



The project on Energy Efficiency improvement in the Commercial and High-rise Residential Buildings in Vietnam

USER GUIDE FOR WEB-BASED OTTV CALCULATION SOFTWARE

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PART 1

SCIENTIFIC BASIS AND ALGORITHMS OF THE WEB-BASED OTTV CALCULATION SOFTWARE

1. GENERAL INTRODUCTION

1.1. Definition and Technical regulation on the overall thermal transfer value

OTTV in QCVN09:2017/BXD

1.1.1. Definition

Overall thermal transfer value OTTV: The total heat transferred into the house through the whole surface area of the building envelope (walls and roofs) including the transparent and the intransparent building envelope, cumulated for 1m² of outside surface of the building, W/m².

1.1.2. Technical regulation on OTTV in QCVN09:2017/BXD

For walls: **OTTV_T ≤ 60 W/m²**

For roofs: **OTTV_M ≤ 25 W/m²**

The OTTV calculation software was developed as a tool for architects in the design of the building in compliance to the energy efficiency requirements and in examination of the technical compliance of QCVN09:2017/BXD concerning the building envelope.

The web-based OTTV calculation software was developed upon the basis of a new, modern technology with high openness and inheritance of earlier developed products such as: window-based OTTV software, software for calculation of solar radiation heat reduction coefficient β -value of shading structure, that is the ASP.Net Core technology. This is one of the newest technology platforms for web development which was developed by Microsoft.

The scientific basis and the development methods for the WEB-based OTTV calculation software also apply the same formulas for OTTV calculation like the WINDOWS-based software, as explained below:

1.2. OTTV calculation method

The OTTV is calculated separately for outside walls and roofs, marked respectively as OTTV_T – for walls and OTTV_M – for roofs.

1.2.1. General theoretical formula:

$$\text{OTTV}_{T,i} = (1 - \text{WWR}_i) \times U_{o,Ti} \times \alpha \times (T_{\text{eq},i} - \Delta T) + (1 - \text{WWR}_i) \times U_{o,Ti} \times \Delta T + \text{WWR}_i \times K_{cs,i} \times I_{o,i} \times \beta + \text{WWR}_i \times U_{o,Ki} \times \Delta T, \quad \text{W/m}^2 \quad (1)$$

$$\text{with } T_{\text{eq},i} = I_{o,i} / h_N + \Delta T = I_{o,i} / h_N + t_N - t_T, \quad \text{K} \quad (2)$$

1.2.2. Calculation formula for OTTV_T for walls (practical):

$$OTTV_T = \frac{\sum_{i=1}^n [\alpha_i \times U_{o,Ti} \times m_i \times (TD_{eq,i} - \Delta T) \times A_{Ti}] + \Delta T \times \sum_{i=1}^n (m_i \times U_{o,Ti} \times A_{Ti})}{A_o} + \frac{\sum_{i=1}^n (\beta_i \times K_{cs,i} \times I_{o,i} \times A_{Ki}) + \Delta T \times \sum_{i=1}^n (U_{o,Ki} \times A_{Ki})}{A_o} \quad (3)$$

Whereas (all following quantities are for the i-th walls under consideration):

- $U_{o,T}$ - total heat transfer of the non-transparent wall, $W/m^2.K$;
- $U_{o,K}$ - total heat transfer of glass windows, $W/m^2.K$;
- α – radiation absorption coefficient of the material surface of the non-transparent wall, dimensionless
- $\Delta T = t_N - t_T$ - temperature difference between outdoor air (t_N) and indoor (t_T), K ;
- TD_{eq} – Equivalent effective temperature difference, which takes into account the effect of solar radiation intensity on the wall surface, K
- I_o – total solar radiation intensity on the wall and glass windows surfaces, W/m^2 ;
- K_{cs} – Solar heat absorption coefficient for glass windows – in Western countries and
- K_{cs} – Solar heat absorption coefficient for glass windows – in Western countries and many countries in the region this is marked as SHGC (Solar Heat Gain Coefficient); dimensionless
- β – Solar radiation absorption reduction coefficient for glass windows due to the shading structure (or the External Shading Multiplier- ESM) – shortly mentioned as "radiation reduction coefficient", dimensionless
- m – the coefficient into account heat accumulation in the covering structure, which depends on the mass and density of the covering structure
- h_N, h_T – respectively the heat exchange coefficients for outside and inside surfaces of building envelope – see Table 3 in the Annex to the current QCVN 09:2017/BXD in act.
- A_o – wall area including windows, m^2 ;
- i – indicator for quantities for the i-th wall;
- A_{Ti}, A_{Ki} – area of non-transparent wall surface of the i-th wall and area of glass window(s) on that i-th wall, m^2 ;
- n – number of outside walls of the building;

1.2.3. Calculation formula for $OTTV_M$ for roofs (practical):

The formula (3) is the practical formula for manual or programmed calculation. Usually $OTTV_{Wall}$ is calculated for each building storey, then A_o will be the whole wall surface area of the considered building storey. In the $OTTV_{Wall}$ calculation for the whole building's wall A_o will be the total outside wall surface area of the whole building.

For roofs, it is only necessary to adjust some of the foot indexes of the quantities in formula

correspondingly:

$$OTTV_M = \frac{\sum_{i=1}^n [\alpha_i \times U_{o,Mi} \times m_i \times (TD_{eq,i} - \Delta T) \times A_{Mi}] + \Delta T \times \sum_{i=1}^n (m_i \times U_{o,Mi} \times A_{Mi})}{A_{Mo}} + \frac{\sum_{i=1}^n (\beta_i \times K_{CMi} \times I_{o,i} \times A_{CMi}) + \Delta T \times \sum_{i=1}^n (U_{o,CMi} \times A_{CMi})}{A_{Mo}}, \text{ W/m}^2 \quad (4)$$

Whereas:

$U_{o,Mi}$ and $U_{o,CMi}$ – respectively the total heat transfer (U-value) of the i th roof and glass roof door (skylight), etc ; $\text{W/m}^2 \cdot \text{K}$.

A_{Mi} and A_{CMi} - respectively the area of the i th roof and the glass roof door (skylight), m^2 ;
 K_{CMi} – solar heat gain coefficient (SHGC) of the i -th glass roof door (skylight) ; dimensionless

A_{Mo} – total roof area, including glass roof door (skylight), m^2 .

NOTES:

- All parameters of outdoor climate such as the air temperature t_N , solar radiation intensity I_o in the formulas (3) and (4) are included in the OTTV calculation software for all provinces and cities in Vietnam and the user only need to submit the parameters of the building envelope structure in the EXCEL file template included in the program. The program will automatically calculate, display and save the results – see the Guide of use of OTTV calculation software.

The β -coefficient – the solar radiation reduction coefficient (BXMT) of glass windows

- due to the effect of the shading structures is also calculated for 5 types of usual shading structures and it is integrated into the OTTV calculation software, the user only need to submit into the EXCEL file template the dimensions of the chosen shading structure on each vertical surface in each orientation, the program will automatically calculate the β -coefficient and inputs into the OTTV calculation program (see the Guide of use of OTTV calculation software).

PART 2

GUIDE OF USE OF THE WEB-BASED OTTV CALCULATION SOFTWARE

2. INSTALLATION AND USAGE OF THE SOFTWARE

2.1. Procedure of steps to use the program

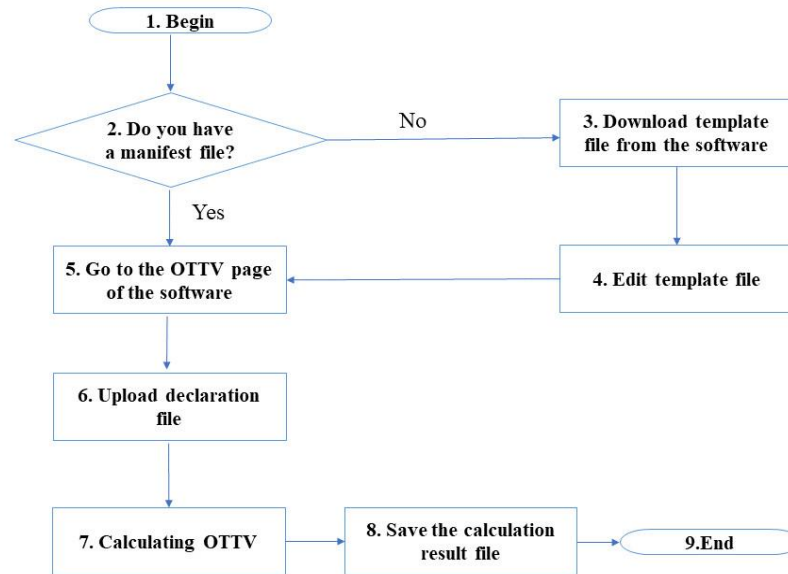


Figure 1. Procedure to use the program

In the diagram above please note at step 2 that there are 2 cases:

- Case 1: The user does not have the submission form, then the new EXCEL file template must be downloaded for submission and then go to step 5 for calculation.
- Case 2: The user already has the EXCEL file template and has submitted data into this template, then go directly to step 5 for calculation.

After getting to the calculation page of the software, the user should upload the submission file and then let the software calculate, then save the results to his/her computer. Details of the issues will be described as following.

2.2. Address of the installation

The software is developed web-based so the whole source code is placed on a web server located in the “National University of Civil Engineering”. The user only need to visit the address <http://ottv-demo1.tk> (or the website of the Ministry of Construction: <http://tietkiemnangluong.xaydung.gov.vn>) to use the DEMO version of the software. The user interface will appear when starting the program.

