Need for Energy Efficiency in the Building Sector

While the construction industry is vital to the achievement of national socio-economic development goals including development of human settlement, it can also contribute to the degradation of the environment. All the more reason why energy efficient buildings and energy efficiency as an integral part of architecture, engineering and the construction process are imperative

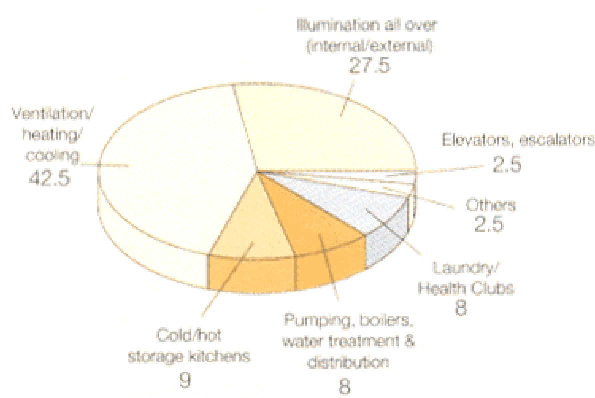
NIFT Campus, Hyderabad

The household sector is the largest consumer of energy in India, accounting for 40-50 per cent of the total energy consumption in the country. In rural areas, the residential (domestic sector) accounts for nearly 80 per cent of the consumption of energy. It has been estimated that at the present rate, India would require over 450 million tones of coal, 94 million tones of oil and 220 million units of electricity by 2006 to maintain its energy needs, most of which consist of non-renewable resources, and one in effect unsustainable.

Of the household consumption, some 27.5 per cent on an average is utilised for illumination and 42.5 per cent for ventilation/cooling/heating in residential buildings, which varies according to conditions such as seasons, latitude, etc.

Household Energy Consumption

(in percentage)



Source: Deodhar: Energy conscious concepts, 1997.

As much as 40 per cent of the energy used for heating, cooling and illumination of buildings and provision of hot water and other building services could be saved by switching over to solar technology without compromising on the comfort levels of its occupants. It this were achieved in Delhi (with savings of 30-40 per cent), an additional two lakh people could be provided electricity for domestic use.

To begin with, buildings can definitely become energy-efficient.

Need for Energy-efficient Design

Inappropriate design, materials and construction practices lead to the "sick building syndrome," invisibly affecting the health of millions. Production of building materials such as asbestos and crusher units in quarries also impact on health besides polluting air, water and land. Construction activities adversely affect the environment through physical disruption, depletion of key renewable resources such as fertile topsoil, forest cover and excessive consumption of energy. There is, therefore, a strong need to adopt cost effective, environmentally appropriate technologies and upgrade traditional techniques and local materials.

Building materials account for about 60 per cent of basic inputs. Of the total costs of a dwelling, cement (18 per cent), bricks (17 per cent), timber (13 per cent) and steel (10 per cent) account for a significant portion, consequently resulting in construction costs between Rs. 4,000 and Rs. 6,000 per sqm even for standard housing, Operation and maintenance (O & M) expenses over the years add up to more than actual construction cost, thus making it imperative to adopt cost-effective materials and technologies to tide over the shortage of housing in the country.

However, while large-scale and inefficient production of building materials, and added costs of transportation, result in higher end costs for the consumer, production and use of appropriate building materials have not received adequate attention and are often discouraged by outdated attitudes and unrealistic building codes and regulations.

Gaining Energy Efficiency in Buildings

There are enough environmental reasons to reduce the energy "embodied" in buildings. A high proportion of this energy is used to produce a small number of key materials such as concrete, mortar, plaster and bricks. The highest energy is used in the manufacture of aluminum, copper, stainless steel and plastics (primary energy requirements for production very from 250 Giga Joules (GJ)/ ton to 100 GJ/ton) followed by glass, cement and plaster boards (primary energy requirements for production vary from 60GJ/ton to 10GJ/ton). The energy embodied in a building is estimated to vary between 15 and 20 years of its energy consumption in use.

