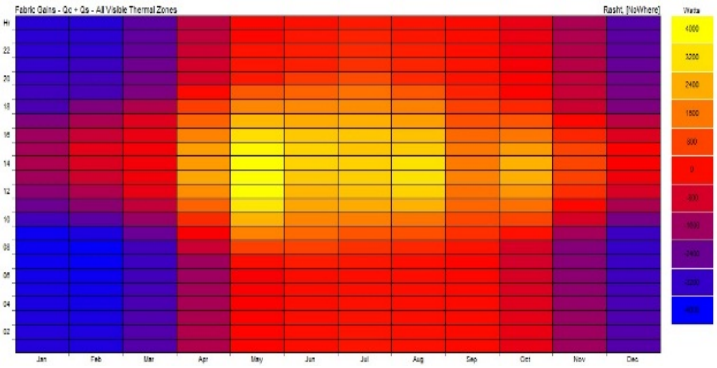
Fabric Gains (heat losses and gains)	Incident (w/m^2)	Absorbed (w/m^2)	Transmitted (w/m^2)	Roof material
	340	200	700	Clay-TiledRoof
	340	190	700	Clay-TiledRoof-Ref_Foil_Gyproc
	340	300	700	Concrete Roof_Asphalt
	340	180	700	Plaster-Foil-Heat Retention-Ceramic tile
	340	160	700	MetalDeck_Insulated

Figure 14. Fabric gains analysis of the selected roof materials.

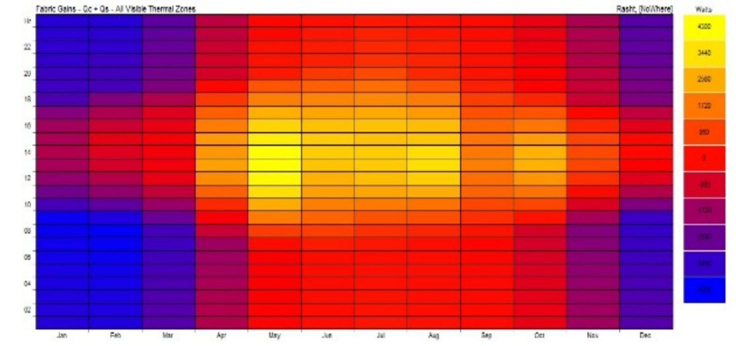