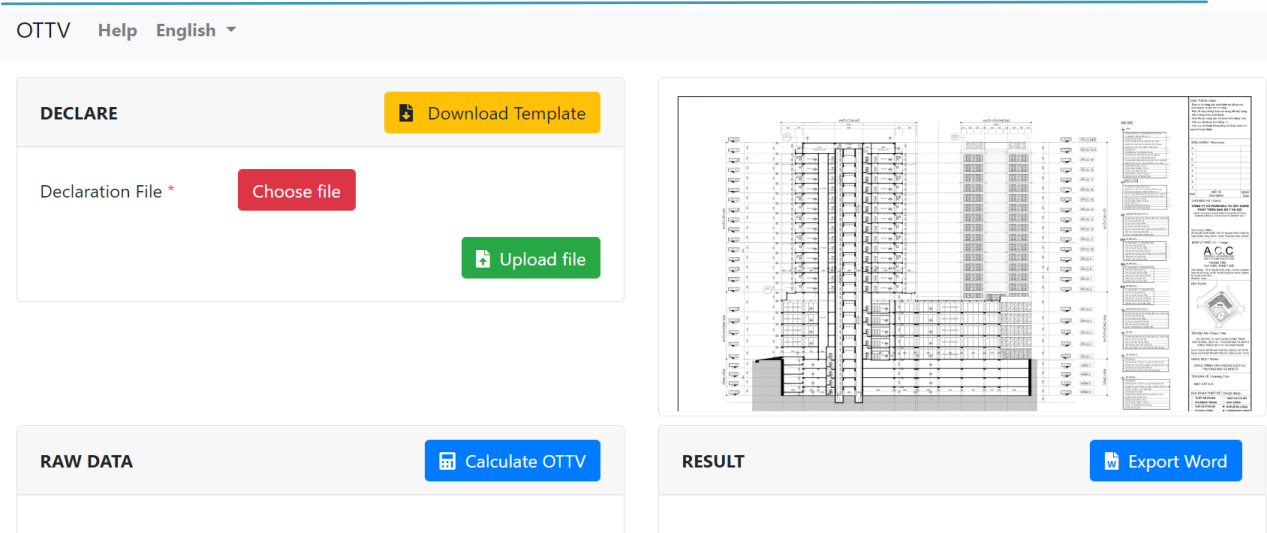


Figure 2: Overview of user interface

2.3. Downloading the submission file template

Step 1: Visit the interface for file template list

In order to access the list of file templates the user can follow two manners:

Manner 1:

The user visit the **Help** page by clicking the menu “**Help**” the interface will display: list of file (Figure 3) and then clicking **Download file** for: 02.Submissions File of building

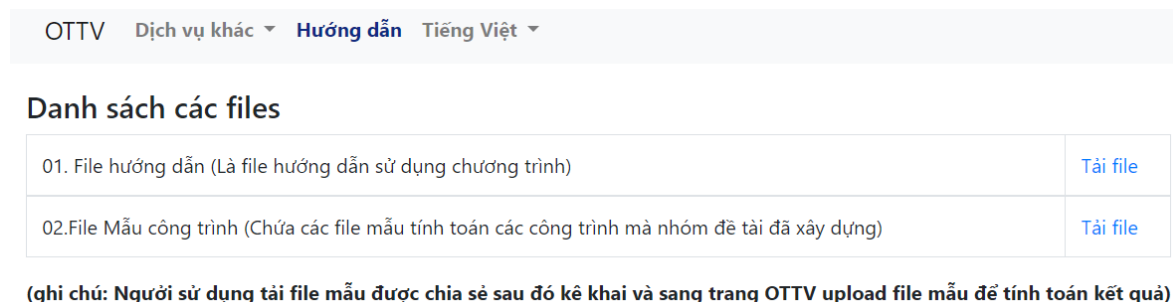


Figure 3. Interface of help page

In the **Help** page there is also the file: 01. Guide of use of the software.

The user can click on **Download file** of this section to download the File “Guide of use of OTTV calculation software” to his/her computer (Figure 3)

Manner 2:

The user visits the OTTV calculation page by clicking on menu “**OTTV**”.

(Figure 2)

Then the user clicks on “**Download template**” button

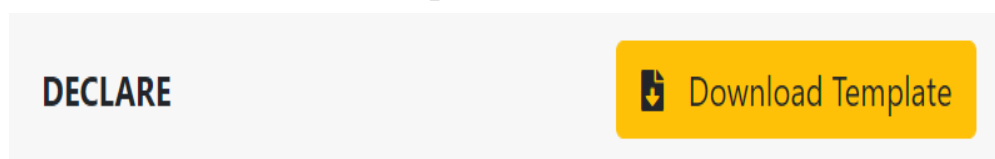
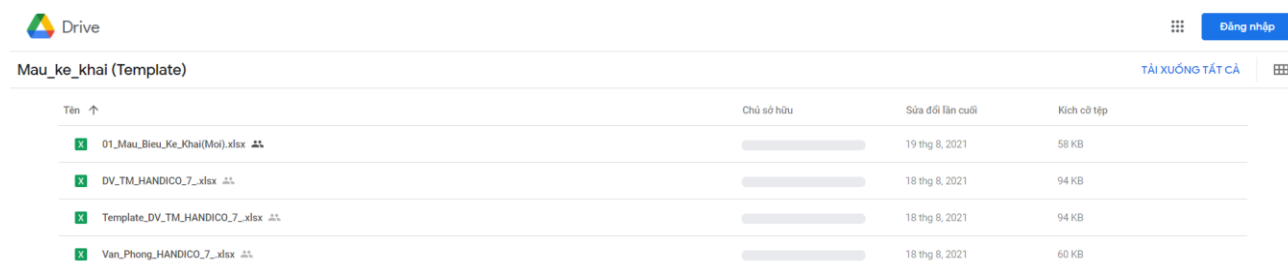


Figure 4. Interface of “Download template” button

Step 2: Downloading the template.

After clicking “Download template” the user will see the interface as in figure 5.



Tên	Chủ sở hữu	Sửa đổi lần cuối	Kích cỡ tệp
01_Mau_Bieu_Ke_Khai(Moi).xlsx		19 thg 8, 2021	58 KB
DV_TM_HANDICO_7_.xlsx		18 thg 8, 2021	94 KB
Template_DV_TM_HANDICO_7_.xlsx		18 thg 8, 2021	94 KB
Van_Phong_HANDICO_7_.xlsx		18 thg 8, 2021	60 KB

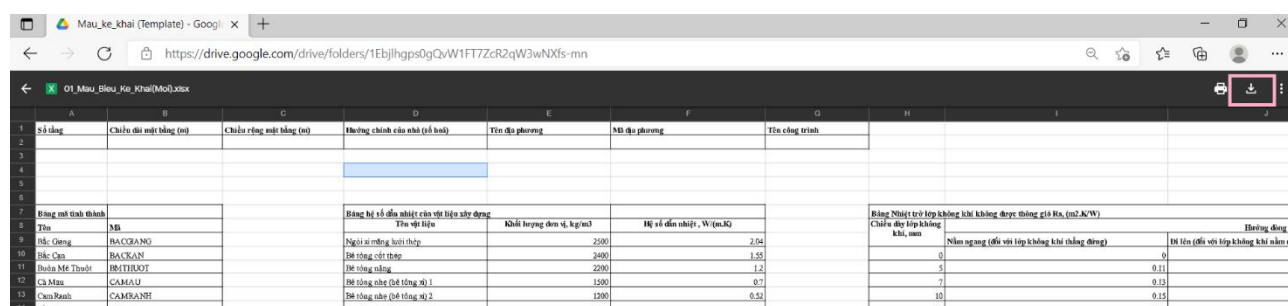
Figure 5. Template list

This list includes 4 file templates:

- 01_Mau_Bieu_Ke_Khai.xlsx → Blank submission file template
- 02_DV_TM_HANDICO7.xlsx → Submitted file template of “Service and Commercial blocks of HANDICO7 building”.
- 03_VP_HANDICO_7.xlsx → Submitted file template of “Office block of HANDICO7 building”.
- 04_(EN)_DV_TM_HANDICO_7 → Submitted file template in **English** of “Service and Commercial blocks of HANDICO7 building”.

***Note:** The purpose of loading further submitted file templates for several buildings is for reference by the user and for test-run of the WEB-based OTTV software with these buildings.*

In order to download any file template the user double-click the file template. The details of the excel submission file template will be displayed (as in Figure 6 below) with the download button on top right.



A	B	C	D	E	F	G	H	I	J
1	Số tầng	Chiều dài mặt bằng (m)	Chiều rộng mặt bằng (m)	Hướng chính của nhà (số bậc)	Tên dự phòng	Mô dự phòng	Tên công trình		
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

Figure 6. Interface of file template display on WEB site

Then the user click the download button. File will be automatically downloaded to the download folder of the computer and the user can save it into any specified folder in his/her computer.

The submission of the parameters of the building envelope structure will be explained in the section “Guide of submission of **EXCEL file template** with parameters of building envelope in the OTTV calculation software” (see next sections).

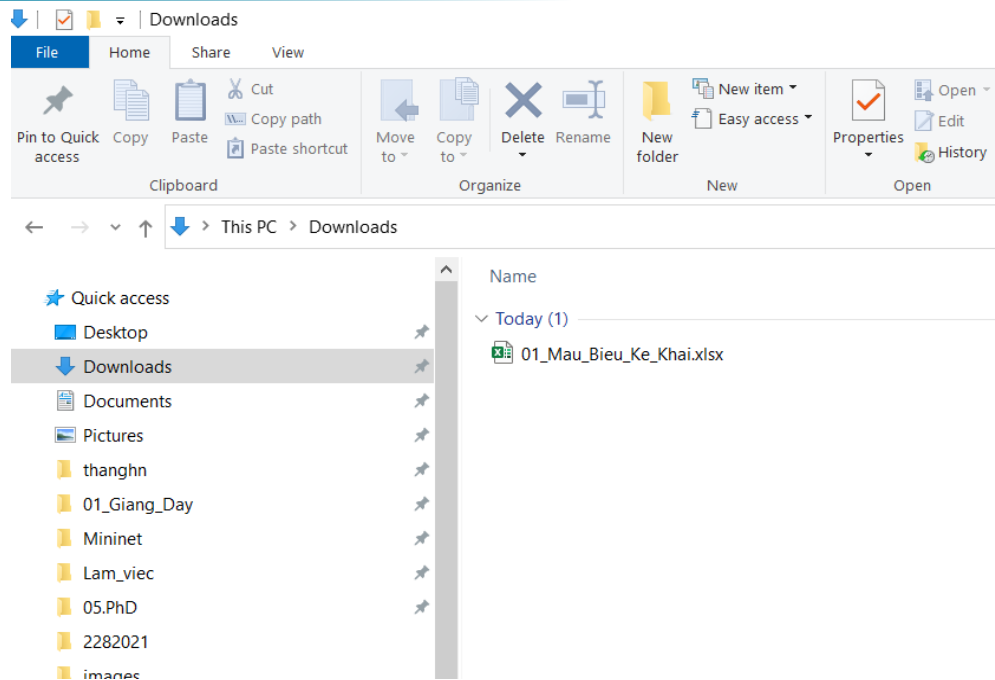


Figure 7. Interface of download folder after downloading the file template

2.4. OTTV calculation

After submitting all structure parameters of the building envelope in the downloaded file template, the user visits the **OTTV calculation** page (as in **Figure 2**). Then the user clicks on the “**Choose file**” button, the computer will inquire to choose the folder, then the user choose the folder in the computer containing the submission excel file, and choose the file, then the name of the excel file will be displayed below “Choose file” (as in Figure 8) and the user clicks the “Upload file” button.