Research and Development on New Building Materials and Technologies

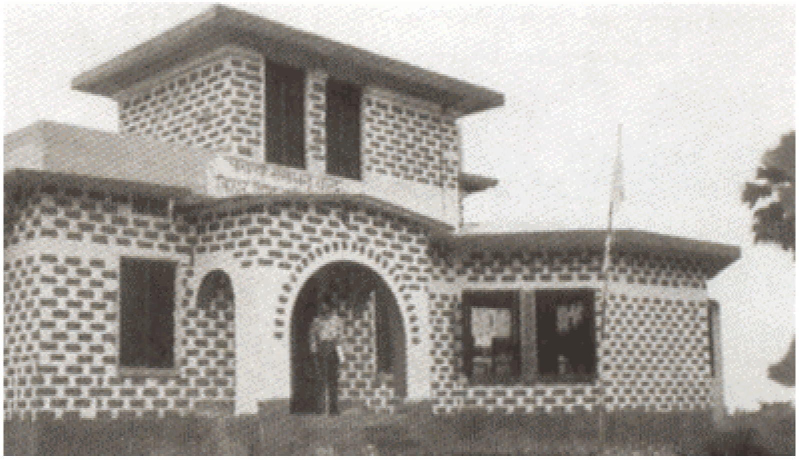
Major R & D institutions such as the Central Building Research Institute (CBRI), Structural Engineering Research Centre (SERC), etc, have developed a number of new alternative building materials and techniques. These efforts offer a variety of technological options for planning, design, materials and construction aspects for varying geo-climatic situations. Some of the significant achievements are:

- Classification of building materials based on comparative assessment of their properties
- Improvements in the performance of conventional building materials and techniques
- Development of energy-efficient manufacturing processes by using renewable raw material resources of wastes and by-products of industry, agriculture and forestry
- Structural design criteria for load categorization and for foundation, walls and roofs; designs against earthquake and high wind forces and other natural hazards
- Improved foundation engineering techniques and practices
- Formulation of user requirements with reference to lighting. Ventilation and thermal comfort

- Fire safety measure required in buildings and performance assessment of materials under fire
- Low-cost sanitation, sewerage disposal systems
- Use of energy-efficient building materials and construction system

Building Materials from Agro-Industrial Wastes

The production of conventional building materials such as cement, bricks and steel consume a lot of thermal and electrical energy. Besides, a substantial quantum of energy or electrical power is consumed while transporting conventional building materials and installing them on site. Need for sophisticated equipment and skilled manpower lead to higher investments, thus rendering the efforts unsustainable in the long run.



Reducing total energy use in built environment: Tips for designers and architects

(a) By reducing use of energy intensive materials; optimising thickness of walls; choice of finishes; heights of storeys, etc;

(b) By replacing energy-intensive materials with low-energy alternatives wherever available, such as:

- Lime-pozzolana mortars in place of conventional cement mortars
- Sun-dried brocks, stabilized-soil blocks or sand-lime bricks instead of kiln fired bricks
- Light-weighht, aerated, concrete blocks instead of dense concrete blocks
- Effective utilisation of waste materials such as gypsum-based plasters instead of cement-based plasters

(c) By selecting lower-energy structural systems such as load-brearing masonry with due diligence in place of reinforced concrete or steel frames; using pure compression-based structural systems such as arches an vaults instead of composite tensile elements

(d) By limiting construction to low-rise buildings sensitive to the location, topography, land-use, population density and ambient environment in place of high-rise buildings

(e) By selection, wherever possible, waste ro recycled materias, or products incorporating such materials; for example
Portland pozzolana cements using flyash (pfa) or blast-furnace slag asphalt roofing sheets incorporating recycled paper building boards and panels for roofing and walling from agricultural waste second-hand or reclaimed building materials.

(f) By designing for longer life and adaptability to varying functional requirements

(g) Using materials with a potential for recycling; optimising the use of reinforced concrete

(h) Designing for the use of materials locally available to reduce transportation costs

On the other hand, the disposal of a variety of industrial wastes such as coal ash from thermal plants, phosphogypsum from fertilizer factories, red-mud from aluminium plants, lime-sludge from quarries and slang from steel industries was creating greater problems. These bye products of industrial processes were generally used for dumping and insensitive landfill, creating rampant pollution of land, air and water and causing substantial damage to the environment.

India offers a wide variety and choice of locally available materials and construction practices in its different regions. However, due to shortage of traditional building materials, especially to urban dwellers, the energy required for production, and the impact on environment by outdated production processes, the Government of India took initiatives so that energy-efficient and environment-friendly building materials, components and construction techniques are promoted.

