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Building Envelope for Green Buildings- An Overview of Codal Provisions

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ABSTRACT

Buildings are responsible for more energy use and CO2 emission, than any other sector, including transportation. Recent efforts world over is to achieve improved energy performance of buildings and finally to achieve net-zero energy. In India, Bureau of Energy Efficiency (BEE) have published the energy conservation building code (ECBC), which among others addresses the requirements of energy efficiency in buildings envelope. In this paper, an overview of ECBC for building envelope have been highlighted. Further, the research direction needed in India in the area of energy-efficiency in buildings is also highlighted.

KEYWORDS: Energy conservation building code, energy efficiency, zero energy, cool roofs, envelope.

I. introduction

Energy is used in buildings for a variety of purposes and it is reported that energy used in buildings is responsible for more than 40% of energy consumption and green-house gas (GHG) emissions in European Union (EU) only. It is also reported that the above emissions could be reduced up to 80%, by comparably simple measures, like better insulation of different components of the existing building stock etc. Realizing the importance of energy conservation, India has come up with comprehensive guidelines in energy-conservation in buildings in 2007 in the form of Energy Conservation Building code (ECBC). The above code defines the norms and standards for energy performance of buildings and their components, based on five climatic zones recognized in India and specified in the National Building Code of India (NBC-2005). One of the aspects that are dealt in Energy conservation Building code (ECBC) is the guidelines on building envelope. The design features of the building envelope among other things affect the energy consumption in the building. Energy-efficiency in buildings should be addressed comprehensively from the planning, design to the execution of buildings. It is therefore necessary to understand the ECBC stipulations, so that energy- efficient buildings can be designed and the existing buildings can be evaluated for their energy -efficiency. Hence, in this paper, an overview of ECBC codal provisions of 'building envelope' have been presented. Further, certain recent trends in well developed countries for the study of energy-efficiency in buildings and the research direction needed in this area have been highlighted.

II. ENERGY EFFICIENCY OF BUILDING ENVELOPE

A. ECBC Guidelines for Buildings

Government of India (GOI) with a view to achieve energy efficiency especially in buildings, has launched the 'energy conservation building code (ECBC). It defines norms and standards for achieving 'energy conservation in buildings and their various components' based on the climatic zones in which they are located. In India, five climatic zones, have been recognized, according to National Building Code of India (2005), namely: hot-dry; warm-humid; composite, temperate and cold, as per the weather conditions.

ECBC considers the following aspects of buildings: (a) building envelopes (except for unconditioned storage spaces or ware houses); (b) mechanical systems and equipment, including: heating, ventilation & air conditioning (HVAC); (c) service hot water heating; (d) interior and exterior lighting and (e) electrical power and motors.

B. ECBC guidelines on building envelope

'Building envelope' refers to the exterior facade, and it comprises of: walls, windows, roof, skylights, doors and other openings. The envelope protects the building's interior and occupants from the weather conditions and other external elements. The design features of the envelope strongly affect the visual and thermal comfort of the occupants, as well as the energy consumption in buildings. The thermal comfort requirements in buildings and their physical manifestations in architectural form are different for each climatic zone. Hence ECBC has prescribed the comfort requirements and physical manifestations in buildings for each climatic zone, separately.

ECBC has set requirements referred as prescriptive requirements for envelope component- based compliance to: (i) exterior roofs and ceilings; (ii) cool roofs; (iii) opaque walls; (iv) vertical fenestration and (v) skylights.

In roofs, the U-factor (thermal conductance) for all assemblies or minimum R-values (ie, thermal resistance) for all the five climatic zones (of India) are prescribed for 24 hours use buildings and daytime use buildings [Table.1]. Exterior roofs can meet the prescriptive requirements by: (i) using insulation with the required R-value (ii) using a roof assembly that meets the maximum U-factor criterion for thermal performance as prescribed in ECBC. The U-factor takes into account all elements or layers in the construction assembly, including the sheathing, interior finishes and air gaps, as well as exterior and interior air films. Various techniques to insulate different types of roofing systems can be adopted. However it is recommended that they are installed according to manufacturer's recommendations and in a manner that will achieve the rated insulation R-value.