DECLARE

Download Template

Declaration File *

Choose file

Upload file

Figure 8. Interface after choosing the submission file

Then the “**Initial data**” section will display the concrete raw data of the submitted building in the EXCEL file so that the user can identify the building to be calculated and avoid mistakes when opening other buildings, and also the user can edit the data before calculation (Figure 9).

RAW DATA Calculate OTTV

Building name
DV-TM HANDICO 7

Building location
Hà Nội

Location Code
HANOI

Roof

0
4
0.44 394 7 15 1600 0.7 15 1800 0.93 30 2400 1.55 50 600 0.17
30 1800 0.93 500 2400 1.55 15 1800 0.93 0

Floor 1

5 93.6 87.5 1
4.5
0
6

Floor 2

4.2
3
6
1

Figure 9. Interface after uploading the submission file

After uploading the submission file and checking the data, the user clicks the button **“Calculate OTTV”** so that the software will calculate and the results will be displayed on the interface (Figure 10)

The user clicks the button **“Save results”** in section **“Kết quả” “Results”** to export word file containing the OTTV calculation results. By default the downloaded file will be downloaded to Download folder.

RAW DATA Calculate OTTV

Building name
DV-TM HANDICO 7

Building location
Hà Nội

Location Code
HANOI

Roof

0
4
0.44 394 7 15 1600 0.7 15 1800 0.93 30 2400 1.55 50 600 0.17
30 1800 0.93 500 2400 1.55 15 1800 0.93 0

RESULT Export Word

Program OTTV10A (run with external data file CT 1)
Solution 1: choose BX_TB and tN_TB monthly values from 3 hottest summer months
Define the OTTV coefficient of the building with input data given in CT 1
Program OTTV10A (run with external data file CT 1):
For implementation of task "Upgrading the web-based OTTV calculation program, in support for QCVN 09:2017/BXD under the project "Energy Efficiency Improvement in Commercial and High-Rise Residential Buildings in Viet Nam" (EECB)
Responsible entity: EECB project – Ministry of Construction
Entity in charge for implementation: Institute of Information Technology in Civil Engineering – National University of Civil Engineering Hanoi
Head of Project: Prof. Dr. Tran Ngoc Chan
Authors of the program: Prof. Dr. Tran Ngoc Chan; Bachelor To Thi Loi and MSc Hoang Nam Thang

Figure 10. Interface after OTTV calculation

In case of errors while uploading the declaration file or in the OTTV calculation, the program will warn about the errors and the user should adjust the data correctly and re-submit input file.

Besides the software also supports other functions such as: Calculation of shading structure, Looking up the locality code, Help, Language choice.

3. GUIDE OF SUBMISSION OF PARAMETERS OF THE BUILDING ENVELOPE IN THE EXCEL FILE TEMPLATE IN THE WEB-BASED OTTV CALCULATION SOFTWARE

3.1. Choosing the submission file template

In order to calculate the OTTV of some building, first one should describe the building so that the software can identify it through declaration of all technical and physical parameters of the building envelope such as opaque wall, glass openings (including windows, glass doors and glass wall), shading structures etc... The technical parameters of the building envelope include outside paint, area, number of material layers, width of material layers, material density (ρ , kg/m³). The physical parameters of the building envelope include the thermal conductivity of the material layers in the opaque wall; the absorptance, transmittance and reflectance of glass to calculate SHGC of glass, the external shading multiplier β -value of shading structure etc...

The program uses EXCEL format for submission files which has clear and legible interface. Besides the program was also developed with the integration of shading structure calculation so the declaration file also include other content than the old format input files.

3.2. Example of a building

For example of submission of building envelope parameters, we choose the representing building the Building complex with Commercial-Service, Offices, Residential and Garage blocks Handico7 in order to introduce the way of OTTV calculation for the building envelope.

3.2.1. Description of building

The building complex Handico7 is a multifunctional building located ground piece B4 with the total projected ground area of 15716 m², in the new urban zone Southwest Hanoi – the new urban zone of the first phase within the administrative border of Yen Hoa ward, Trung Hoa, Cau Giay district, Hanoi.

To the Northwest : planned road 40m.

To the Northeast : planned road 30m.

To the Southeast : planned road 13,5m.

To the Southwest : planned road 17,5m.

The building consists of three blocks connected to each other by 5 storeys at the foot, the building has 19 storeys and 4 basements.

+ *Office and Service Building Block (Service and Trade Block – marked as CT1 in the calculation)*

- Ground floor : public zone, trade and service;
- Storeys 02 - 05 : trade and service zone (contiguous space on the whole floor area of the building) ;
- Roof floor : outdoor space;

- Total floor area : 18760 m².

+ Office and Service Building Block (Office Block – marked as CT2 in the calculation):

- Storeys 06-19 : Office zone for rent;
- Roof floor : Outdoor space;
- Total floor area : 18054 m².

+ Apartment Building Block (Residential Block – marked as CT3 in the calculation):

- Storeys 06-19 : Apartment zone;
- Roof floor : Outdoor space;
- Total floor area : 16044 m².

Material finishes outside the building:

- Building walls: constructed with brick of thickness 220, mark 75, and cement mortar of mark 50 for plastering
- The stone part is plastered with cement mortar of mark 75 and thickness 15; the stone: for the foot building block (5 foot storeys) natural granite is used;
- Glass windows and glass walls: using powder coated aluminum frames and safety glass of thickness 12,38 mm.

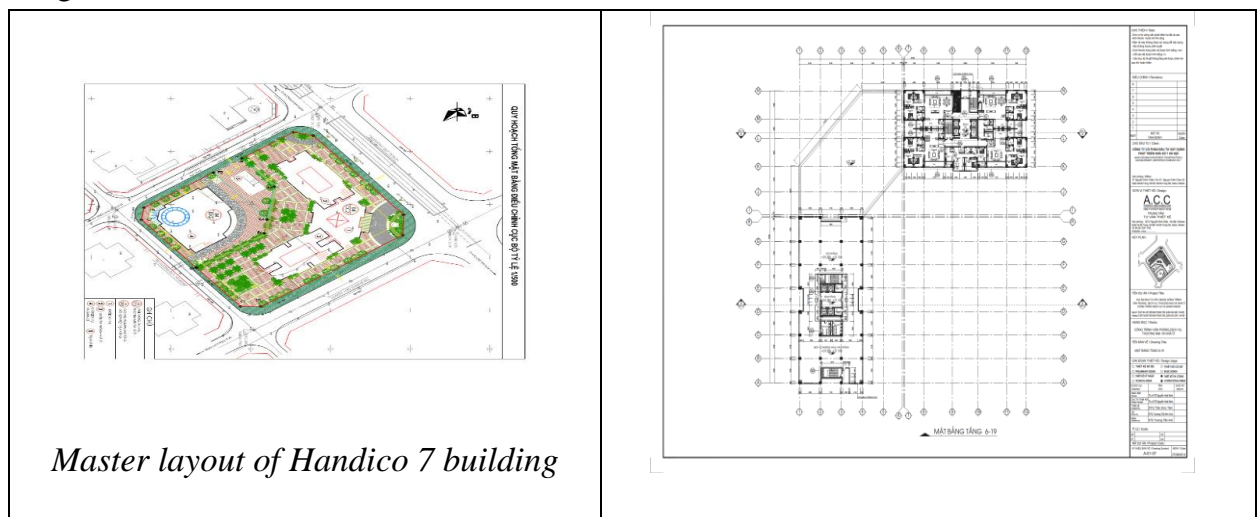


Figure 11 – Drawing of Master layout of Handico7 building

3.2.2. Choice of building for submission template

In this guide for submission, we take for example the submission file template: **“Office building block HANDICO 7 – Cau Giay, Ha Noi”** - This office building block is a tower with 14 same floors, 4 wall surfaces in 4 orientations staying on the foot building block Commercial - Service (5 floors) – see the floor layout drawing attached below:

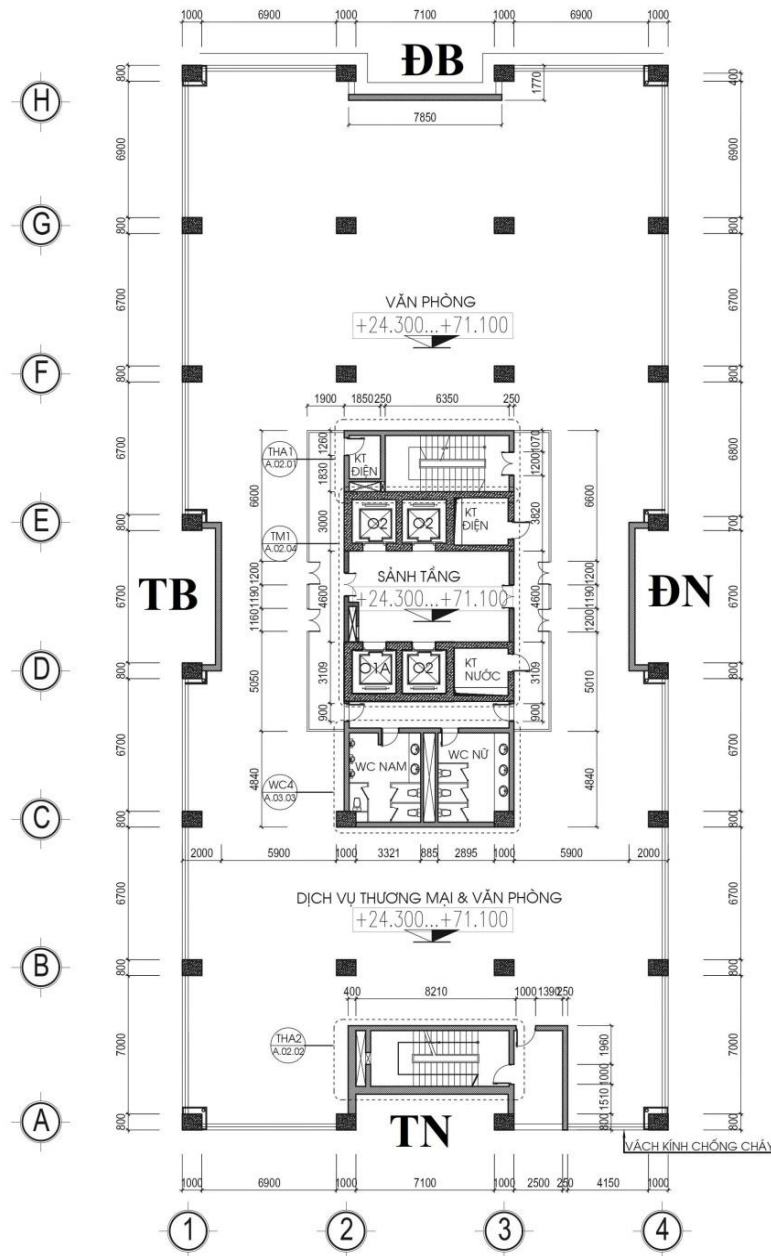


Figure 12. Floor layout of floor no. 1 (same for all 14 floors) of Office building block Handico 7

The main façade of the Office building is in the Southeast orientation (in the drawing that is the right side – figure 12). Other façades: left side – to the Northwest; bottom side: to the Southwest; top side: to the Northeast.

The Office building block (marked as CT2 in the calculation) has in the drawings floors numbered from 6 to 19 (upon foot block of 5 floors). But in the submission file for building envelope of the Office building block, for ease of programming, the order of the floors is re-numbered from 1 to 14. Height of storey: 3,6 m. Total outside surrounding wall surface: 7932.96 m².

Since the floor layout of the building is the same for all 14 floors, it is only necessary to submit the parameters for 1 floor and to note that the rest 13 floors are the same as floor 1 (see EXCEL file – first row of Floor sheet).

Roof: horizontal roof, without roof openings.

3.3. Explanation of EXCEL file for submission of building envelope parameters

The EXCEL file template for submission includes 3 types of sheets (Figure 13)

- Sheet for general submission,
- Sheets for floors,
- Sheet for roof.

Số tầng	Chiều dài mặt bằng (m)	Chiều rộng mặt bằng (m)	Hướng chính của nhà (số hoá)	Tên địa phương	Mã địa phương	Tên công trình
14	53.8	24.9	7	Hà Nội	HANOI	VP HANDICO 7

Bảng mã tỉnh thành		Bảng hệ số dẫn nhiệt của vật liệu xây dựng		
Tên	Mã	Tên vật liệu	Khối lượng đơn vị, kg/m ³	Hệ số dẫn nhiệt, W/(m.K)
Bắc Giang	BACGIANG	Ngói xi măng lưới thép	2500	2.04
Bắc Kan	BACKAN	Bê tông cốt thép	2400	1.55
Buôn Mê Thuột	BMTHUOT	Bê tông nặng	2200	1.2
Cà Mau	CAMAU	Bê tông nhẹ (bê tông xi)	1500	0.7
Cà Mau	CAMAU	Bê tông nhẹ (bê tông xi) 2	1200	0.52
Cần Thơ	CANTHO	Bê tông nhẹ (bê tông xi) 3	1000	0.41
Cao Bằng	CAOBANG	Bê tông bọt hấp hơi nóng 1	1000	0.4
Châu Đức	CHAUDOC	Bê tông bọt hấp hơi nóng 2	800	0.29
Đà Lạt	DALAT	Bê tông bọt hấp hơi nóng 3	600	0.21
Đà Nẵng	DANANG	Bê tông bọt hấp hơi nóng 4	400	0.15

Figure 13. Interface of sheet for general submission, for floors and for roof

3.3.1. General submission

In the sheet for “general submission” the general parameters of the whole Office building block will be submitted.

When clicking the sheet “General submission” in the EXCEL template, a table will be displayed with the number of floors, the length of floor layout, the width of floor layout, the main orientation (digitalized) of the building, the name of the locality where the building is constructed and its code – **digits and letters in red**.

Simultaneously, the table with Names and Codes of localities will be displayed so that the user can click to choose the Name and Code of the locality of building. By this way the software will receive the initial input data such as: geographical latitude, start month of the 3 consecutive hottest months in the year and the average of highest temperatures of those 3 months at the chosen locality. These data serve the determination of the solar radiation density and the calculation of transferred heat into the house from solar radiation

and due to the temperature difference, whereas the indoor temperature is regulated for OTTV calculation according to QCVN 09:2017/BXD at $t_T=26\text{ }^{\circ}\text{C}$.

Besides, the sheet for general submission also displays the tables in the Annexes of QCVN 09:2017/BXD (QCVN09) for physical parameters of the materials: density ρ , thermal conductivity coefficient λ of the material, thermal resistance R_a of the air layer etc... so that the user can look up and fill in the submission file without the QCVN 09 document. In case the Annexes of QCVN09 do not include the material in the design, the user can look up other documents such as ISO... and cite the information source.

Main orientation of building: Digitalized in 16 orientations. The digitalized orientations 1, 2, 3, 4,16, begin with North and then one by one clock-wise.

The digitalized codes for building orientations are: 1 – North; 2 – North-Northeast; 3 – Northeast; 4 – East-Northeast; 5 – East; 6 – East-Southeast; 7 – Southeast; 8 – South-Southeast; 9 – South; 10 – South-Southwest; 11 – Southwest; 12 – West-Southwest; 13 – West; 14 – West-Northwest; 15 – Northwest; 16 – North-Northwest

3.3.2. Sheet for floors (only floor 1 representing all 14 floors)

The first row of the sheet for floor 1 includes: floor 1; floor height 3,6 m; number of same higher floors: 13 and number of orientations (vertical surfaces): 4. Below it that is the row for the digitalized orientations: concretely here 3-NE; 7- SE, 11-SW and 15-NW.

Below each orientations there is a submission table for different wall types (i.e. types of structures on the outside wall including columns, beams, brick walls....). The first row of this table includes the number of wall types – here the number of wall types of each orientations is 4. These tables are aligned horizontally in the EXCEL file and can be extended or cut off by the arrows on the toolbars below the display.

For example the table for orientation 3 (NE): there are 4 wall types corresponding to 4 columns of the table with the number (also the number of wall type) 1; 2; 3; 4 – consecutively wall, column, beam 1 and beam 2. Each column contains the rows indicating consecutively: absorptance α of outside surface, area (excluding windows), number of structural layers and then the parameters of each structural layer including: width b (mm), density ρ , kg/m^3 and thermal conductivity coefficient λ , W/(m.K) .

The areas of columns, beams, brick walls should be pre-calculated by the user and then entered into the submission table. Below is an example for area calculation of columns, beams and brick walls in orientation 3 (NE)

From the floor layout drawing for floor 1 – Figure 12 – in orientation NE we obtain:

- Columns: there are 4 columns, each of width 1m, so the total wall area of columns is: (number of columns) \times (column width) \times (floor height) = $4 \times 1 \times 3,6 = \mathbf{14,4\text{ m}^2}$;
- Beam 1: this is the horizontal beam over the columns for carrying the next floor. Due to the lack of the side layout view of the building in this document, the reader should imagine himself/herself. The length of this beam is just the same as the width of the floor layout of the floor in orientation NE: 24,9 m. Beam height: 277 mm (notated in

the side layout view). So the wall area of beam 1 is: $24,9 \times 0,277 = 6,897 \rightarrow$ rounded to **6,9 m²**

- Beam 2: this is the beam (constraint) over the 2 windows in orientation NE (notated in the side layout view). The total length of these beams is 15 m; height 236,5 mm. So the wall area is: $15 \times 0,2365 = 3,547 \approx$ **3,55 m²**.

- Brick wall:

- The brick wall area is: (area of vertical surface) - (area of columns) - (area of beam 1) - (area of beam 2) - (area of windows).

(On the vertical surface in orientation NE there are 2 windows (CS) of dimensions 6,7 x 2,65 m – notated in the side layout view and submitted in the table “single-glazed glass window” below the table “Wall”)

We obtain:

- Vertical surface area in orientation NE: (width of floor layout) \times (floor height) = $24,9 \times 3,6 = 89,64 \text{ m}^2$;
- Total area of columns, beams and windows: $14,4 + 6,9 + 3,55 + 2 \times 6,7 \times 2,65 = 60,36 \text{ m}^2$
- So the area of brick wall in orientation NE is: $89,64 - 60,36 =$ **29,28 m²**.

All amounts of column, beam and brick wall areas calculated above (numbers underlined and in bold) are entered into the submission table for floor 1 and orientation 3 (NE).

