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An Investigation on Window's Function in the Cold Climate

A Case Study of a Residential House in Iran, Ardebil

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Abstract— **Nowadays, enhancing the quality of the indoor environment in order to provide comfort and convenience is receiving more and more attention from the designers and the researchers in the architecture field. Various approaches are possible to achieve the desired improvements.**

Window, as the interface between the indoor and outdoor environment plays a highly important role in creating comfort for the residents. In a good design, light is one of the factors that can create feelings of satisfaction from the environment, reduce stress, regulate sleeping habits, and ensure better hygiene.

Keywords-component; daylighting; comfort; windows;

State of issue— **In this research, it has been tried to ascertain the interaction of light and heat by investigating the function of window in using the daylight, and dos and don's of architectural designing in cold climates.**
Since the general view in this research is an architectural view with the aim of using the results in real projects, this paper is a connection between mathematical calculations and the use of them in an architectural design. Therefore, to get the optimized windows' size, dimensions of each window are calculated to gain appropriate daylight for every space. It is clear that bigger windows cause more heat transfer and smaller ones enforce the occupiers to use electrical energy for lighting.
The studies in this research are based on library studies and computer simulation. The library studies have been done for achieving familiarity with the foundations of physics of light and heat, heat transfer, understanding climate and comfort conditions in cold climates, and investigating the architectural characterization. Finally, computer simulations have been conducted to investigate the obtained results.

I. Introduction (Heading 1)

Daylighting is a very important issue in today architecture in terms of human comfort [13]; [3]; [19], health [18]; [9], and satisfaction [10]; [8]; [3], [17]. Daylighting provides visual quality and comfort [18] and improves the living environment by making the indoor quality more pleasant and attractive [8]; [17]. It also improves the occupants' performance [10]; [8] and has undeniable impact on user's behavior and perception.

Buildings are responsible for between 30 and 40 percent of all primary energy use, greenhouse gas emissions, and waste generation [12]. Daylighting is recognized as a potential energy-efficient design strategy for buildings. Natural light can help reduce the electrical demand [13], [5].

Window as an interface of indoor and outdoor spaces from which most of daylight penetrates into an interior, play an important role in energy performance [22]. Windows characterize energy use and visual comfort patterns in buildings. Choosing their areas and proportions is part of fundamental early design stage decisions, which are hard to change later [16]. Therefore, Daylighting design and building design should always be linked to each other [1].

The daylighting performance of a building depends very much on a good understanding of the subtle interactions of a large number of design features, which may be rather complex [14]. Yoong and Tulloch present some design criteria and utilization of switchable windows in the tropics [6]. Reference [9] investigates daylighting assessment and optimization through several factors such as: windows, glazing, interior finishes, skylight, light shelves, light wells and light while Li et el gives an indication of daylighting performance in residential buildings by five parameters affecting the interior daylight illuminance including building area and orientations, window area, glass type and external obstruction [14]. Reference [4] evaluates the impact of different kinds of glazing systems, window size, orientation of the main windowed façade and internal gains on winter and summer energy need and peak loads of a well-insulated residential building. Typical windows widely used in residential building in Malaysia are examined with the intention of identifying their daylighting performance and evaluating the quantity of the daylighting entering into the interior [21].

Computer-based building energy simulations have proved useful in analyzing daylighting schemes [15]. Reference [12], through using building simulation modeling, evaluate various window properties such as U-value, solar heat gain coefficient (SHGC), and visible transmittance (Tvis) with different window wall ratios (WWRs) and orientations in five typical Asian climates [12]. A computational method is presented By Stavrakakis (2011) optimize window sizes for thermal comfort and indoor air quality in naturally ventilated buildings [20]. Andersen discusses a new approach in daylighting simulation named Lightsolve as a complementary method to daylighting performance evaluation, instead of summarizing time and emphasizing spatial light distribution, it offers a way to evaluate broader areas in a space with an emphasis on how this performance varies over the seasons and time of day.

