Vol..2, Issue 12

ISSN:2349- 0012

I.F. 8.1

HEAT TRANSFER FROM A MULTILAYERED WALL

Olimjonova Dilrabo G‘ulomjon qizi

Andijan machine building institute

Annatation

Generally, the envelope of a structure is designed by architects to respond to many considerations including structural and aesthetic. Before the oil crisis of 1973, the energy efficiency of the envelope components was rarely considered as an important factor in the design of a building. However, standards and regulations have been developed and implemented to improve the energy efficiency of various components of building envelopes. For energy retrofit analysis, it is helpful to determine if the building was constructed or modified to meet certain energy efficiency standards. If it is the case, retrofitting of the building envelope may not be cost-effective especially for high-rise commercial buildings. However, improvements to the building envelope can be cost-effective if the building or industrial facility was built without any concern for energy efficiency such as the case with structures constructed with no insulation provided in the walls or roofs.

Key words: building envelope, roof, indoor, wall, cooling, heating

Where R_j = the *R*-value of each homogeneous layer part of the construction of the wall or roof assembly.

It includes the *R*-value due to convection at both inner and outer surfaces of the wall or roof obtained by Eq. (6.3).

*N*L = the number of layers (including the convection boundary layers) that are part of the wall or roof assembly. For instance, in the wall assembly presented in Figure 6.2, *N*L = 5 (3 conductive layers and 2 convective layers).

The overall *U*-value of the wall or roof can be defined simply as the inverse of the overall *R*-value:

$$U_T = \frac{1}{R_T}$$

It should be noted that practitioners usually prefer to use *R*-values rather than *U*-values inasmuch as the *U*-values are small especially when insulation is added to the wall or roof assembly. For doors and

windows, the use of *U*-values is more common because these components have low *R*-values.

From Eq. (6.1), it is clear that in order to reduce the heat transfer from the above-grade building envelope components, its *R*-value should be increased or its *U*-value decreased. To achieve this objective, thermal insulation can be added to the building envelope. In the next section, calculation methods

of the energy savings due to addition of insulation are presented to determine the cost-effectiveness of such a measure.

To characterize the total heat transmission of the entire building, a building load coefficient (BLC) is defined to account for all the above-grade building envelope components (roofs, walls, doors, and windows):

$$BLC = \sum_{i=1}^{N_E} A_i . U_{T,i} = \sum_{i=1}^{N_E} \frac{A_i}{R_{T,i}}$$

where *A*i is the area of each element of the above-grade building envelope including walls, roofs, windows, and doors.

Infiltration Heat Loss/Gain

Air can flow in or out of the building envelope through leaks. This process is often referred to as air infiltration or exfiltration. Thus, infiltration (and exfiltration) is rather an uncontrolled flow of air unlike ventilation (and exhaust) for which air is moved by mechanical systems. Generally, air infiltration occurs in all buildings but is more important for smaller buildings such as detached residential buildings. In

larger buildings, air infiltration is typically less significant for two reasons:

1. The volume over the envelope surface area (from which air leakage occurs) is small for larger buildings.

2. The indoor pressure is generally maintained higher than outdoor pressure by mechanical systems in larger buildings. Typically, infiltration is considered significant for low-rise buildings and can affect energy use, thermal comfort, and especially structural damage through rusting and rotting of the building envelope materials due to the humidity transported by infiltrating or exfiltrating air. Without direct measurement, it is difficult to estimate the leakage air flow through the building envelope. There are two basic measurement

techniques that allow estimation of the infiltration characteristics for a building. These measurement techniques include fan pressurization or depressurization techniques and tracer gas techniques.

Fan pressurization/depressurization techniques are commonly known as blower door tests and allow the estimation of the volumetric air flow rate variation with the pressure difference between the outdoors and indoors of a building. Several pressure-differential values are typically considered and a correlation

is found in the form of:

$$\dot{V} = C.\Delta P^{n}$$

where C and n are correlation coefficients determined by fitting the measured data of pressure differentials and air volumetric rates. Using the correlation of Eq. (6.7), an effective leakage area (ELA) can be determined as follows:

$$ELA = \dot{V}_{ref} \cdot \sqrt{\rho / 2.\Delta P}$$

Using English units, the effective leakage area (in inches squared) can be estimated using a modified Eq. (6.8a) as follows:

$$ELA = 0.186\dot{V}_{ref} \cdot \sqrt{\rho / 2.\Delta P}$$

where V_{ref} is the reference volume air rate through the building at a reference pressure difference (between indoors and outdoors) of typically 4 Pa and obtained by extrapolation from Eq. (6.7). The ELA provides an estimate of the equivalent area of holes in the building envelope through which air leaks can occur.