The width b of the material layers (all with 3 material layers) of brick wall, columns and beams is also read from the floor layout drawing (figure 12). Concerning the parameters ρ and λ of each material layer each type of structure has 3 material layers: cement-sand mortar covering the outside and inside surface with $\rho = 1800 \text{ kg/m}^3$ and $\lambda = 0,93 \text{ W/(m.K)}$. The middle layer in brick wall is fired clay brick in combination with hard mortar with $\rho = 1800 \text{ kg/m}^3$ and $\lambda = 0,81 \text{ W/(m.K)}$; for columns and beams it is reinforced concrete with $\rho = 2400 \text{ kg/m}^3$ and $\lambda = 1,55 \text{ W/(m.K)}$. All these data are taken from Annex 5 of QCVN 09 and indicated in the tables of excel file template of the software. In case the material is not included in Annex PL 5 of QCVN 09 the user can look up in other sources – for example ISO – then it is necessary to notate the information source in the file “Notes” of the user and this file should be saved into the submission profile of the building envelope for ease of checking later (if any).

Over the windows of floor 1 there is no shading structure so it is entered into the row “Label of shading structure” the number 0.

NOTE:

The OTTV calculation software integrated the calculation of β -coefficient – solar radiation reduction coefficient of glass windows due to shading structures – for 5 types of common shading structures (5 types of shading structures in the annex), so for buildings with shading structures the user only need to submit in the EXCEL file template the

dimensions of the chosen shading structure in each vertical surface of each orientation, the program will automatically calculate the β -coefficient and input into the OTTV calculation)

The Office building block Handico7 does not have double-glazed glass windows so the table “Double-glazed glass window” is left unfilled.

Thus we have submitted the parameters for orientation 3–NE.

For other orientations we submit the parameters similarly and thus finish the the submission sheet for floor 1.

In the excel file template the software developers prepare 6 auxiliary columns (total 10 columns) so that in case the orientation 3 of the considered floor has more than 4 wall types no additional columns should be added in. Below are several cases when using this file template:

- If there are less than 4 wall types, the user keeps the original EXCEL template and only needs to fill in the number of wall types in the design (please note that the number of wall types in the vertical surface in each orientation must be filled in correctly and completely, for example the wall in orientation northeast has 4 types, the user fills in the number 4 into the row of number of wall types; the software will then identify wall type from 1 to 4 for calculation and return the OTTV value of the vertical surface of the building).

- If there are more than 4 wall types of the file template the user continues the submission in the next columns and the number of wall types on the vertical surface must be entered correctly.

For the rows for the material layers of wall structure, the software developers also prepare auxiliary layers (10 layers) and the user should enter the exact number of structural layers in the submission table; the software will then identify the layer from 1 to the number of layers for calculation, the layers without submission data should be left unfilled and the form should be kept.

Below is the submission table in sheet Floor (orientation 3–NE) of the Office building block Handico7.

Door		Height (m)	Number of further same floor(s)	Number of orientations											
1		3.6	13	4											
Orientation					3 (Northeast)										
Wall	Number of wall types			4											
	Order			1	2	3	4								
	Name of wall structure			Brick wall	Col-umn	Beam 1	Beam 2								
	Absorptance α of outside surface			0.42	0.42	0.42	0.42								
	Area (not including glass), m ²			29.28	14.4	6.9	3.55								
	Number of structure layers			3	3	3	3								
	Width b, mm; density ρ , kg/m ³ and thermal conduc-tivity λ , W/(m.K) of material layers in envelope structure		Layer 1	b, mm	15	15	15	15							
				ρ , kg/m ³	1800	1800	1800	1800							
				λ , W/(m.K)	0.93	0.93	0.93	0.93							
			Layer 2	b, mm	220	770	770	370							
				ρ , kg/m ³	1800	2400	2400	2400							
				λ , W/(m.K)	0.81	1.55	1.55	1.55							
			Layer 3	b, mm	15	15	15	15							
				ρ , kg/m ³	1800	1800	1800	1800							
				λ , W/(m.K)	0.93	0.93	0.93	0.93							
			Layer 4	b, mm											
				ρ , kg/m ³											
λ , W/(m.K)															
Layer 5	b, mm														

			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 6	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 7	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 8	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 9	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 10	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Thermal resistance of air layer R _a	m ² .K/W	0	0	0	0							
Single-glazed glass window	Number of single-glazed glass window types			1										
	Type			1										
	Width	B, m		6.7										
	Height	H, m		2.65										

	Glass thickness		$b, \text{ mm}$	8.5											
	Number of glass windows			2											
	Coefficient K_{cs} (SHGC)			0.4											
	Optical coefficients of glass	τ													
		α													
		ρ													
	Type and dimensions of shading structure	Label of shading structure			0										
		Width of shading structure		$Cc, \text{ m}$											
		Distance from upper edge of window to shading structure		$Dc, \text{ m}$											
		Distance from side edge of window to shading structure		$Ec, \text{ m}$											
		Sloping angle of shading structure to the horizontal plane		$GOC, \text{ degrees}$											
		Sloping angle of vertical plate to wall surface θ (in decimal degrees)		$\theta, \text{ degrees}$											
		Shader on which side		TP (left: 1; right: 2)											
		β -value (ESM) of shading structure depending on wall direction													
Double-glazed glass window (Thickness and optical coefficients)	Number of double-glazed glass window types			0											
	Type														
	Dimension	B (m)													
		H (m)													
	Glass thickness (mm)		Outside layer												

of the two glass layers can differ from each other)			Inside layer															
	R _a – Thermal resistance of air layer, m ² K/W																	
	Number of same-type windows																	
	Coefficient K _{cs} (SHGC) from the table																	
	Optical coefficients of outside glass layer		tI															
			aI															
			rI															
	Optical coefficients of inside glass layer		tII															
			aII															
			rII															
	Type and dimensions of shading structure	Label of shading structure																
		Width of shading structure		Cc, m														
		Distance from upper edge of window to shading structure		Dc, m														
		Distance from side edge of window to shading structure		Ec, m														
		Sloping angle of shading structure to the horizontal plane		GOC, degrees														
Sloping angle of vertical plate to wall surface θ (decimal degrees)		θ, degrees																
Shader on which side		TP (left: 1; right: 2)																
β-value (ESM) of shading structure depending on wall direction																		

3.3.3. Sheet for roof

In Roof sheet there are 4 types of table as following:

a) Table “Roof”

The first row of the table “Roof” is the number of roof type – similar to wall, here roof types refer to structure types in the roof including the crossbeams, longitudinal beams, auxiliary beams... and the roof panel, over the whole beam system and the roof panel there are the heat-insulating and water-resistant structural layers and the upmost brick tiles on the roof.

According to the roof drawing, there are 5 roof structure types, including 4 beam types and roof panel corresponding to the number 1; 2; 3; 4 and 5 (all numbers in submission in red). Below the columns with names of roof structures (Beam 1, Beam 2, Beam 3, Beam 4 and Roof panel) are the absorptances α of outside surfaces ($\alpha=0,44$ – that is the absorptance of the upmost outside surface of roof so it is the same for all types of roof structures). The next row contains the area of each roof structure – calculated from the roof drawing and entered into the submission table, consecutively 141,16; 12,166; 9,796; 169,6 and 956,878 m².

Each roof structure has 6 material layers from top to bottom: 1) brick tiles of thickness 15 mm, $\rho=1600$ kg/m³ and $\lambda=0,7$ W/(m.K); 2) coherent mortar of cement and sand of thickness 15 mm, $\rho=1800$ kg/m³ and $\lambda=0,93$ W/(m.K); 3- water-resistant concrete of thickness 30 mm, $\rho=2200$ kg/m³ and $\lambda=1,28$ W/(m.K); 4- heat insulation by light concrete of thickness 30 mm, $\rho=1200$ kg/m³ and $\lambda=0,52$ W/(m.K); 5- carrying reinforced concrete in beams or roof panel of width – for beams $b=500$ mm, for roof panel $b=150$ mm, $\rho=2400$ kg/m³ and $\lambda=1,55$ W/(m.K); 6- mortar covering the bottom surface of thickness 15 mm, $\rho=1800$ kg/m³ and $\lambda=0,93$ W/(m.K).

b) Table “Roof door neck”:

It contains the information about the opaque wall part served as the foot for mounting glass door for receiving the light from above. This wall part is built with bricks or concrete... consisting of several material layers of various thickness b , density ρ and thermal conductivity coefficient λ such as in common wall structures, so the submission table is designed as same as the table for wall.

The Office building block Handico 7 does not have any roof door neck so in the row “number of types of roof door neck” the number 0 is entered and the rows below are left unfilled.

c) Table “Roof door of vertical glass”:

The Office building block Handico7 does not have any roof door of vertical glass so the first row of this table “Number of roof door types” contains 0 and the rows below are left unfilled.

d) Table “Roof door of horizontal or sloping glass”:

The Office building block Handico7 does not have any roof door of horizontal or sloping glass so the first row of this table “Number of roof door types” contains 0 and the rows below are left unfilled.

