Equations available for calculation:

OTTV Calculator consists of following equations for OTTV Calculation:

1. RETV India (2017): Composite Climate or Hot-dry Climate
(source: Energy Conservation Building Code for Residential Buildings in India - 2017)
$RETV = 6.11(1\text{-}WWR)U_{opaque} + 1.90(WWR)U_{non\text{-}opaque} + 70.94(WWR)SHGC_{equivalent}$

2. RETV India (2017): Warm-humid Climate
(source: Energy Conservation Building Code for Residential Buildings in India - 2017)
$RETV = 5.19(1\text{-}WWR)U_{opaque} + 1.34(WWR)U_{non\text{-}opaque} + 66.70(WWR)SHGC_{equivalent}$

3. RETV India (2017): Temperate Climate
(source: Energy Conservation Building Code for Residential Buildings in India - 2017)
$RETV = 5.27(1\text{-}WWR)U_{opaque} + 0.95(WWR)U_{non\text{-}opaque} + 78.92(WWR)SHGC_{equivalent}$

4. ETTV Singapore (2009)
(source: Energy performance of residential buildings in Singapore: K.J. Chua, S.K. Chou - 2009)
$ETTV = 3.4(1\text{-}WWR)U_w + 1.3(WWR)U_f + 58.6(WWR)(CF)(SC)$

5. ETTV Singapore (code)
(source - Code on Envelope Thermal Performance for Building: Singapore)
$ETTV = 12(1\text{-}WWR)U_w + 3.4(WWR)U_f + 211(WWR)(CF)(SC)$

6. RETV Singapore (code)
(source: Code on Envelope Thermal Performance for Building: Singapore)
$ETTV = 3.4(1\text{-}WWR)U_w + 1.3(WWR)U_f + 58.6(WWR)(CF)(SC)$

7. Hong Kong (1995)
(source: Parameterization Study of the Overall Thermal Transfer Value Equation for Buildings: Hong Kong, 1995)
$OTTV = 11.4(1\text{-}WWR)U_w + 2.6(WWR)U_f + 204.2(WWR)(CF)(SC)$

8. Malaysia (2007)
(source: Malaysia Standards MS1512:2007 Clause 5.2.2)
$ETTV = 15(alpha)(1\text{-}WWR)U_w + 6(WWR)U_f + 194(WWR)(CF)(SC)$

where:
WWR = Window to Wall ratio = $A_{non\text{-}opaque}/A_{envelope}$
$A_{non\text{-}opaque}$ = Window area (m^2)
$A_{envelope}$ = Facade area (m^2)
U_{opaque} = U-Value for walls (W/m^2-K)
$U_{non\text{-}opaque}$ = U-Value for windows (W/m^2-K)
$SHGC_{equivalent}$ = Shading coefficient
$U_w = U_{opaque}$
$U_f = U_{non\text{-}opaque}$
$SC = SHGC_{equivalent}$
CF = Correction factor
alpha = Solar absorption coefficient

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Conclusion

The work uses Overall Thermal Transfer Value (OTTV) as performance criteria other than Energy Performance Index (EPI). EPI shows the energy usage index of that building and lacks the ability to define which factors in the building are leading to higher energy consumption. Whereas OTTV directly talks about the thermal performance of the building envelope. It provides huge opportunity to experiment with wall and window construction, envelope design, WWR, building orientation, etc. to provide the most efficient building envelope with minimal cost. As part of the outcome of the task, an online tool is developed to calculate Overall Thermal Transfer Value (OTTV) based on various equations followed by different countries. [Link to the tool - https://carbse.shinyapps.io/ottv_india/]

For Further Information, contact

Ms. Asha Joshi
Centre for Advanced Research in
Building Science and Energy
CEPT University, K.L.Campus, Navarangpura
Ahmedabad 380 009, INDIA

Phone: +9179 2630 2470 Ext 383
Email: ashajoshi@cept.ac.in
Website: www.carbse.org

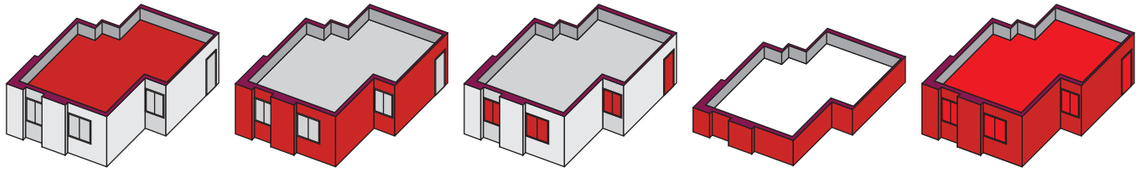
Optimizing Building Envelope for Energy Efficiency through

Overall Thermal Transfer Value (OTTV)

Background: India is moving towards adaptation of sustainable approaches for managing constantly increasing urban energy demand. Hence, there is need for good policies for achieving energy efficiency in Building Energy Sector, as it contributes to one third of the total energy consumption. Energy Performance Index (EPI) shows the energy usage index of a building and has been used as a key parameter for evaluation of buildingenergy efficiency.But at the same time, it lacks the ability to define which factors in the building cause higher energy consumption.This work tries to introduceOverall Thermal Transfer Value (OTTV) as performance criteria other than Energy Performance Index (EPI).OTTV directly talks about the thermal performance of the building envelope. It provides huge opportunity to play with wall construction and window material, building envelope design, Window Wall ratio (WWR), building orientation, etc. This helps designers in decision making while designing an energy and cost efficient building envelope. An online web based tool for calculation of OTTV, also known as OTTV Calculator, is developed as a part of this work.