To determine the building air infiltration rate under normal climatic conditions (due to wind and temperature effects), the LBL infiltration model developed by Sherman and Grimsrud (1980) is commonly used:

$$\dot{V} = ELA.\left(f_s.\Delta T + f_w.v_w^2\right)^{1/2}$$

where ΔT is the indoor–outdoor temperature difference, vw is the period-average wind speed, and fs and fw are the stack and wind coefficients, respectively. Table 1 provides the crack coefficients for three levels of building heights. Table 2 lists the wind coefficients for various shielding classes and building heights. Blower door tests are still being used to find and repair leaks in low-rise buildings. Typically, the

leaks are found by holding a smoke source and watching where the smoke exits the house. Several weatherstripping methods are available to reduce air infiltration through the building envelope

TABLE 6.1 Stack Coefficient, f_s

	IP Units[a] House Height (Stories)			SI Units[b] House Height (Stories)		
	One	Two	Three	One	Two	Three
Stack Coefficient	0.0150	0.0299	0.0449	0.000139	0.000278	0.000417

Source: ASHRAE, *Handbook of Fundamentals*, Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2009.

[a] IP Units for f_s: $(ft^3/min)^2/in^4 \times °F$

[b] SI Units for f_s: $(L/sft)^2/cm^4 \times °C$

TABLE 6.2 Wind Coefficient, f_w

Shielding Class[c]	IP Units[a] House Height (Stories)			SI Units[b] House Height (Stories)		
	One	Two	Three	One	Two	Three
1	0.0119	0.0157	0.0184	0.000319	0.000420	0.000494
2	0.0092	0.0121	0.0143	0.000246	0.000325	0.000382
3	0.0065	0.0086	0.0101	0.000174	0.000231	0.000271
4	0.0039	0.0051	0.0060	0.000104	0.000137	0.000161
5	0.0012	0.0016	0.0018	0.000032	0.000042	0.000049

Source: ASHRAE, *Handbook of Fundamentals*, Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2009.

a IP Units for *f*w: (ft3/min)2/in4.mph

b SI Units for *f*w: (L/sft)2/cm4.(m/s)2

c Description of shielding classes: 1–no obstructions or local shielding; 2–light local shielding: few obstructions, few trees, or small shed; 3– moderate local shielding: some obstructions within two house height, thick hedge, solid fence, or one neighboring house; 4– heavy shielding:

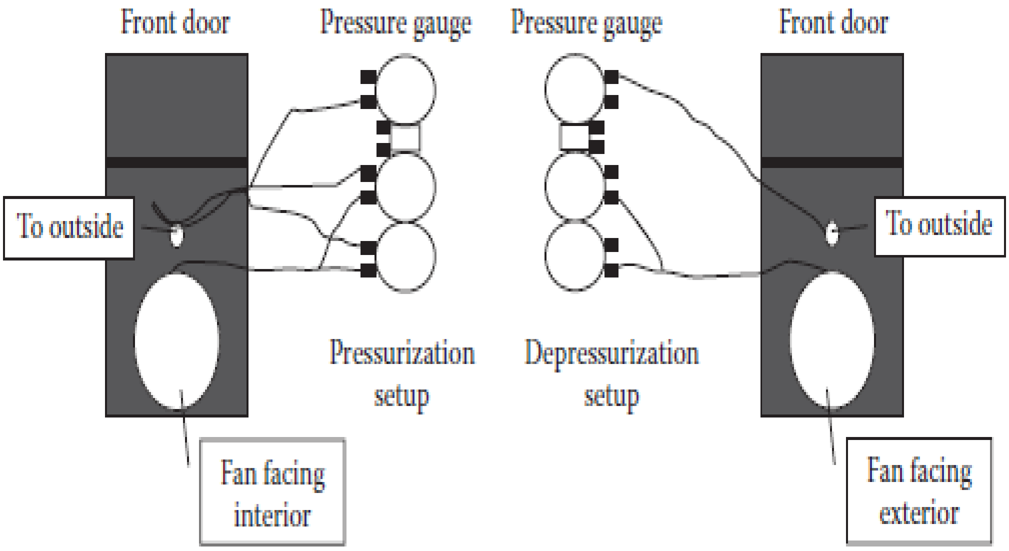
obstructions around most of perimeter, buildings or trees within 30 ft (10 m) in most directions; typical suburban shielding; 5–very heavy shielding: Large obstructions surrounding perimeter within two house heights; typical downtown shielding.

including caulking, weatherstripping, landscaping around the building to

ISSN:2349- 0012
I.F. 8.1

reduce the wind effects, and installing air barriers to tighten the building envelope.