This paper focuses on daylighting in a conventional residential building in the cold climate of Iran to reach the optimized area for windows considering both energy and architectural matters.

II. Materials and Methods

A. Study area

The area chosen for this study is Ardebil in Iran. Iran is located in the southwest of Asia. Iran's area is about 1,648,000 km2 and it lies approximately between 258N and 408N in latitude and between 448E and 648E in longitude [2].

Ardebil is located in a mountainous cold climate. One of the features of this climate is the cold weather in winter and seasonable weather in summer. Heavy snowfalls in parts of the North and the North West of the country, a great difference between day and night temperatures and low air humidity are the characteristics of this climate. The average temperature in the warmest month of the year is over 10° C and in the coldest month is less than-3 ° C.

The weather conditions during the year make it necessary in residential areas to maximize the use of sunshine, save energy and insulate buildings against cold winds. Therefore, the form of the buildings is designed to confront these conditions. They have central yards and cubic forms to reduce the ratio of external surfaces to internal spaces. Small rooms with a short height, small doors and windows, thick walls and flat roofs are other characteristics of the architecture of this climate. The materials used in this area have high thermal resistance and thermal capacity.

The cities in this climate have compressed urban spaces and the streets are narrow and are formed based on the topography of the place.

B. Selection of a Conventional Residential Building

The selected conventional apartment has average conditions in various parameters: a three-bedroom apartment in the 2nd floor of a three-floor building surrounded by the same buildings in both the north and the south directions.

C. Windows Area Calculations

In calculating the areas of the selected windows different parameters are assessed step by step: amount of illumination, Window Light Exposure Coefficient, Window Transfer Coefficient, Window Carrier Wall, Type of Window (frame, color, additional element). Total areas of each space in the apartment (e.g., living room, bedroom, kitchen, etc) are calculated.

D. Computer Simulation

Having assessed the areas of windows in each space in the selected building, by modeling each space separately, the computer simulation by Relux Software is used to compare the calculated results with the real condition after applying aesthetics and architectural matters.

III. Results and Discussions

A. Daylighting calculations

Iran has three different daylight parts as [7]:

1- Central deserts and the south areas of the country
2- A small area in the north of the country near the Caspian sea
3- Mountainous areas in the west and the north-west

The city of Ardabil is in the 3rd Area and the natural illumination in Iran is between 4000 – 40000 lx. If this illumination is divided to four parts as

1- Less than 4000 lx
2- 4000-8000 lx
3- 8000-16000 lx
4- More than 16000 lx

In a one-year period we will have

TABLE I. Table Type Styles Hourly Distribution of daylight in the 3rd Area of Iran [7]

	Less than 4000 lx	*4000-8000 lx*	*8000-16000 lx*	*More than 16000 lx*
Area 3	4923	756	1094	1977

The amounts in this table are gathered as the minimums, therefore better conditions can be considered.

The most important factor to start the calculations is the amount of illumination in the place. However, it is clear that specifying the exact amount of this factor is impossible because of the variable daily and annual conditions; therefore, an average amount is calculated.

So that during a year the hours with the illuminance less than 4000 lx weren't considered. 4000lx was considered for the hours with 4000-8000 lx, 8000 lx was considered for the hours with 8000-16000 and 16000 lx was considered for the hours with illuminance more than that. “Eq. (1)”

$$E = \frac{(756 * 4000) + (1094 * 8000) + (1977 * 16000)}{756 + 1094 + 1977}$$

E= 11300 lx (1)

Thus the amount 11300 lx as the average annual illuminance is considered in the calculations.

