

ENERGY EFFICIENCY IN BUILDINGS:

THERMAL EFFICIENCY APPLIED TO BUILDING ENVELOPES

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1. Introduction

In view of the continuously increasing cost of electric energy, it is becoming more and more important to use electricity in the most efficient way. The commercial sector is responsible for 20% of the total electric energy consumption in the country. Over 55% of this consumption is being used for air conditioning [6]. An annual growth of about 8% is evident in this form of end-use. This increasing demand is to be met through construction of thermal (or nuclear in long term) power plants which imposes a heavy capital strain on the national economy in addition to the undesirable environmental effects [4].

Aim of this paper is to discuss the possibilities of conserving energy in the building sector through improved efficiency, by analyzing the building envelop.

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For this, a procedure is developed to define a performance index, to be incorporated in a more general code for buildings [5].

2. Energy Efficiency Policies

Energy efficiency policies applied to building sector branch out into the three main categories economic, informational and regulatory. The economic policies cover the taxes and tariffs while the informational policies guide the information flow through media and other forms to the designers, owners and the users of buildings. The regulatory policies direct the formulation and enforcement of codes and standards related to buildings. Though the first two categories are being effectively used in Sri Lanka, the third is not being used in its full extent. The building code presently being implemented by the Urban Development Authority (UDA) covers only the lighting and ventilation aspects leaving the thermal comfort and energy aspect completely untouched. However, air conditioners are widely being used in today's commercial sector partly due to psychological reasons.

Further, the existing code has not been successful in integrating the energy saving aspects into building design practices even in the areas of lighting and ventilation.

3. Role Of Building Code

A carefully formulated building code, appropriate to the local climate, makes energy efficient design and better environment adoption integral parts of the building architecture, improving comfort and enhancing the long term economic gains. Proper implementation of such building codes will avoid the practice of conceiving the building without incorporating climatic constraints. The errors committed in this practice are later patched up by the engineer by making use of highly energy intensive technical equipment.

The properly determined building code prevents the extra loads on air conditioning system which definitely leads to reductions in electricity consumption. To fulfill this requirement the standards incorporated shall,

1. set minimum requirements for the energy efficient design of new building so that they may be constructed, operated and maintained in a manner that minimizes use of energy without constraining the building function nor the comfort and productivity of the occupants,
2. provide criteria for energy efficient design and methods for determining compliance with these criteria, and
3. provide sound guidance for energy efficient design.

Currently, at least forty countries have some form of existing voluntary or mandatory standards for energy use in new buildings, and six more countries have standards on their legislative drawing boards. Countries with existing building energy standards such as Sweden, are increasing their technical stringency while

others are making legal status stronger. Many countries without energy standards that could support their development [1].

4. Performance Index Of A Building

The performance index of a building is defined as the area weighted average rate of overall thermal transfer from the external environment into the conditional space of the building through the envelop. Four different modes of heat transfer can be identified. They are 1) through opaque walls, 2) through fenestration, 3) through roof and floor and 4) due to air migration. Contributions made by all these modes can be separately calculated.

Heat transfer through opaque walls

This is basically the conduction heat transfer through the walls due to the temperature difference across them. The heat flow rate Q_1 is given by $Q_1 = UA(T_e - T_n)$ where U , A , T_e and T_n are thermal conductance per unit area of the wall, total cross sectional area of the wall, equivalent external temperature and Neutral temperature respectively.

Heat transfer through Fenestration

Heat transfer through fenestration system consists of two parts:

1. Conduction heat transfer due to temperature difference across the glass,
2. Radiation heat transfer through glass.

Hence the amount of heat transfer rate through fenestration Q_2 can be expressed as $Q_2 = A_r U_r * T + A_r S_f S_c$ where A_r , U_r , $*T$, S_f and S_c are area of fenestration system, thermal conductance of glass, temperature difference across glass, solar radiation fall on one square meter of the plane and shading coefficient respectively.

Shading coefficient of the fenestration system is the combined shading effect produced by the self shading effect of glass (given by the shading coefficient S_{c1}) and by the shading effect of external shading devices (given by the shading coefficient S_{c2}). The coefficient S_{c1} is to be specified by the manufacturer of glass whereas the coefficient S_{c2} depends on the type of sun shading devices used [3]. There are three basic types of such devices commonly used in buildings. The effect of each type of fenestration system which correspond to size shape position and orientation has been calculated and tabulated.

Heat transfer through roof and floor

The roofs and floors of most commercial buildings are concrete slabs. Thermal performance of these are very similar to that of the walls and thus can be calculated using the same method.

Heat transfer due to air migration

The heat transfer caused by migration of air through the doors and windows of a building depends mainly on the frequency and duration of the openings of them. Thus this is considered to be less important for evaluation of the performance of the structure and is not incorporated in the performance index.

The overall performance index is obtained by summing up all the heat transfers contributed by the first three modes and then taking the average per unit area.

References

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