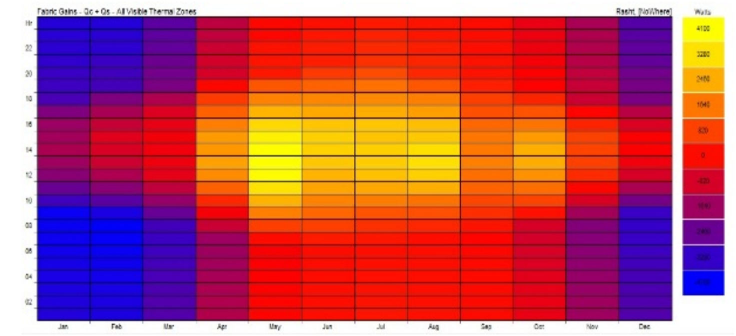
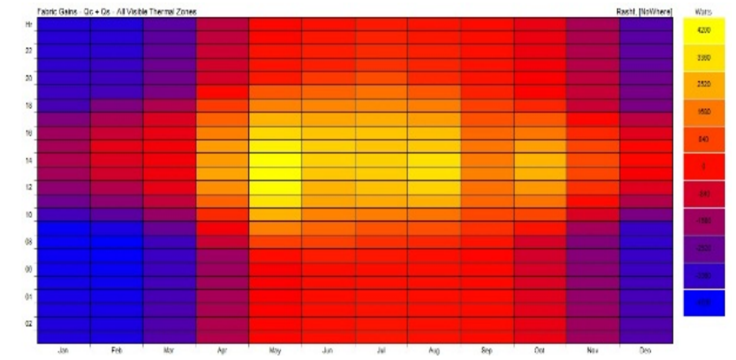
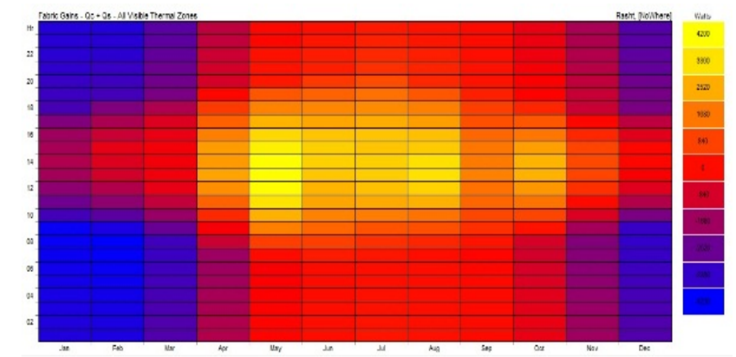
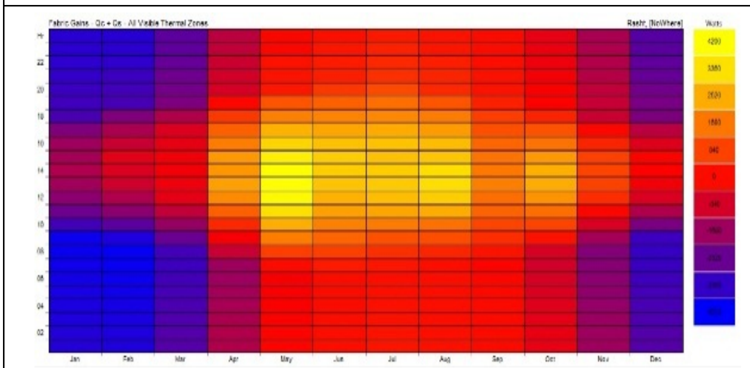
Fabric Gains (heat losses and gains)	Incident (w/m^2)	Absorbed (w/m^2)	Transmitted (w/m^2)	Door material
	340	200	700	FoamCore_Plywood
	340	20	700	GlassSliding_Door
	340	180	700	HollowCore_Plywood
	340	150	700	Solid Core_Oaktimber
	340	130	700	Solid Core_Pine timber