- Calculation of Window Light Exposure Coefficient

To start the calculations that are directly related to the window and its details, a casement window that is thermal break and double glazed which is a product of Kavir Co. licensed by the BHRC (Road, Housing & Urban Development Researchcenter) http://www.bhrc.ac.ir/portal/Default.aspx?tabid=390 was chosen. A casement window is selected because they are more airtight than sliding windows. *“Fig. 1”*

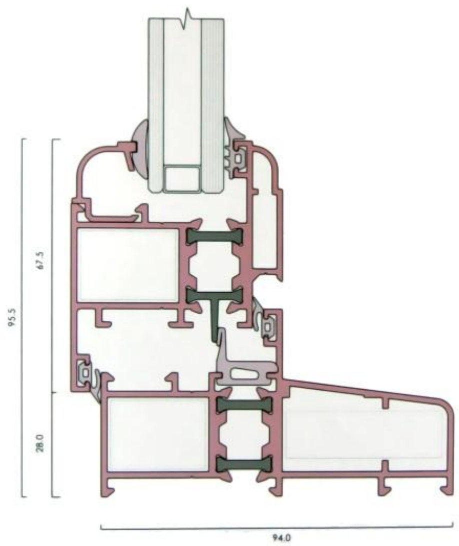


Figure 1. Kavir Co. Product Casement Window

- Calculation of Window Transfer Coefficient

To calculate Window Light Exposure Coefficient, x Factor, the transfer coefficient of the glass (T) is needed. (T) is different for various types of glass with different colors and thicknesses. The glass used in the selected window is a High-SHGC Low-E. The (T) for this glass is 87%. The outer glaze is 6mm thick and the other is 4mm. If the window is double glazed, 9% of it must be reduced; therefore (T) would be 79%.

- Window Carrier Wall

It is obvious that the thickness of the wall which the window is located on has a negative effect on the exposure of the window. Likewise the place that the window is located on (near the outer side of the wall, in the middle, or near the inner side) is important since each kind with the same window has different exposures.

To calculate the Loss Exposure Coefficient, Y Factor, the area of the wall around the window (Win. environment x Wall Thickness) is needed. The area is divided by 4 and the result should be divided by the window's area to be shown as the percentage of the window’s area. This percentage is called (F). The Y can be defined by the amount of (F) by the table below: ”Table II”

TABLE II. AMOUNTS OF WINDOW LOSS EXPOSURE COEFFICIENT OF CARRIER WALL [7]

	0 to 10	**10 to 20**	**20 to 30**	**30 to 40**	**40 to 50**	**50 to 60**	**More than 60**
Front	1%	2.5%	4%	5.5%	7%	8.5%	10%
Middle	2%	5%	8%	11%	14%	17%	20%
Back	4%	10%	16%	22%	28%	34%	40%

The thickness of the wall is 38cm (3cm plastering + 20cm brick + 10cm thermal insulating material polystyrene + 5cm cement).

However, to calculate the F amount, the window’s dimensions are needed which are still unknown. In this step, like structural calculations, approximate dimensions must be considered by designers based on their experience and other different factors.

For example, if a 2m*2m window is considered, the (F) amount would be: “Eq. (2)”

L = 2+2+2+2=8 m
$A_w = 2 * 2 = 4\ m^2$
$8 * 0.38 = 3.04\ m^2$
3.04 / 4 = 0.76
$F = 0.76 / 4\ m^2 = \%\ 19$ (2)

By considering the place of the window near the inner side of the wall and according to the table 2, the amount of Y can be estimated to be 10%. Since the window is double glazed with 6mm & 4mm glasses with 10mm space in between, we will have:

- Frame Color

Bright colored window frames don’t have a negative effect on Y, however dark colors do. Based on the studies, white colored frames have no effect on Y. However, black frames reduce the window’s exposure by 1.5%.Therefore the effect of the color would be between 0 – 1.5%. The selected window has a black frame thus it reduces the window's exposure by 1.5%. “Eq. (3)”

87% - (0.09 * 0.87) – 10% – 1.5% = 67.5% (3)