Below is the submission sheet Roof of the Office building block Handico7 :

Roof	Number of types		5							
	Order		1	2	3	4	5			
	Name of roof components		Beam 1	Beam 2	Beam 3	Beam 4	Roof panel			
	Absorptance α of outside surface		0.44	0.44	0.44	0.44	0.44			
	Area (not including roof doors) m ²		141.16	12.166	9.796	169.6	956.878			
	Number of structure layers in roof		6	6	6	6	6			
	Width b, mm; density ρ , kg/m ³ and thermal conductivity λ , W/(m.K) of material layers in roof structure	Layer 1	b, mm	15	15	15	15	15		
			ρ , kg/m ³	1600	1600	1600	1600	1600		
			λ , W/(m.K)	0.7	0.7	0.7	0.7	0.7		
		Layer 2	b, mm	15	15	15	15	15		
			ρ , kg/m ³	1800	1800	1800	1800	1800		
			λ , W/(m.K)	0.93	0.93	0.93	0.93	0.93		
		Layer 3	b, mm	30	30	30	30	30		
			ρ , kg/m ³	2200	2200	2200	2200	2200		
			λ , W/(m.K)	1.28	1.28	1.28	1.28	1.28		
		Layer 4	b, mm	30	30	30	30	30		
			ρ , kg/m ³	1200	1200	1200	1200	1200		
			λ , W/(m.K)	0.52	0.52	0.52	0.52	0.52		
		Layer 5	b, mm	500	500	500	500	150		
			ρ , kg/m ³	2400	2400	2400	2400	2400		
			λ , W/(m.K)	1.55	1.55	1.55	1.55	1.55		

		Layer 6	b, mm	15	15	15	15	15						
			ρ , kg/m ³	1800	1800	1800	1800	1800						
			λ , W/(m.K)	0.93	0.93	0.93	0.93	0.93						
		Layer 7	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 8	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 9	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Layer 10	b, mm											
			ρ , kg/m ³											
			λ , W/(m.K)											
		Thermal resistance of air layer R_a		m ² .K/W	0	0	0	0						
Roof door neck: Vertical wall of roof door neck	Number of types			0										
	Digitalized orientation													
	Absorptance α of outside surface													
	Area (not including roof openings), m ²													
	Number of structure layers of roof													
	Width b, mm; density ρ , kg/m ³	Layer 1	b, mm											
ρ , kg/m ³														

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		Layer 10	b, mm										
			ρ , kg/m ³										
			λ , W/(m.K)										
	Thermal resistance of air layer R_a		m ² .K/W	0	0	0	0						
Glass roof door (vertical glass)	Number of roof door types			0									
	Number glass layers in window (single-glazed: 1; double-glazed: 2)												
	Order												
	Digitalized orientation												
	Dimensions of roof door of vertical glass		B, m										
			H, m										
	Thickness of single-glazed glass (mm)												
	Thickness of double-glazed glass (mm)		Outside layer										
			Inside layer										
	Thermal resistance of air layer R_a		m ² .K/W										
	Coefficient K_{cs} (SHGC) of glass roof door												
	Optical coefficients of single-glazed glass		τ										
			α										
			r										
	Optical coefficients of double-glazed glass	Optical coefficients of outside glass layer	τI										
			αI										
			$r I$										
		Optical	τII										

		coefficients of inside glass layer	α_{II}										
			r_{II}										
	Label of shading structure on the vertical surface of roof door												
	Width of shading structure		C_c, m										
	Distance from upper edge of roof opening to shading structure		D_c, m										
	Distance from side edge of roof opening to shading structure		E_c, m										
	Sloping angle of shading structure to the horizontal plane		$GOC, \text{degrees}$										
	Sloping angle of vertical shader plate to wall surface θ (decimal degrees)		$\theta, \text{degrees}$										
	Shader on which side		TP (left: 1; right: 2)										
Glass roof door (horizontal or sloping glass)	Number of roof door types			0									
	Number glass layers in window (single-glazed: 1; double-glazed: 2)												
	Order												
	Digitalized orientation												
	Sloping angle of glass (decimal degrees)												
	Area												
	Thickness of single-glazed glass (mm)												
	Thickness of double-glazed glass (mm)	<i>Outside layer</i>											
		<i>Inside</i>											

		<i>layer</i>											
Thermal resistance of air layer R_a		$m^2.K/W$											
Coefficient K_{cs} (SHGC) of glass roof door													
Optical coefficients of single-glazed glass		τ											
		α											
		r											
Optical coefficients of double-glazed glass	Optical coefficients of outside glass layer	τI											
		αI											
		$r I$											
	Optical coefficients of inside glass layer	τII											
		αII											
		$r II$											
Label of shading structure on the vertical surface of roof door													
Width of roof door		B, m											
Height of roof door		H, m											
Width of shading structure		Cc, m											
Distance from upper edge of roof opening to shading structure		Dc, m											
Distance from side edge of roof opening to shading structure		Ec, m											
Sloping angle of shading structure to the horizontal plane		$GOC, \text{degrees}$											
Sloping angle of vertical shader plate to wall surface θ (decimal		$\theta, \text{degrees}$											

	degrees)											
	Shader on which side	TP (left: 1; right: 2)										

NOTES:

- 1) All types of tables in sheets for floors and sheet for roof contain auxiliary columns and rows. These auxiliary columns and rows should be kept unfilled and the form should be kept while running the program. If the rows and columns are lacked, the user can insert them into the table (use INSERT command in EXCEL).
- 2) As in the sheets for floors, the data of the roof such as the material names, thickness, coefficients ρ and λ of structural layers, information sources... should be saved by the user in a separate file as an attachment to the EXCEL submission file for the building envelope for ease of checking when necessary.

4. OTTV CALCULATION FOR MUSTER BUILDING

As mentioned above, the Office building block of Handico7 building is chosen for muster OTTV calculation – verifying the compliance to QCVN09:2017/BXD.

4.1. OTTV calculation

Following the steps in Part 2, after loading the template and submitting the parameters of the building envelope, the user saves the file to the folder in his/her computer and visits the address <http://ottv-demo1.tk> (or the website address of the Ministry of Construction: <http://tietkiemnangluong.xaydung.gov.vn>) to load the OTTV calculation software, then clicks on the button Download template on the interface, the EXCEL file template will be displayed, in this file the parameters of the building envelope of the Office building block Handico 7 are submitted. Then the user clicks the button “**Choose File – Chọn tệp**” on the interface to upload the submission file. After choosing the data, in the part “**Dữ liệu ban đầu**” (“**Initial data**”) the concrete initial data of the submitted building from the filled in EXCEL file will be displayed so that the user can recognize the building in consideration and avoid mistakes by calculating for other buildings, as well as editing the data before the calculation. After uploading the declaration file and checking the data, the user should click the button “**Tính toán OTTV**” (“**Calculate OTTV**”) so that the program start the calculation.

After calculating OTTV, the user clicks the button “**Lưu file KQTT**” – “**Save results**” in the section “**Kết quả**” – “**Results**” to export to word file containing the OTTV calculation results. The downloaded file will be saved by default in Download folder.

4.2. Calculation results

The calculation results are exported to a Word file with sections and titles already programmed specially for the Results file. Concretely the OTTV calculation results for the Office building block Handico7 is shown below:

Date.....

Program OTTV-WEB(OTTV10D) run with external data file CT 2.

Solution 1: choose BX_TB and tN_TB monthly values from 3 hottest summer months

Define the OTTV coefficient of the building with input data given in CT 2.

Upgrading the web-based OTTV calculation program, in support for QCVN 09:2017/BXD

Responsible entity: Science – Technology and Environment Department, Ministry of Construction

Entity in charge for implementation: Institute of Information Technology in Civil Engineering – National University of Civil Engineering Hanoi

Head of Project: Prof. Dr. Tran Ngoc Chan

Authors of the program: Prof. Dr. Tran Ngoc Chan; Bachelor To Thi Loi and MSc Hoang Nam Thang

OTTV calculation results for building **OFFICE HANDICO 7**

Building location: **Hanoi**

Geographic latitude of building location: 21.02° N

Ground floor dimensions of the building: 53.80 x 24.90 m²

Main building façade to the SOUTH-EAST

Number of floors in the building: 14 floors

Height of floors:

Floor 1: Floor height H = 3.60 m

Floor 2: Floor height H = 3.60 m

Floor 3: Floor height H = 3.60 m

Floor 4: Floor height H = 3.60 m

Floor 5: Floor height H = 3.60 m

Floor 6: Floor height H = 3.60 m

Floor 7: Floor height H = 3.60 m

Floor 8: Floor height H = 3.60 m

Floor 9: Floor height H = 3.60 m

Floor 10: Floor height H = 3.60 m

Floor 11: Floor height H = 3.60 m

Floor 12: Floor height H = 3.60 m

Floor 13: Floor height H = 3.60 m

Floor 14: Floor height H = 3.60 m

I) INPUTS FOR CALCULATION (PARAMETERS):

1- Heat exchange coefficient of outside surface of building envelope:

- For walls: $h_N = 25.000 \text{ W/(m}^2\text{K)}$ (= 21.50kcal/m²h°C)

- For roofs: $h_N = 25.000 \text{ W/(m}^2\text{K)}$ (= 21.50kcal/m²h°C)

2- Heat exchange coefficient of inside surface of building envelope:

- For walls: $h_T = 7.692 \text{ W/(m}^2\text{K)}$ (= 6.62 kcal/m²h°C)

- For roofs: $h_T = 5.882 \text{ W/(m}^2\text{K)}$ (= 5.06 kcal/m²h°C)

3- Outdoor temperature (t_{TB} monthly average of 3 hottest months in summer): t_{N_TB}=28.9 °C)

4- Indoor temperature with air-conditioners: t_T= 26.0 °C

5- Practical temperature difference DT: 2.9 K and DT_{tt}: 2.9 K

6- Average total radiation intensity for 3 hottest months on walls in various directions and on roof:

Orien-tation	Solar radiation intensity I _o (W/m ²)	T _{deq} °C
NE	263.28	13.43
SE	220.76	11.73
SW	220.76	11.73
NW	263.28	13.43
Mái	679.02	30.06

Table1.1: Average total radiation intensity of 3 hottest months on walls in various directions and on roof

II) BUILDING WALLS AND GLASS WINDOWS:

- 1- Total wall surface area of the building (including glass windows): 7,933.0 m²
- 2- Total glass window surface of the building: 3,932.6 m²
- 3- Total wall surface (gross) and glass window surface of the building in each orientation:

Orien- tation	Total wall surface (gross) (m ²)	Total glass window surface (m ²)	Window- wall-ratio WWR	Heat transfer through wall opaque Q _{op} (W)	Heat transfer through glass window Q _{cs} (W)	qCS through 1 m ² building envelope in considered orientation qCS (W/m ²)	Q _{tg} through wall in considered orientation Q _{tg} (W)	qTG through 1 m ² building envelop in considered orientation (W/m ²)	Ratio Q _{opa} /Q _{tg} of considered orientation (%)
NE	1,255.0	497.1	0.396	4,930.5	60,324.4	48.07	65,254.9	51.998	7.556
SE	2,711.5	1,469.2	0.542	6,761.7	153,286.4	56.53	160,048.1	59.025	4.225
SW	1,255.0	497.1	0.396	4,449.6	51,869.6	41.33	56,319.2	44.877	7.901
NW	2,711.5	1,469.2	0.542	7,492.6	178,272.2	65.75	185,764.7	68.509	4.033