Figure 15. Fabric gains analysis of the selected door materials.

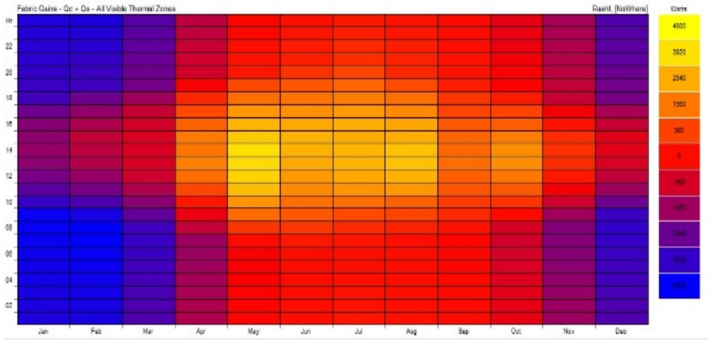
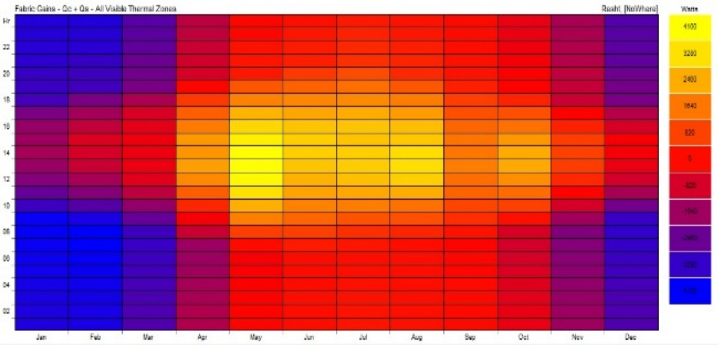
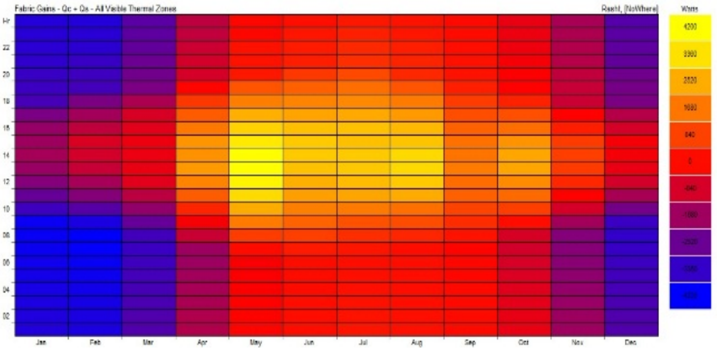
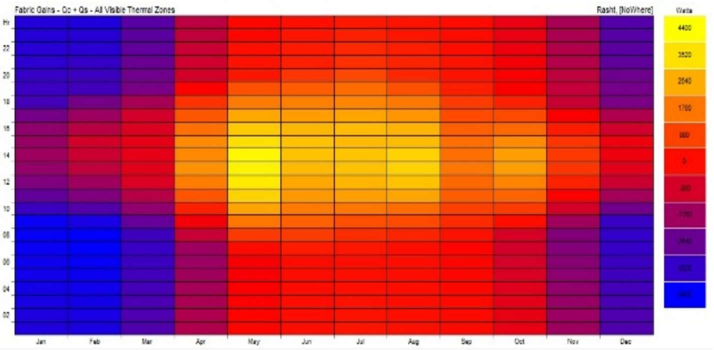
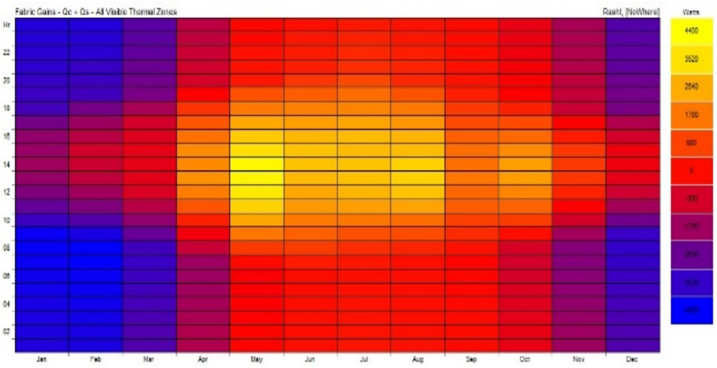
Fabric Gains (heat losses and gains)	Incident (w/m²)	Absorbed (w/m²)	Transmitted (w/m²)	Windows material
	340	100	700	Double Glazed-LowE-AlumeFrame
	340	90	700	Double Glazed-LowE TimberFrame
	340	90	700	Double Glazed- TimberFrame
	340	70	700	Single Glazed-TimberFrame
	340	90	700	Translucent_Sky light

Figure 16. Fabric gains analysis of the selected window materials.

4. DISCUSSION

Figures 7 to 16 present the selection of optimum materials along with the comparative analysis of the results obtained from the simulation of hourly solar exposure and fabric gains. Table 3 shows the simulation and analysis results of selecting optimum materials in the main building components to find the best material based on the maximum transmission and absorption of solar energy in Rasht. These comparisons are made based on solar radiation analysis and heat losses/gains (Figures 12 to 16).

Table 3. Selection of optimum materials of residential building components for energy conservation in Rasht number for different geometric cases (must be typed).