- Additional Elements

Fence and mesh are two usual additional elements for windows. Optional elements like curtains which are controlled by occupiers are not necessary to be considered. Window mesh with 1-3mm grid has a reduction in the window's exposure by 3%. Since the mesh is used on only one half of the window, the reduction amount would be 1.5%. Therefore we have: "Eq. (4)"

$$87\% - (0.09 * 0.87) - 10\% - 1.5\% - 1.5\% = 66\ \% \tag{4}$$

- Calculating window area

In this part, the method of calculating the window's area for one of the bedrooms is explained and only the results are shown for the other spaces. The method used for calculating the area of the windows in this study uses the Daylight Factor (DF). The Daylight Factor is the ratio of internal light level to external light level. This factor is related to various interior and exterior elements which define the real amount of DF. Calculating the DF for every place in a space is impossible; therefore it can be considered as a factor of the average interior light level. DF can be calculated by the "Eq. (5)" below: [7]

$$\overline{DF} = \frac{W}{A} \times \frac{T\theta}{(1-R^2)} \tag{5}$$

W= Window Area
A= Different Surfaces Area (ceiling, floor, walls) excluded Windows Area
T= Window Transfer Coefficient
θ= Sky Visibility Angle (◦C)
(If we draw a line from the center of the top edge of a window and another line from the edge of the building in front, the angle between these two lines is θ)
R= GPA of Surfaces Reflection

Therefore the DF is the most important parameter to calculate the interior light level. DF can be considered by the "Table III":

TABLE III. VALUES OF DAYLIGHT FACTOR IN RESIDENTIAL SPACES [7]

Residential Houses	The Minimum of Average Daylight Factor
Kitchen	2.5%
Living Room	2%
Bedroom	1.5%

- Window's Area in the Southern bedroom

According to table 3, the DF for bedrooms is 2%; therefore based on the average annual Daylight (11300lx/year) we will have: "Eq. (6)"

$$11300 * 0.02 = 226 \text{ lx} \tag{6}$$

which is appropriate for this space.

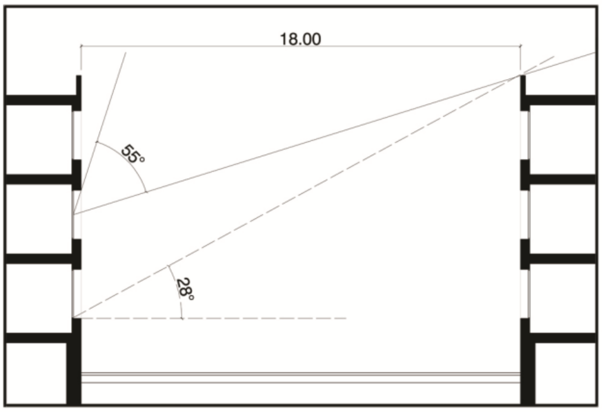
The height of the room is 284cm; therefore the amount of A in this room will be: "Eq. (7)"

$$A = 2[\ (3.40 * 3.80) + (3.40 * 2.84) + (3.80 * 2.84)\ ] - 4$$

$$A=62.74 \text{ m2} \tag{7}$$

The reduction of 4m2 is because of the window's approximate considered area. According to the calculations the θ angle is 55° "Fig. (2)"

Figure 2. Value for θ Angle in Southern Bedroom



The next step is calculating the R factor. The R amounts for various surface colors are different. In this room, the color of the ceiling is almost white. The walls are creamy and the wooden floor is brown. In this case we have: "Table IV"

TABLE IV. Reflection Coefficient of Different Colors (Author)

Color	Reflection Coefficient
Absolute White	0.7
Bright	0.6
Semi-Bright	0.5
Semi-Dark	0.4
Dark	0.3
Black	0.2

What we have in this building: "Table V"

TABLE V. REFLECTION COEFFICIENT OF IN THE SELECTED BUILDING S (AUTHOR)