Table 1: Roof Assembly U-Factor and Insulation R-Value Requirement

Climate Zone	24-Hour use buildings Hospitals, Hotels, Call Centers etc.		Daytime use buildings other Building Types	
	Maximum U-factor of the overall assembly (W/m^2K)	Minimum R-value of insulation alone (m^2K/W)	Maximum U-factor of the overall assembly (W/m^2K)	Minimum R-value of insulation alone (m^2K/W)
Composite	U-0.261	R-3.5	U-0.409	R-2.1
Hot and Dry	U-0.261	R-3.5	U-0.409	R-2.1
Warm and Humid	U-0.261	R-3.5	U-0.409	R-2.1
Moderate	U-0.409	R-2.1	U-0.409	R-2.1
Cold	U-0.261	R-3.5	U-0.409	R-2.1

'Cool roofs' are roofs that are covered with a reflective coating that has a high emissivity property that is very effective in reflecting the sun's energy away from the roof surface. These 'cool roofs' are known to stay 10oC to 16oC cooler than a 'normal roof' under hot summer. This quality greatly reduces the heat gain inside the building and the cooling load that needs to be met by HVAC systems. Further, they can cut maintenance costs and increase the life-expectancy of the roof. In India, lime coats, white tiles grouted with white cement, special paints are used as

cool roofing materials. Currently, in India, THERMATEK-a private company manufactures and markets a variety of thermal insulation products. ECBC has prescribed the requirements of minimum solar reflectance and initial emittance levels for designing cool roofs. 'Opaque walls' can meet the prescriptive requirements of ECBC by either using a construction that has an assembly U-factor lower than the specified value or by using insulation with R- value (for insulation above) more than the prescribed value. 'Fenestration' system include windows, skylight (ie a fenestration surface having a slope of less than 60 degrees from the horizontal plane), ventilators, and doors that are more than one-half glazed. All fenestration other than skylights are called 'vertical fenestration'. ECBC limits the area of vertical fenestration under the prescriptive approach, to a maximum of 60% of the gross wall area. Losses through fenestration is specified in ECBC by the two requirements, namely : (i) maximum U-factor (or thermal transmittance, which is the relative ability of a material to radiate the absorbed heat) and (ii) maximum SHGC (solar heat gain coefficient- which is the preferred specification for solar heat gain through fenestration products and shall be determined in accordance with ISO-15099) for the following window-to-wall ratio (WWR) ie upto 40% and more than 40% and up to 60%. WWR is defined as the ratio of vertical fenestration area to gross exterior wall area. ECBC prescribes the U-factor and SHGC requirements for two WWR ranges for rated fenestration.

A fenestration product is comprised of three areas: the vision area, the glazing, and the opaque area or the frame. In a window, as glazing occupies a very large area (say 90-95% of total area), it is most important part to address for achieving energy efficiency. There are a large number of glazing products that are available from different manufactures complying with ECBC requirements for fenestrations. ECBC stipulates that the 'Skylight' area is limited to a maximum of 5 % of gross roof area and the maximum U-factor and maximum SHGC requirements have also been stipulated

C. Buildings Envelope Sealing

'Air leakage' is the passage of air through a building envelope. Leakage, to the interior is referred to as 'infiltration' and leakage to the exterior is referred to as ex-filtration'. Excessive air movement significantly reduces the thermal integrity and performance of the envelope and is, therefore, a major contributor to energy consumption in a building. In addition to energy loss, excessive air leakage can cause condensations to form within and on walls and this can create many problems including reduction in R-value of insulation, permanent damage to insulation and serious degradation of materials. Building sealing is more important in air-conditioned buildings, then, in naturally-ventilated buildings.

ECBC has identified several areas in the building envelope, where attention should be paid to infiltration control, which include: (i) joints around fenestration and door frames; (ii) opening at penetrations of utility services through roofs, walls and floors; (iii) site-built fenestration and doors; (iv) building assemblies used as ducts; (v) all other openings in the building envelope.

III. studies on Energy performance: National Vs International

Concerted efforts have been taken in well developed countries like, USA and in European Union (EU) to assess the energy performance of buildings (in USA) and the large-scale savings that could result from insulating residential buildings (in EU). The results indicate that the energy performance occur during the planning, design and construction phases of buildings projects. Further, behavior issues impact decisions made by stakeholders in building industry. Energy-retrofit and various incentive schemes have been suggested so that the existing building stock can be made energy-efficient and future building stock be made energy-efficient.

In India, such studies are rare. However they are required and important, in the context of India's energy-deficient/energy-starved condition in the decades ahead

IV. Concluding remarks

Several measures are suggested in ECBC to achieve energy-efficiency in buildings and to satisfy the requirements of 'green buildings'. Energy efficiency in buildings can be achieved only by addressing various codal requirements right from planning and design and right through the construction phases of building projects. It is necessary that energy-efficiency of various commercial and public buildings in India are assessed and wherever necessary energy-retrofit' be carried out, so that India will be able to avoid huge 'energy-deficits'/energy-starvation in the coming decades.

REFERENCES

[1] Bureau of Energy Efficiency, Govt. of India, 'Energy Conservation Building Code (ECBC)', user guide, July 2009.