Say yes to energy-efficient windows

Windows are an integral part of buildings, providing view, light and ventilation. But windows and other glazed openings have become one of the biggest causes of energy inefficiency, especially in air-conditioned buildings, since they are the weakest thermal links and result in unwanted heat gain and losses.

Introduction

The term 'window' originated from its ability to provide a room access to 'wind' (air). In old and medieval architecture windows were just small openings in the wall to allow daylight and fresh outside air inside the room. These openings were suitably closed when necessary.

As time passed, windows acquired a broader meaning. After innumerable innovative designs, they now provide a very effective link of the internal space of a building to the outside world while maintaining the necessary barrier and privacy that a building needs. Today, windows are often glazed (covered with glass). Conventional glazings, however, provide only a minimum level of thermal resistance.

In India, air-conditioned (AC) buildings are fairly energy-intensive and account for substantial parts of the annual energy consumption. Already large conglomerates of such buildings in many cities have made it difficult to manage utility peak demand.

Glass being partially transparent (typically 80 to 85%) allows in the near ultraviolet, visible and near infrared regions that compose the solar spectrum (seen graph on pg 7). But glass is practically opaque to longer wave thermal radiation. These characteristics can conveniently be used to heat the building interior during winter with available solar energy and also have adequate daylight. However, this may also result in overheating of the building during summer. To minimize unwanted heat gains and losses through windows and to avoid glare of daylight, normally some controlling devices are used. Traditional window control systems that are often used include:

- Interior shading devices such as shades, drapes, blinds, etc
- Fixed exterior shading devices such as overheating, fins, etc
- Operable exterior sun control devices such operable fins, louvers, shade systems, etc

However, operable options are rarely used in an energy-efficient manner. Also, these obstruct the outside view and do not allow the daylight to come in. as a result, even during daytime artificial lighting is used inside AC buildings. The artificial lighting systems not only consume energy but also contribute to the cooling load of the building. The lighting used in many such buildings are often not energy efficient.

Efforts to improve the energy efficiency of glazings have resulted in a number of new products. These glazings help minimize unwanted solar gains in summer as well as heat losses in winter while maximizing the amount of useful daylight in buildings. In addition, the new glazing system can drastically reduce the entry of damaging UV radiation and, being air tight, result in lower noise transmission.

Energy-efficient glazings

- Insulating glazings
- Solar control glazings
  - Heat absorbing glazings
  - Heat reflecting glazings
- Low-e glazings
- Smart windows

Ordinary windows have a single glass pane. It is possible to construct a window using two or three glass panes. These panes are held apart by spacer bars, and air cavity contains a desiccant material to remove any trace of moisture. These windows, with multiple glazing (glasses), provide a heat barrier through insulating air cavity between the glass layers and are known as insulating glass units (IGUs). Such windows are available in the market and can be very useful in reducing heat gains or

losses. The usefulness of such a glazing in a particular climate can be judged by examining the figures of merit of glazing (see Table 1).

Table 1: The figures of merit of a glazing

Visible transmittance (VT)	The fraction of visible light incident on the glazing that transmits to the interior. This decides the entry of daylight and cutting down the need for artificial light.
Solar heat gain factor (F)	The portion of directly transmitted and absorbed solar energy that enters into the interior of the building. This causes heat input to the building.
Shading co-efficient (SC)	Describes the ability of glazing to transmit solar heat gain relative to the solar heat gain of a 3 mm clear single glass pane. The lower the SC, less is the solar heat gain.
Coolness factor (CF)	It is the ratio of the visible transmittance to the shading co-efficient of a glazing. A value more than 1 offers a better choice in hot climate.
Window U value	Measure of thermal conductivity, expressed in Watt / sq.m.K. Lower the U value better is the thermal resistance of the glazing.

Solar control glazings: these glazings can modulate the entry of solar heat and light into buildings, and are one of the earlier developments toward energy efficiency and thermal comfort. In recent times, combinations of new material and coating processes have contributed to the development of unique products. In these techniques, solar control is achieved either by an absorptive process or by a reflective process.