OTTV

As all building typologies have certain potential for energy conservation, OTTV here plays significant role as a measure of control, to enhance energy efficiency of the building. OTTV is a measure of heat gain into the building through the building envelope. It also acts as an index for comparing the thermal performance of buildings. The concept of OTTV is based on the assumption that the envelope of a building is completely enclosed. OTTV comprises of two values: Envelope Thermal Transfer Value (ETTV) & Roof Thermal Transfer Value (RTTV). ETTV is measure of heat transfer through walls or building envelope. Whereas, RTTV is the measure of heat transfer through the roof of the building.



Principles of OTTV

As per the ASHRAE Standard 90-1975, the OTTV is calculated based on three major components:

a. Conduction through opaque wall, Q_{wc}.
b. Conduction through window glass, Q_{gc}. and
c. Solar radiation through window glass, Q_{gs}.

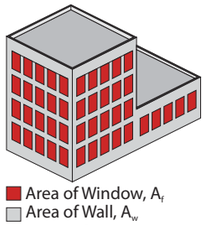
- The equation is as follows: $OTTV_w(ETTV) = \frac{Q_{wc} + Q_{gc} + Q_{gs}}{A}$

OTTV Calculation

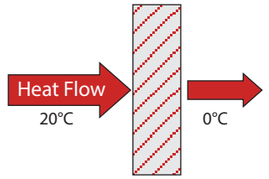
The following steps explain and determine the procedure to calculate OTTV for any building project.

Step 1: Envelope Area Calculation:

Building Envelope refers to the outermost layer of the building that separates external environment from internal environment of the building.



Step 1



Step 2

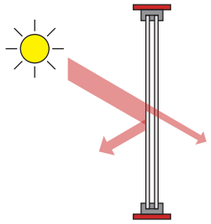
Step 2:U-Value Calculation

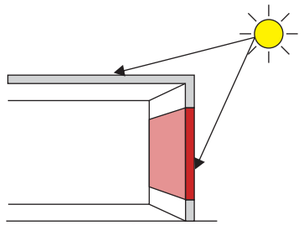
The Thermal Transmittance or U-Value of a construction is defined as the quantity of heat flow through a unit area of a building section under steady state conditions in unit time per unit temperature difference of the air on either side of the section.

Here the U-value is calculated using the CARBSE Tool: Assembly U-Factor Calculator
[It can be found at: http://www.carbse.org/resource/tools/]

Step 3: Shading Coefficient (SC)

It is the ratio of the solar heat gain through a particular type of glass under a specific set of conditions to the solar heat gain through that of double strength sheet clear glass under the same conditions. SC max = 1


Step 3


Step 4

This value again depends on the type of window glass used, it could be different from project to project.

Step 4: Solar Factor (SF)

The Solar Factor (SF) is the hourly radiation per square meter for the horizontal and vertical surfaces (W/m^2). This can be obtained from weather files available for different cities or different climate zones.

Step 5: ΔT, Difference in Temperature

It is the temperature difference between indoors and outdoors environment of the building.

Step 6: Equivalent Temperature Difference Tdeq

It is the temperature difference which results in total heat flow through a structure as caused by the combined effects of solar radiation and outdoor temperature.

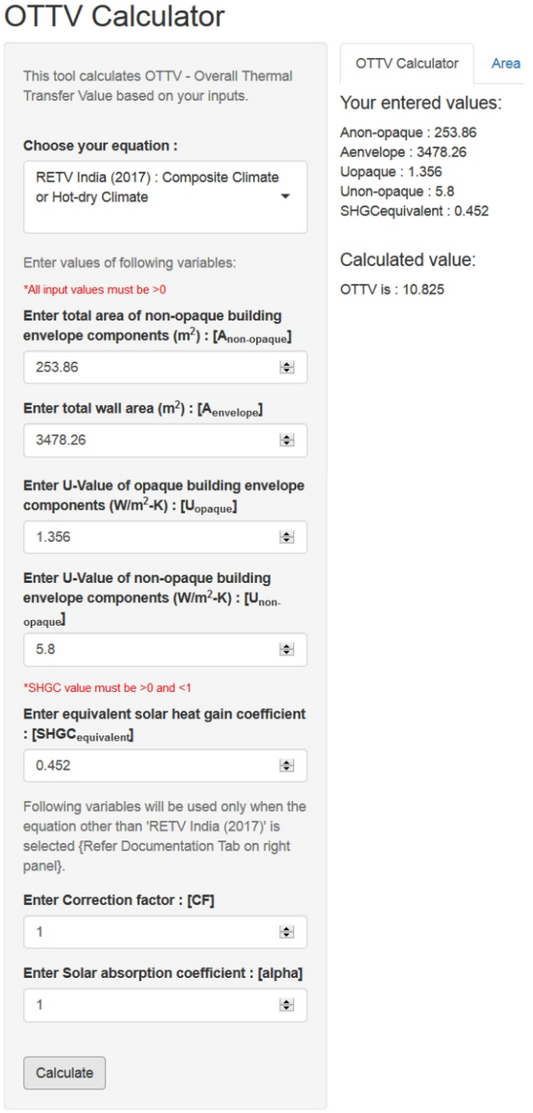
OTTV Tool

Centre for Advanced Research in Building Science and Energy (CARBSE) at CEPT University has developed a dynamic OTTV (Overall Thermal Transfer Value) Calculator to measure the heat gain into the building through the building envelope. This tool can also be used as an index for comparing the thermal performance of buildings.

The tool is based on following salient feature;

- It provides choices of equations for different countries like India, Singapore, Hong Kong and Malaysia. Detailed explanation has been mentioned in the Documentation Tab present on the right panel.
- It also provides provision to enter Correction Factor and Solar Absorption coefficient for selected equations.

The output page of OTTV Calculator shows relevant variables used to calculate OTTV value.



Screenshot of OTTV Calculator