Table 2.1: Total wall surface and total glass window surface of the whole building in each orientation

4- Heat conduct coefficient U-value of walls on each floor:

Floor	Max (W/(m ² K))	Min (W/(m ² K))	Average upon dt (W/(m ² K))
1	2.268	1.208	1.782
2	2.268	1.208	1.782
3	2.268	1.208	1.782
4	2.268	1.208	1.782
5	2.268	1.208	1.782
6	2.268	1.208	1.782
7	2.268	1.208	1.782
8	2.268	1.208	1.782
9	2.268	1.208	1.782
10	2.268	1.208	1.782

11	2.268	1.208	1.782
12	2.268	1.208	1.782
13	2.268	1.208	1.782
14	2.268	1.208	1.782

Table 2.2: Heat conduct coefficient U-value of walls on each floor

5- Average heat conduct coefficient U-value of walls: 1.782 W/(m²K)

6- **Window-wall-ratio (WWR) of the building:** WWR = 0.496

7- Maximal window-wall-ratio WWR max = 0.496 on walls of floors 1 to 14

8- Minimal window-wall-ratio WWR min = 0.496 on walls of floors 1 to 14

9- U-Value; SHGC and β -coefficient (shading structure) of WINDOWS of each floor and each orientation

Floor	Orientation Of building walls	Order of window in considered orientation	Window x layer(s)	U (W/(m ² K))	SHGC	β (shading)
1	NE	1	1	5.528	0.4000	1.000
1	SE	1	1	5.528	0.4000	1.000
1	SW	1	1	5.528	0.4000	1.000
1	NW	1	1	5.528	0.4000	1.000

Table 2.3: U-Value; SHGC-coefficient and β -coefficient (shading structure) of WINDOWS on each floor and in each orientation

NOTE: For floors 2 to 14 the same as with floor 1.

10- OTTV value of walls of the whole building: OTTV_t = 58.917 W/m²

CONCLUSION: The building has compliant OTTV_t to QCVN 09:2017/BXD.

11- OTTV values of walls on each floor:

Floor	OTTV W/m ²)
1	58.917
2	58.917
3	58.917
4	58.917
5	58.917
6	58.917
7	58.917
8	58.917
9	58.917
10	58.917
11	58.917
12	58.917
13	58.917
14	58.917

Table 2.4: OTTV values of walls on each floor

12- OTTV component values of walls in each orientation:

No.	Orien- tation	OTTV (W/m ²)
1	NE	8.226
2	SE	20.175
3	SW	7.099
4	NW	23.417
Total		58.917 (agrees with the data in section 10)

Table 2.5: OTTV component values of walls in each orientation

NOTE: The OTTV component values (different from the OTTV value of each storey as mentioned in Section 11) aim to evaluate the heat transfer into the building in each direction in relation to the total surface of the building. The sum of these OTTV component values is the OTTV_t of the whole building as mentioned in Section 10 above. Referring to the OTTV component values of each direction, the architect and designer can adjust the architectural design, wall material, glass, WWR rate... on each wall surface reasonably and with consideration of main and other directions ... so that their total sum OTTV_t of the whole

building complies the requirements of QC 09:2017.

- 13- Heat transfer through opaque wall of the whole building: $Q_t = 23,634.45 \text{ W}$
- 14- Heat transfer through windows of the whole building: $Q_{cs} = 443,752.55 \text{ W}$
 Among which:
 - Q through windows due to temperature difference: $63,042.42 \text{ W}$
 - Q through windows due to solar radiation: $380,710.13 \text{ W}$
- 15- Total heat transfer through the building envelope of the whole building: $Q_{tg} = 467,387.00 \text{ W}$
- 16- Rate of heat transfer through walls to the total heat transfer: $Q_t/Q_{tong} = 5.057 \%$
- 17- Heat transfer through 1m^2 window due to ΔT and solar radiation: $OTTV_{cs} = 112.84 \text{ W/m}^2$
- 18 - Heat transfer through 1m^2 window only due to solar radiation: $OTTV_{cs,bx} = 96.81 \text{ W/m}^2$

III) ROOF, WITH ROOF DOOR NECK AND ROOF DOORS OF GLASS IN VERTICAL, HORIZONTAL OR SLOPING DIRECTION:

- 1- Total roof surface area (including roof doors): $1,289.6 \text{ m}^2$
- 2- Total surface of roof doors of glass: 0.0 m^2
- 3- Glass openings-roof-ratio: $SRR = 0.000$
- 4- Equivalent temperature difference of horizontal roof doors $T_{Deq-mai} = 30.06 \text{ K}$
- 5- U-value of each component of horizontal roof:

Roof component	U-Value ($\text{W}/(\text{m}^2\text{K})$)
1	1.498
2	1.498
3	1.498
4	1.498
5	2.264

Table 3.1: U-value of each component of horizontal roof

- 6- Average equivalent temperature difference upon surface of vertical wall of roof door neck:

$T_{Deq-tuong \text{ dung co cua mai}}: \text{N/A}$

- 7- Average U-value upon surface of vertical wall of roof door neck:

$U_{oTB-tuong \text{ dung co cua mai}}: \text{N/A}$

- 8- Average U-value of roof including roof door: $2.067 \text{ W}/(\text{m}^2\text{K})$
- 9- There is no roof door of single-glazed vertical glass
- 10- There is no roof door of double-glazed vertical glass
- 11- There is no horizontal or sloping single-glazed glass on roof and roof doors
- 12- There is no horizontal or sloping double-glazed glass on roof and roof doors

13- OTTV value of the whole roof (including roof doors): OTTV_m = 13.935 W/m²

CONCLUSION: The building has compliant OTTV_m to QCVN 09:2017/BXD.

Note: the allowed limit (25 W/m²) of OTTV_m is applied to the case when the roof has roof door(s) for receiving light. In case the roof does not have any roof door, the calculated OTTV_m is often less than the allowed limit. That is common, there is no need to adjust the roof structure if the load-carrying layers and the auxiliary layers stay within the technical limits which can not be reduced.

ANNEX

A. Drawings of 5 common shading structure types

- 1) *Long continuous horizontal shader at an distance d from the upper edge of the window, perpendicular to or at a sloping angle α to the wall;*

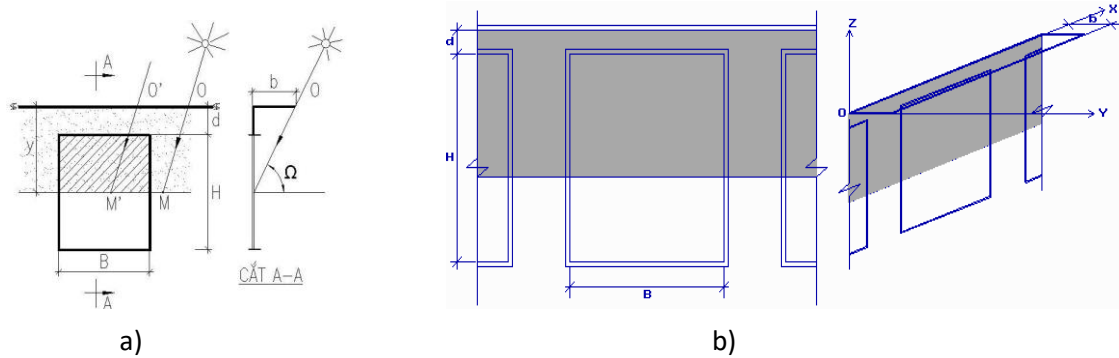


Figure 1 – Shader in form of horizontal, perpendicular to the wall, long continuous plate of width b , at an distance d from the upper edge of the window (from the upper glass edge of window)

a) Front view and side view drawings; b) Shadow on the window

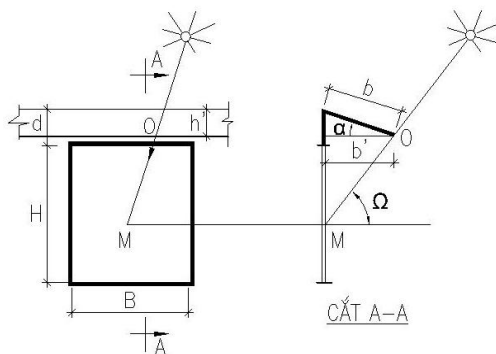


Figure 2 – Shader in form of horizontal, sloping at angle α , long continuous plate of width b , at a distance d from the upper edge of window (from the upper glass edge of the window)

2. *Limited length shader at a distance d from the upper edge of the window, perpendicular to or at a sloping angle α to the wall and exceeding the window by a margin e to both sides;*

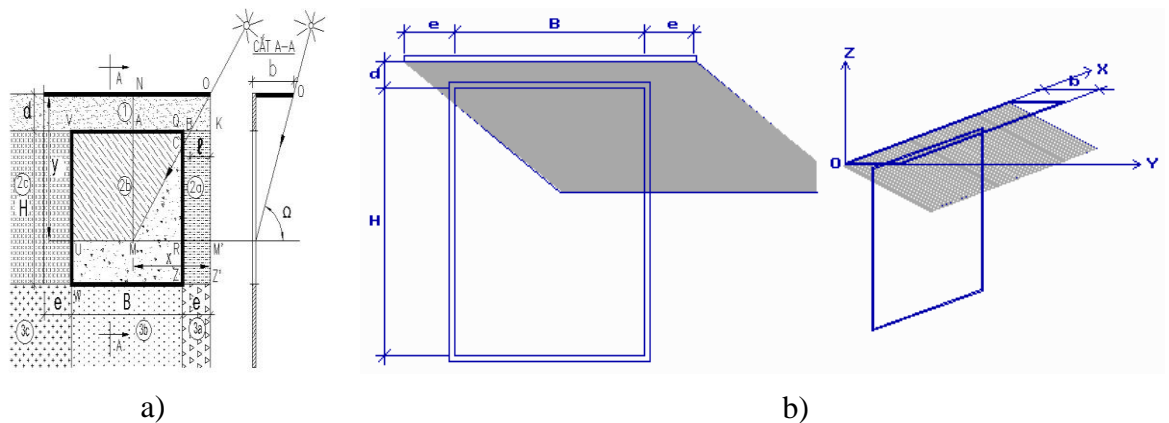


Figure 3 – Limited length shader of width b , at a distance d from the upper edge of window (from the upper glass edge of window) and exceeding the window by a margin e to both sides (from the glass side edges of window)

a) Front view and side view drawings; b) Shadow on the window

3. High continuous vertical shader at a distance e from the side edges of window and perpendicular to or at a sloping angle θ to the wall;