Heat absorbing glazings: these are essentially the tinted glasses produced as admixture of metallic oxides in their composition. Due to their wavelength filtering properties, which can vary according to the quantity of the dopant and the thickness used, these glazings can substantially reduce the glare and excessive sunlight to enter into the building. The solar radiation is absorbed, however, raises the temperature of the glazing, which in turn radiates the thermal energy. This secondary emission contributes significantly to the heat gain in the building. This undesirable effect can be eliminated / reduced by adding an inner clear glazing (ordinary glass) with the heat absorbing glazing. As the clear glass is opaque to long wave radiation, it would prevent the heat radiation to flow to the interior of the building. Also, the inner space between the two glasses would act as an insulating space offering resistance to heat conducting from the outside.

Heat reflecting glazings: the reflecting glazings have thin coating of pure metal-like gold, silver or bronze on one side of the double glazings of the window unit. The manufacture of these glazings is done by coating a thin metallic reflective layer on the surface of the float glass as it leaves the glass furnace. These glazings can considerably diminish the transfer of solar radiation (both heat and glare) in a hot climate. The sealed double glass unit provides thermal resistance.

Energy and light control characteristics are uniquely demonstrated by low-e (low emissivity) type of optical coatings. These optical coatings are normally applied to glass or plastic glazing materials. In order to understand the role of these optical coatings, we may consider two typical climate types – cold and warm. In cold climates, an ideal window must be responsive to daylight and solar heat, so it might be transparent to the entire incident solar spectrum from 290 nm to 3,000 nm. Also, the window, in this climate, must offer maximum resistance to thermal radiation from inside the room. This would facilitate using all the solar energy available to heat the room and at the same time out allowing any heat to come out from the room. In warm climate, a window with glazing must prevent infrared portion (770 nm to 3,000 nm) of the solar spectrum to enter into the building. This is because any entry of the heat to the building is undesirable but at the same time it must allow the visible light to come in so that the daylight would be available through the window. These coatings essentially reduce the radiative heat transfer either from the outside from the building to the inside (in hot climate) or from the inside of the building to the outside (in cold climate) because of their low emissivity property. These glasses are comparatively new developments. However, they have already captured more than one-third of the market of glazing business in Japan, USA and Europe. The performance characteristics of a few typical glazings mentioned are given in Table 2.

Table 2: Performance characteristic of a few typical glazings

Type of Glazing	SC	VT	CF	U(W/sq m K)
Single glazing (clear glass)	1.00	0.91	0.91	6.46
Double glazing	0.82	0.78	0.95	3.31
Heat reflecting with plastic	0.56	0.74	1.32	2.50
Tinted glass (Green)	0.72	0.75	1.04	6.45
Tinted glass (Green) + clear glass	0.58	0.66	1.14	3.37
Low-e coating with glass	0.67	0.74	1.10	1.94
Low-e double glazing	0.85	0.78	0.92	2.27

In temperate climates, the necessity of heating and cooling of a building varies with seasons. Therefore, the property of the window glazings must be dynamic rather than static. Ongoing global research is trying to devise a window which would automatically respond to the climate of the place. Such windows are known as smart windows. Essentially, these are chromogenic devices. Activation of chromogenic material is possible both electrically and non-electrically. Non-electrically activated types include devices based on photochromic and thermochromic materials. As suggested by their names, these devices are activated by light heat respectively. The optical properties of these devices vary from a high transmittance colored state depending on the input signal. The optical properties of the glazings based on electrochromic devices change when an electric field is applied. These changes are reversible, can happen again and again based on the input signal. The elctrochromic glazings hold the greatest potential for future commercial applications.

Conclusion

With use of suitable energy-efficient glazings (EEGs), windows can be transformed from energy liability to energy assets. It has been estimated that with diminished unwanted heat gains and reduced air-conditioning loads, a one square meter of EEG in a commercial buildings can save roughly 70 units (kWh) of electricity per year. Thus, both the future and the existing stock of AC buildings in India represent a potential area of energy conservation through EEGs alone. The energy efficiency results in concomitant reduction of net environmental emission. This includes reduction of net environment emissions of greenhouse gases and acid rain precursors because of reduced energy consumption, and slowing down of ozone layer depletion and global warming due to use of a lower amount of chlorofluorocarbons. These glazings are expensive compared to the conventional glazings. But, for a new construction, the use of such glazings would reduce the installed air-conditioning capacity and thereby related investment. Further, reduced annual energy consumption due to the use of these glazings will pay back the investment.
Already in many countries, the EEGs are used extensively. In India, too, EEGs are now being used in some buildings. Increasing use of EEGs in our country will be step forward to green buildings movement.

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Reference Book:

The Bulletin on Energy Efficiency
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