Elements	Color	Reflection Coefficient
Ceiling	White (Not absolute white)	0.65
Walls	Bright (Cream)	0.6
Floor	Dark Brown	0.35

So we have: "Eq. (8)"

$$R = \frac{0.65(3.40 * 3.80) + 0.6[2(3.40 * 2.84) + 2(3.80 * 2.84) - 4] + 0.35(3.40 * 3.80)}{2[(3.40 * 3.80) + (3.40 * 2.84) + (3.80 * 2.84)] - 4}$$

$$R = 0.56 \tag{8}$$

Therefore the window's area would be the only unknown parameter. "Eq. (9)"

$$2 = \frac{W}{62.74} * \frac{0.66 * 55}{1 - 0.56^2}$$

$$W = 2.39 \text{ m2} \tag{9}$$

However, this is the amount of the area without considering the window's frame area. The area of the chosen window frame is 18% of the window; therefore the window area can be resulted as: "Eq. (10)"

$$\frac{2.39}{W} = 0.82 \quad (10)$$

W = 2.91 m2

- Calculating window's Dimensions and grouping

After calculating the windows' area for every space of the apartment like the calculations for the chosen bedroom, the results were achieved as below: "Table VI"

TABLE VI. Initial values of Windows Areas (obtained from calculation)

Name of Space	Required Window Area
Living Room	10.02 m2
Dining Room	4.23 m2
Kitchen	3.41 m2
Southern Bedroom	2.91 m2
Small Northern Bedroom	2.66 m2
Big Northern Bedroom	2.91 m2

However, it is impossible to provide the exact area for each window, since some other architectural factors such as the façade of the building, the ratio of the walls and the interior design and furniture are important to be paid attention to.

In this step, it is attempted to provide a ratio for each window very close to the calculated amounts. It seems that the height of the windows is more important to be considered because of the various factors mentioned. By trial and error, if the height of windows is considered 150cm (except the living room's window), it is possible to provide the area of the windows close to the calculated amounts. The results are available in "Table VII"

TABLE VII. Final values of Windows Areas

Name of Space	Ratio	Area	Percentage Difference from the Values obtained from the Calculation
Living Room	2.35 * 4.20 m	10.02 m2	1.5 %
Dining Room	1.50 * 2.70 m	4.23 m2	4.3 %
Kitchen	1.50 * 2.20 m	3.41 m2	3.2 %
Southern Bedroom	1.50 * 2.00 m	2.91 m2	7.2 %
Small Northern Bedroom	1.50 * 1.80 m	2.66 m2	1.5 %
Big Northern Bedroom	1.50 * 2.00 m	2.91 m2	7.2 %

The biggest differences are in the southern bedroom and the big northern one. Since the northern bedroom has a small window on another wall and the southern bedroom's window is facing the south, better daylighting conditions can be considered for these spaces.

- Computer Simulation

At the end of this study, computer Simulation by Relux software was used to compare the calculated results with the real condition. By modeling each space separately and adjusting various conditions such as space and window dimensions, windows' place on the walls, windows' exposure factor, average external light (Daylight) and the site's latitude, the software analyzes these data and after its process some new data is available. Some data such as the average interior light level and its maximum and minimum amounts in the space and some other diagrams are given by this software. Since the minimum amounts were considered in the calculations, the results of the simulation made it clear that every space has a little more light level than what was resulted in the calculations "Table VIII".

TABLE VIII. COMPARISON BETWEEN DAYLIGHTING VALUES FROM CALCULATION AND SIMULATION

Name of Space	Daylighting Values from Calculation	Daylighting Values from Simulation
Living & Dining Room	11300 * 2.25% = 254 lx	311 lx
Kitchen	11300 * 2.5% = 283 lx	330 lx
Southern Bedroom	11300 * 2% = 226 lx	272 lx
Small Northern Bedroom	11300 * 2% = 226 lx	243 lx
Big Northern Bedroom	11300 * 2% = 226 lx	261 lx

IV. CONCLUSION

A conventional residential building in the cold climate of Iran was analyzed from the perspective of daylighting. The optimized areas for its windows were calculated. Having applied the architectural and aesthetic matters in the proportion of each window, the computer simulation by Relux Software was used to compare the calculated results with applied condition.