Fired clay brick making, for example, has been banned since July 1997 in Delhi as none of the 300 brick kilns could control their emission levels. This encouraged the brck manufacturers to switch over to making flyash bricks. The National Housing and Habitat Policy also made it possible for a number of waste-based materials and components to become popular, and entrepreneurial efforts are being made to establish production units in different states.

Appropriate Region Specific Design Solutions

Besides appropriate and energy-efficient building materials and technologies, the overall design must consider and optimise space configurations. While fulfilling functional requirements, the design must simultaneously respond to the climate, topography, hydro-geological conditions and socio-cultural perceptions.

Solar passive architecture, a subset of bio-climatic designing, must be resurrected. In ancient civilizations, for example, climatological factors were considered before deciding location of settlements and their design, Buildings in the hilly regions, especially the lower Himalayas, amply demonstrate the principles of traditional bio-climatic architecture, in which the orientation of the dwellings maximised solar gain during cold climates. Two-stroreyed structures, with a fireplace for shelter for livestock on the lower floors, ensured space heating in the upper floors. Thicker walls with minimal fenestrations in the hot arid climate, as against ample ventilation through jalis (lattices) and larger openings strategically located to maximise airflow within the building in warm humid climates, demonstrate traditional wisdom in energy efficient design. These ideas need to be relooked at, coupled with new technological advancements now available in lighting, heating, ventilation and air-conditioning.

Towards a New Dimension in Building Sciences

The need for energy efficiency in the building sector could be summarised on the following scores:

- Improved comfort conditions
- Long term economic gains
- Optimal resource use
- Enhanced environmental quality
- Better ecologic adaptation
- Environmental sustainability

It is imperative to produced innovative building materials and take recourse to alternative technology, considering the short supply of material, increasing cost and, energy and environment issues. Substantial emphasis must be given on producing and applying appropriate materials and technologies that encourage recycling of industrial and agricultural waste. Professionals in the construction business and the media have equal responsibility in changing the mindset of the people towards the use of strong, functional, durable, aesthetic, cost-effective, eco-sensitive, environment-friendly and energy-efficient building materials and technology. A series of institutional support mechanism for land, finance, regulatory media, marketing support, testing support and awareness creation would be needed; some of the existing initiatives will have to be substantially strengthened, for instance, entrepreneurship.

It is high time we ushered in an era of "Neo Architecture" to add a new dimension to energy use in the building sector based on the principles of sustainability. Going beyond superficially decorating facades with "green idioms", it will reflect this character by using appropriate building materials, technologies and techniques, non-conventional energy systems and region specific design solutions. It is time to remember Winston Churchill who said: "We shape our buildings and thereafter our buildings shape us". The true pursuit can go a long way in contributing to the vision of a sustainable world system.

Vivekananda Kendra, Kanyakumari

Other than solar water heating and solar cooking, solar energy can be used for a number or other applications such can be used for a number of other applications such as air heating, drying, desalination of water, cooling, etc. Emerging technologies based on solar energy include:

- **Building-integrated photovoltaics (BIPV):** Photovoltaics (PVs) are being particularly preferred for their distributed nature of technology on the ample surface area available; produce power at the point of use at retail rates, and usually at peak demand times.

  Homes and commercial buildings provide substantial surface area, allowing system designers and integrators to displace the cost and losses inherent in power transmission and distribution. There are thousands of square kilometers of available surface area on buildings with the proper orientation and solar access both in rural and urban areas where this technology could be extensively adopted.
- **Harnessing sunlight through fibre optics:** A bunch of optical fibres and a solar concentrator can be used for illuminating offices, multi-storeyed buildings, commercial complexes and residential buildings. The concentrator allows in concentrated sunlight, which is then cooled and thrown on an optical fibre bunch. The natural light emerges from the other end to illuminate interiors. The system will greatly benefit offices since a typical office uses about 50 per cent of its day time in internal illumination while residential buildings use only five per cent.

  In housing and urban development projects, designs based on principles of resource optimization, recycling and reuse, and minimal wastage should be adopted, coupled with environmental sustainability as a key parameter. Land use should also be considered at the design level. Low-rise high-density development and cluster planning have been accepted as successful design models for achieving high densities and promoting acceptable socio-cultural life styles of inhabitants without high-rise constructions.

Most human settlements of the present day expend considerable amount of energy in sourcing and conveying water Hence, diligent and optimal use is warranted through water conservation, rain water harvesting, and waste water recycling integrated into housing and urban development designs.

Courtesy: V. Suresh, Chairman & Managing Director,
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