It should be mentioned, however, that the blower door technique cannot be used to determine accurately the amount of fresh air supplied to the building through either infiltration or ventilation. For this purpose, it is recommended to use the tracer gas techniques described below. In a typical blower test, the house should first be prepared. In particular, windows are closed, interior doors that are normally open are kept open, and the fireplace ash is cleaned. The main entrance door is generally used to place the blower fan to either introduce air (for the pressurization test) or extract air (for the depressurization test). The airflow rate is generally measured using a pressure gauge attached to the blower setup. The pressure gauge should first be checked to make sure that it reads zero with the fan set to off. An additional pressure gauge is used to measure the differential in pressure between the inside and outside of the house. Figure 6.3 shows the setup for both the depressurization and pressurization tests. Example 6.1 illustrates how the results of blower door tests can be used to determine the infiltration rate in a house. The results and the analysis presented in Example 6.1 are based on actual tests performed by Azerbegi, Hunsberger, and Zhou (2000).



Typical blower door setup for both pressurization and depressurization tests.

Foundation Heat Transfer Calculations

The practice of insulating building foundations has become more common over the last few decades. However, the vast majority of existing residential buildings are not insulated. It was estimated that in 1985 less than 5 percent of the existing building stock had insulated foundations. Earth-contact heat transfer appears to be responsible for 1 to 3 quadrillion kJ of annual energy use in the United States.

This energy use is similar to the impact due to infiltration on annual cooling and heating loads in residential buildings (Claridge, 1988). In addition to the energy-saving potential, insulating building foundations can improve the thermal comfort especially for occupants of buildings with basements or earth-sheltered foundations.

Typically, the foundation heat transfer is a major part of heating/cooling loads for low-rise buildings including single-family dwellings, small commercial and institutional buildings, refrigerated structures, and large warehouses. A detailed discussion of the insulation configurations for various building types as well as various calculation techniques to estimate foundation heat transfer can be found in

Krarti (1999). In this section, only a simplified calculation method is provided for annual and seasonal foundation heat loss or gain from residential foundations.

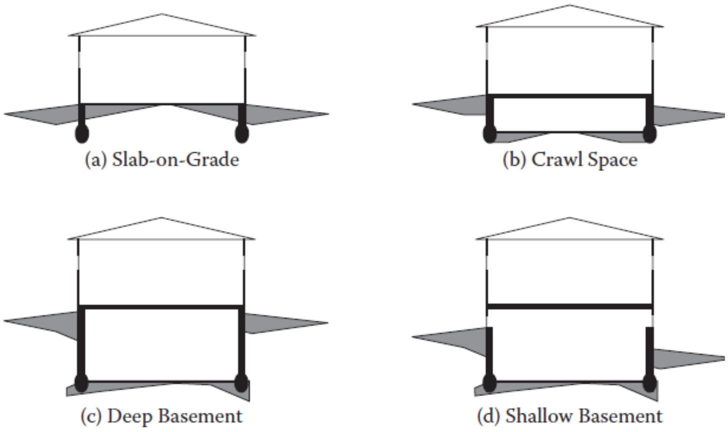
It should be noted that in the United States, there are three common foundation types for residential buildings: slab-on-grade floors, basements, and crawlspaces. The basement foundations can be either deep or shallow. Typically, shallow basements and crawlspaces are unconditioned spaces. Figure 9 shows the three common building foundation types. In some applications, the building foundation can include any combination of the three foundation types such as a basement with a slab-on grade floor.

Among the factors that affect the selection of the foundation type include the geographical location and the speculative real estate market.

A recent report from the U.S. Census Bureau indicates that the share of houses built with crawlspaces remained constant at about 20 percent over the last seven years (Krarti, 1999). However, the percentage of houses with slab foundations has increased from 38 percent in 1991 to 45 percent in 1997.