The results show that there is not much difference between the calculated data and simulated one by the software just a little more light level than what was resulted in the calculations.

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1 Copy Room

1.1 Description, Copy Room

1.1.1 Luminaire data/Room elements

Luminaire data:
Type No.\Make

Structural elements

Virtual measuring surface

No.	xm[m]	ym[m]	zm[m]	Length	Width	Rotation angle z axis	L axis	Q axis
Ref. plane 1	1.70	1.90	0.75	2.40	2.80	0.00	0.00	0.00

Window

No.	Wall	x'[m]	y'[m]	Width	Height	tau[%]	Partit.	Pollut.
Wi 1.1	1	0.80	1.00	1.80	1.50	60	1.00	0.90

Picture

No.	Wall	x'[m]	y'[m]	Width	Height	rho[%]
W 2.1	2	0.50	1.00	0.50	1.50	20
W 2.2	2	1.25	1.00	0.50	1.50	20
W 2.3	2	2.00	1.00	0.50	1.50	20
W 2.4	2	2.75	1.00	0.50	1.50	20

Object :
Installation :
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Date : 02.09.2010

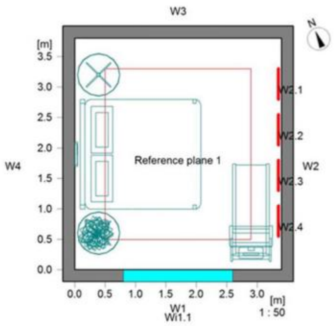
1.1 Description, Copy Room

1.1.3 3D view, View from the back

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1.1 Description, Copy Room

1.1.2 Floor plan



Room data:		Reflectance:
W1 :	3.40	88.9 %
W2 :	3.80	88.9 %
W3 :	3.40	88.9 %
W4 :	3.80	88.9 %
W5 :	-----	-----
W6 :	-----	-----
Floor:	-----	20.0 %
Ceiling:	-----	70.0 %
Room height [m]:		2.84
Height of reference plane [m]:		0.75

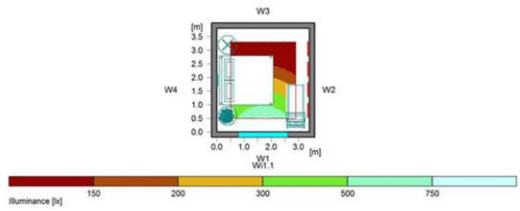
Structural elements
Pi : Pillar
Tr : Partition
Wo : Real working surface
m : Virtual measuring area
S : Skylight
W : Picture
Wi : Window
DF : Door
F : Furniture

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1 Copy Room

1.2 Summary, Copy Room

1.2.1 Result overview, Reference plane 1



General

Calculation algorithm used	High indirect fraction
Height of evaluation surface	0.75 m
Calculation mode used:	Overcast sky acc. CIE
Date, Time:	21.03. 09:53 (TST 09:31)

Geographical data:

Location	: Ardebil
Latitude (degrees)	: 38.00 °
Longitude (degrees)	: 48.16 °
North angle	: 0.00 °

Illuminance

Average daylight ratio	Dav	: 2.4
Minimum daylight ratio	Dmin	: 0.91
Maximum daylight ratio	Dmax	: 6.54