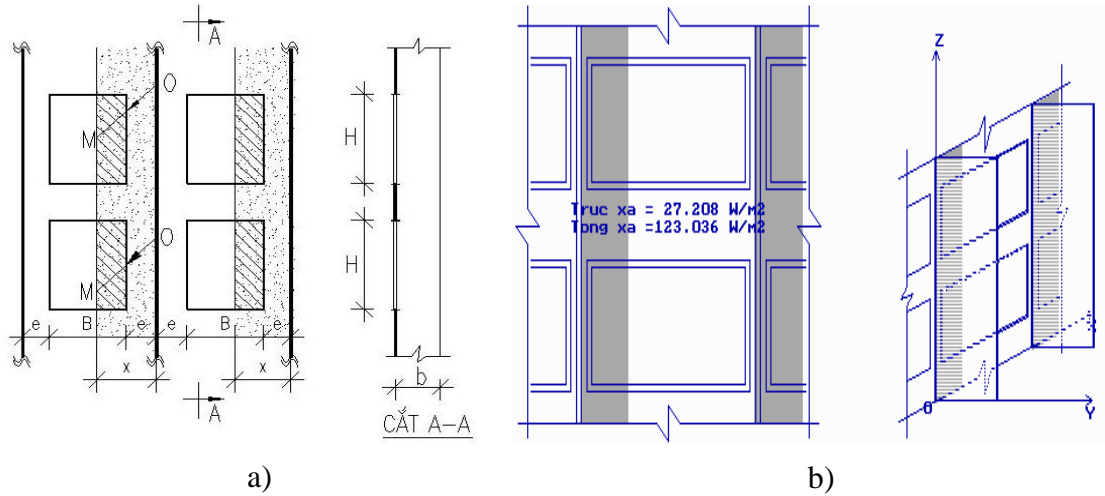


Figure 4 – Shader in form of high continuous vertical plate of width b , perpendicular to the wall and at a distance e from the side edges of window (from the glass side edges of the window)

a) Front view and side view drawings; b) Shadow on window

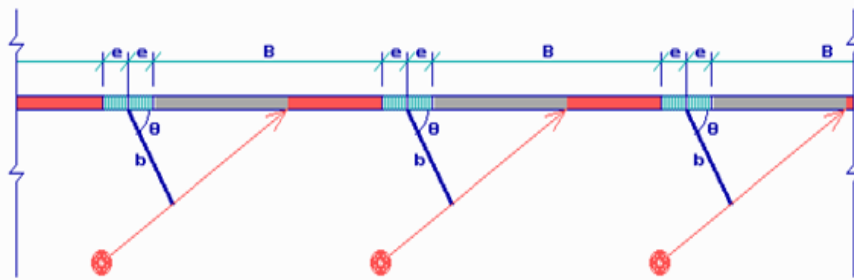
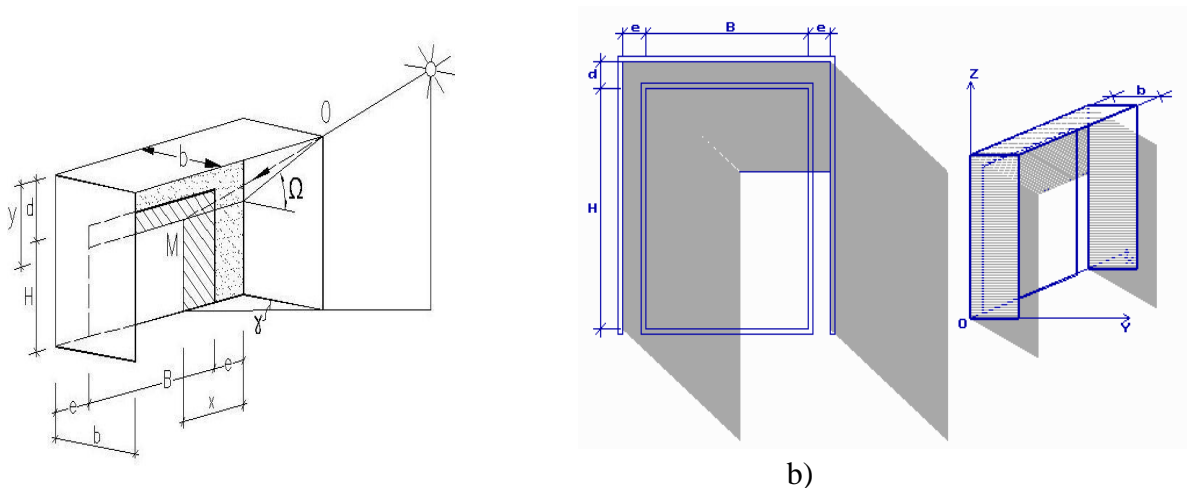


Figure 5 – High continuous vertical sloping shader of width b , at a sloping angle θ to the wall ($<90^\circ$; $=90^\circ$ or $>90^\circ$ degrees) and at a distance e from the side edge of the window

4. Egg-crate form shader consisting of horizontal or sloping plate at an angle α to the horizontal plane over the window and 2 vertical plates on both sides of the window. The vertical plates are at a distance e to the side edges of the window;



a)

Figure 6 – Egg-crate form shader of width b , at a distance d from the upper edge of window (from the upper glass edge of the window) and at a distance e from both side edges of window (from the glass side edges of the window)

a) 3D-view drawings from front view and side view; b) Shadow on the window

- 5) *L-form shader: similar to egg-crate form shader, but only with 1 vertical plate on the left or right of the window;*

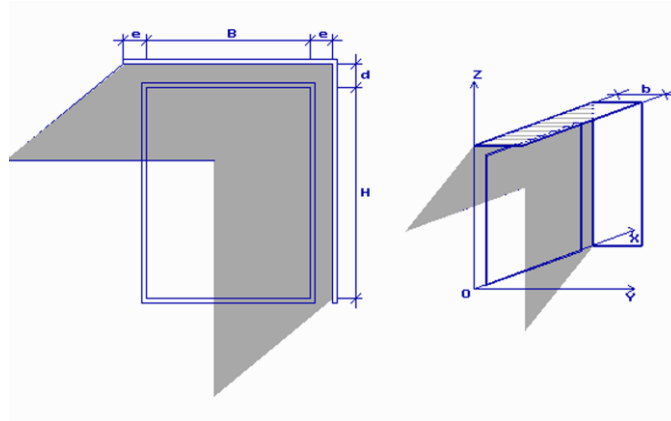


Figure 7 – L-form shader of width b , at a distance d from the upper edge of window (from the upper glass edge of the window) and at a distance e from the right or left edge of window (from the glass side edge of the window)

Note for figure 7: Similar to egg-crate form shader (figure 6), but with only 1 vertical plate on the left or right of the window (viewed from the outside).

B. Several shading structures in practice which applies the principle of the 5 common shading structure types

1. Long continuous structure

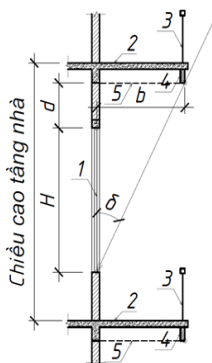


Figure 1a

The shading effect of side corridor with hung sunshades is equivalent to long continuous shader over the window. The calculation schemata for the equivalent long continuous shader to the side corridor are shown on Figure 1a. On this figure, the dashed line 5 would be the equivalent long continuous shader with width b measured from glass surface to lower edge of the sunshade 4 and d would be the distance from the upper edge of window to the equivalent shader. Thus the dimensions H , d , b and the skyview angle δ should be inputted into the program for calculation.

1- Window; 2- Side corridor; 3- Banister; 4- Hung sunshades on the edge of corridor; 5- Equivalent long continuous shader.

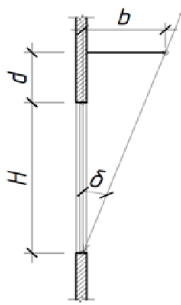


Figure 1b

Figure 1b: Long continuous shader over window with glass layer further behind the outside wall surface
- The width b of shader and the skyview angle δ are measured from the outside glass surface – see Figure 1b

2. Limited length shading structure

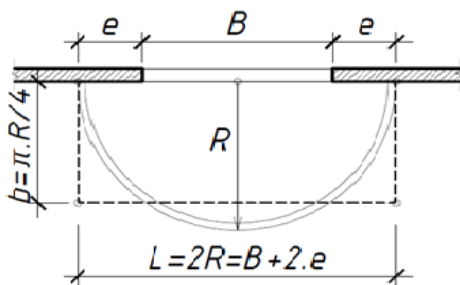


Figure 2

Limited length shading structure equivalent to the shading effect of semicircular balcony or lodge

Chú giải :

- If the balcony or lodge has the rectangular layout then it is considered as limited length shading structure.
- In case the balcony or lodge has not a rectangular layout but a curved layout, for example a semicircle, then replace the semicircle with a rectangular with the same area and the dimensions of the equivalent shading structure would be: width $b = \pi R/4$; length $L = 2R = B + 2e$ – see Figure 2

3. High continuous shading structure

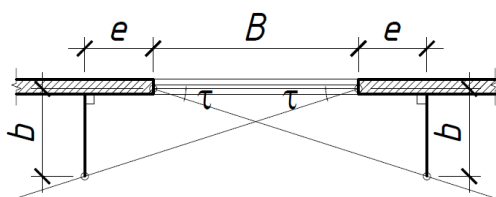


Figure 3- High continuous shader beside window with glass layer further behind the outside wall surface

- The width b of shader and the skyview angle τ are also measured from the outside glass surface – see Figure 3