Meanwhile, the share of houses built with basements has declined from a peak of 42 percent in 1992 to

Building Envelope



Foundation types for the buildings.

37 percent in 1997. In 1993, houses were built with almost an equal number of basement and slab foundations.

Moreover, data from the U.S. Census Bureau clearly indicates that the foundation type selection depends on the geographical location. In the Northeast and Midwest regions, the basement foundation is the most common with a share of about 80 percent during the period between 1991 and 1997, whereas the slab foundation is more dominant in the South and the West.

Summary

Energy efficiency improvements of building envelope systems are generally expensive and are not costeffective especially for large commercial buildings. However, increasing the energy performance of a building shell can be justified for low-rise and small buildings based on energy cost savings but also based on improvement in indoor thermal comfort and integrity of the building structure. For residential buildings, weatherstripping to reduce infiltration losses is almost always economically justifiable.

References

1. H. *Monitoring Peak Power and Cooling Energy Savings of Shade Trees and White Surfaces in the Sacremento Municipal Utility District (SMUD) Service Area: Data Analysis, Simulations and Results*, LBNL Report # 34411, Berkeley, CA, 1993.

2. Akbari, H. and Sezgen, O. *Case Studies of Thermal Energy Storage (TES) Systems: Evaluation and Verification of System Performance.* LBL-30852. Lawrence Berkeley Laboratory, University of California, Energy and Environment Division. Berkeley, CA, 1992.

3. Air Conditioning and Refrigeration Institute, Standard 1060-2001, Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment, Arlington, VA., 2001.

4. *Proposed ASHRAE Guideline 14P, Measurement of Energy and Demand Savings*, Atlanta, GA:American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1997.

5. *ASHRAE Guideline 14, Measurement of Energy and Demand Savizngs*, Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2002.

6. Olimjonova, D., & Topvoldiyev, N. (2023). ANALYSIS OF HEAT STORAGE CAPACITY OF RESIDENTIAL BUILDINGS. Interpretation and Researches, 1(8).

7. Alijanov, D. D., & Axmadaliyev, U. A. (2021). APV Receiver In Automated Systems. The American Journal of Applied sciences.

8. Topvoldiyev, N. (2022). PHYSICAL AND TECHNICAL FU NDAMENTALS OF PHOTOELECTRIC SOLAR PANELS ENERGY. *Th eoretical & Applied Science*.

9. Topvoldiyev, N. (2023). *Quyosh havo isitish kollektorlarini o`rnatish va foydalaniz.*

10. ME Yulchiev, AAO Qodirov Electricity Quality And Power Consumption In Low Power (0.4 Kv) Networks, THE AMERICAN JOURNAL OF ENGINEERING AND TECHNOLOGY (TAJET) SJIF-5.32 DOI-10.37547/tajet

11. NM Aripov, OA Qosimov MODELS AND METHODS FOR INCREASING THE EFFICIENCY OF INNOVATIVE RESEARCH 2 …

12. Эгамов.Д, Боихонов. З, Узаков. Р статья Эффективность применения «Переносного АВР-0,4 кВ» для обеспечения бесперебойного электроснабжения потребителей. Конф. Гомель. Сексия «энергетика» 2020г.

13. ME Yulchiev, AAO Qodirov Electricity Quality And Power Consumption In Low Power (0.4 Kv) Networks, THE AMERICAN JOURNAL OF ENGINEERING AND TECHNOLOGY (TAJET) SJIF-5.32 DOI-10.37547/tajet

14. Zuhritdinov Alisher Faraxidin o'g'li, Yo'lchiyev Mash'albek Erkinovich, Xakimov Temurbek Bahodirjon o'g'li. (2023). STUDY OF TEMPERATURE DEPENDENCE OF LINEAR EXPANSION COEFFICIENT OF SOLID BODIES. INTERNATIONAL BULLETIN OF APPLIED SCIENCE AND TECHNOLOGY, 3(5), 888–893. https://doi.org/10.5281/zenodo.7969053

15. Sharobiddinov , S., & Mamarasulov, Q. (2023). QUYOSH HAVO ISITISH KOLLEKTORINI ENERGIYA SAMARADORLIGINI OSHIRISH. *Interpretation and Researches*, *1*(8). извлечено от https://interpretationandresearches.uz/index.php/iar/article/view/538