Wall	
Brick Conc block Plaster	
U-value (W/m^2.K)	1/88
Admittance (W/m^2.K)	4/4
Solar absorption (0-1)	0/7
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/44
Thermal lag (hrs)	7/7
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	340
Weight (Kg)	584/5
Window	
Double Glazed-Low E	
U-value (W/m^2.K)	5/1
Admittance (W/m^2.K)	5
Solar absorption (0-1)	0/94
Visible transmittance (0-1)	0/737
Thermal decrement (0-1)	1/74
Thermal lag (hrs)	0/47
(SBEM) CM1	0/64
(SBEM) CM2	-
Thickness (m)	0
Weight (Kg)	0
Floor	
ConcSlab-OnGround	
U-value (W/m^2.K)	0/88
Admittance (W/m^2.K)	6
Solar absorption (0-1)	0/467
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/3
Thermal lag (hrs)	4/6
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0/2
Weight (Kg)	2/439
Door	
Foam Core Ply Wood	
U-value (W/m^2.K)	2/31
Admittance (W/m^2.K)	3/54
Solar absorption (0-1)	0/404
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/98
Thermal lag (hrs)	0/4
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0/4
Weight (Kg)	22
Roof	
Conc Roof Asphalt	
U-value (W/m^2.K)	3/1
Admittance (W/m^2.K)	3/1
Solar absorption (0-1)	0/6
Visible transmittance (0-1)	0
Thermal decrement (0-1)	1
Thermal lag (hrs)	0/2
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0/132
Weight (Kg)	31/760
Partition	
Famed-Plastboard-Partition	
U-value (W/m^2.K)	2/2
Admittance (W/m^2.K)	2/
Solar absorption (0-1)	0/4
Visible transmittance (0-1)	0
Thermal decrement (0-1)	0/93
Thermal lag (hrs)	0/3
(SBEM) CM1	0
(SBEM) CM2	0
Thickness (m)	0/1
Weight (Kg)	25/104

According to Table 3, the optimum materials were selected based on the highest absorption using simulation software. The following findings based on comparative results are presented as follows:

- Brick Conc block Plaster with the total radiation incident of 340 W/m^2, a radiation absorption of 240 W/m^2, and a radiation transmission of 700 W/m^2 is the optimum material for walls.
- Double Glazed-Low E with the total radiation incident 340 W/m^2, a radiation absorption of 100 W/m^2, and a radiation transmission of 700 W/m^2 is the optimum material for windows.
- Foam Core Ply Wood with the total radiation incident of 340 W/m^2, a radiation absorption of 200 W/m^2, and a radiation transmission of 700 W/m^2 is the optimum material for doors.
- ConcSlab- OnGround with the total radiation incident of 340 W/m^2, a radiation absorption of 220 W/m^2, and a radiation transmission of 700 W/m^2 is the optimum material for floors.
- Conc Roof Asphalt with the total radiation incident of 340 W/m^2, a radiation absorption of 300 W/m^2, and a radiation transmission of 700 W/m^2 is the optimum material for roof.

5. CONCLUSIONS

This research analyzed and simulated the optimum materials in the residential buildings under study based on the different materials used in the mild climate zone. According to the analysis performed using simulation software, it was revealed that the optimum material of the main building components in the mild climate zone of Rasht city were (a) the Brick Conc block Plaster for walls with the total radiation absorption of 240 W/m^2, (b) Double Glazed-Low E for windows with the total radiation absorption of 100 W/m^2, (c) Foam Core Ply Wood for doors with the total radiation absorption of 200 W/m^2; (d) ConcSlab- OnGround for floors with the total radiation absorption of 220 W/m^2; (e) Conc Roof Asphalt for roofs with the total radiation absorption of 300 W/m^2; and (f) Famed-Plastboard-Partition for partition. According to the diagrams obtained for all stories of the building in the two hot and cold days of the year, as determined by the design and material selection requirements, the building will be in an almost thermal comfort zone (below 30 degrees) in the warm season.

6. ACKNOWLEDGEMENT

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