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1 Copy Room

1.3 Calculation results, Copy Room

1.3.1 Table, Reference plane 1 (E)

110	112	114	114	115	117	116	115	115	113	113	111	109	106	(103)
114	118	119	120	120	123	122	121	120	118	118	116	113	110	107
117	122	123	124	124	126	125	125	122	122	121	118	116	112	110
122	126	127	128	132	132	132	132	132	127	127	124	122	116	115
										135	132	128	123	119
										143	140	136	130	125
										152	147	145	139	133
										164	160	153	148	141
										179	174	167	161	151
										199	190	184	172	163
										221	211	199	190	175
										243	234	221		
										271	261	246		
										307	293	273		
										350	330	305		
										396	370	339		
298	348	389	425	453	471	489	491	485	474	452	420	377		
	377	434	477	515	543	559	564	559	543	513	478	422		
	411	485	542	593	624	645	650	643	628	594	545	476		
	447	540	609	676	714	736	[742]	736	713	670	618	539		

[m] vertical axis: 3.00, 2.75, 2.50, 2.25, 2.00, 1.75, 1.50, 1.25, 1.00, 0.75
Horizontal axis: 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 [m]

Height of the reference plane		: 0.75 m
Average illuminance	Eav	: 272 lx
Minimum illuminance	Emin	: 103 lx
Maximum illuminance	Emax	: 742 lx
Uniformity g1	Emin/Eav	: 1 : 2.63 (0.38)
Uniformity g2	Emin/Emax	: 1 : 7.18 (0.14)
Date, Time		: 21.03. 09:53 (TST 09:31)

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1.3 Calculation results, Copy Room

1.3.2 Table, Reference plane 1 (D)

0.97	0.99	1	1.01	1.01	1.03	1.03	1.02	1.01	1	0.99	0.98	0.96	0.93	(0.91)
1.01	1.04	1.05	1.05	1.06	1.08	1.08	1.07	1.06	1.04	1.04	1.02	1	0.97	0.94
1.03	1.08	1.08	1.09	1.1	1.11	1.1	1.1	1.08	1.07	1.07	1.04	1.03	0.99	0.97
1.08	1.11	1.12	1.13	1.16	1.16	1.16	1.16	1.16	1.12	1.12	1.1	1.08	1.02	1.02
										1.19	1.17	1.13	1.09	1.05
										1.26	1.23	1.2	1.15	1.1
										1.34	1.3	1.28	1.22	1.17
										1.44	1.41	1.35	1.3	1.24
										1.57	1.54	1.47	1.42	1.33
										1.75	1.68	1.62	1.52	1.43
										1.94	1.86	1.75	1.68	1.54
										2.14	2.07	1.95		
										2.38	2.3	2.16		
										2.7	2.59	2.4		
										3.08	2.91	2.69		
										3.49	3.26	2.99		
2.63	3.07	3.43	3.75	3.99	4.15	4.31	4.33	4.27	4.18	3.98	3.7	3.32		
	3.33	3.83	4.21	4.54	4.79	4.93	4.97	4.93	4.79	4.52	4.21	3.72		
	3.62	4.28	4.78	5.23	5.5	5.69	5.73	5.67	5.54	5.23	4.8	4.19		
	3.94	4.76	5.37	5.96	6.29	6.48	[6.54]	6.49	6.29	5.9	5.45	4.75		

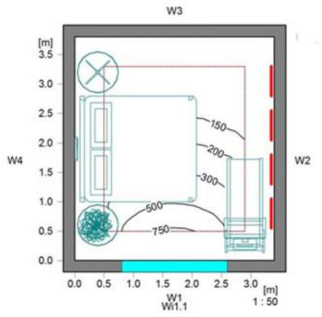
[m] vertical axis: 3.00, 2.75, 2.50, 2.25, 2.00, 1.75, 1.50, 1.25, 1.00, 0.75
Horizontal axis: 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 [m]

Average daylight ratio	Dav	: 2.4
Minimum daylight ratio	Dmin	: 0.91
Maximum daylight ratio	Dmax	: 6.54
External illuminance	Ea	:11300 lx
Uniformity g1	Dmin/Dav	: 1 : 2.63 (0.38)
Uniformity g2	Dmin/Dmax	: 1 : 7.18 (0.14)
Date, Time		: 21.03. 09:53 (TST 09:31)

Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

1.3 Calculation results, Copy Room

1.3.3 Isolines representation, Reference plane 1 (E)



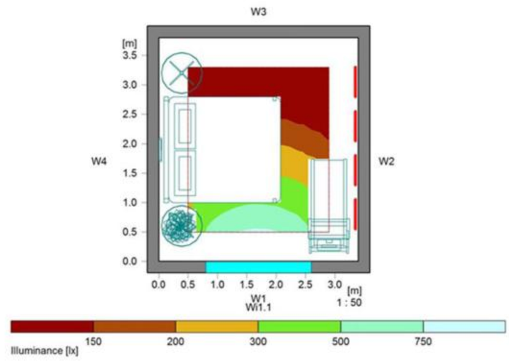
Illuminance [lx]

Height of the reference plane		: 0.75 m
Average illuminance	Eav	: 272 lx
Minimum illuminance	Emin	: 103 lx
Maximum illuminance	Emax	: 742 lx
Uniformity g1	Emin/Eav	: 1 : 2.63 (0.38)
Uniformity g2	Emin/Emax	: 1 : 7.18 (0.14)
Date, Time		: 21.03. 09:53 (TST 09:31)

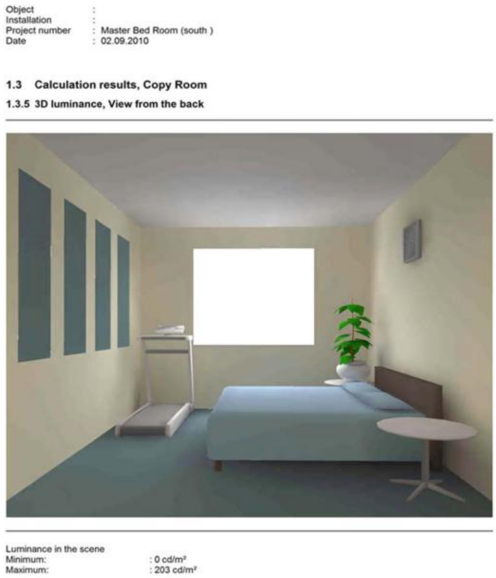
Object :
Installation :
Project number : Master Bed Room (south)
Date : 02.09.2010

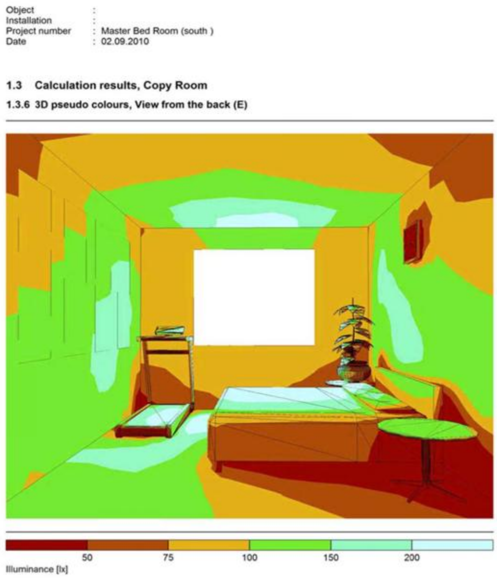
1.3 Calculation results, Copy Room

1.3.4 Pseudo colours, Reference plane 1 (E)



Height of the reference plane		: 0.75 m
Average illuminance	Eav	: 272 lx
Minimum illuminance	Emin	: 103 lx
Maximum illuminance	Emax	: 742 lx
Uniformity g1	Emin/Eav	: 1 : 2.63 (0.38)
Uniformity g2	Emin/Emax	: 1 : 7.18 (0.14)
Date, Time		: 21.03. 09:53 (TST 09:31)





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