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BUILDING ENERGY: BANGLADESH PERSPECTIVE

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Abstract- *Energy demand is becoming an important factor for building design as this sector is one of the most energy consumed area. According to Bangladesh Power Development Board (BPDB), approximately 48% of total electricity is consumed by domestic households and approximately 10% by commercial users in Bangladesh. Being situated in hot climate, considerable level of energy is used for cooling purpose. Electricity demand goes on peak during March-September as this is the warmest season. Temperature goes beyond 40°C, cooling system, for example air coolers becomes inevitable, in apartments and commercial buildings to provide comfort artificially. In addition, lighting and ventilation also consumes a considerable energy. Building design considering proper energy can play a vital role in energy consumption. Different insulation techniques and salient design features can reduce the energy consumption in buildings. This paper aims to review these improved design features, existing insulation techniques considering similar climate areas. Radiant Barrier Technique can be handy in increasing the indoor comfort by controlling indoor temperature and thus consume less energy for cooling and lighting purpose. The paper will also evaluate their effect on domestic and commercial electricity demand.*

Keywords: Building energy, Green building, Building insulation, Radiant barrier

1. INTRODUCTION

Much awareness is growing throughout the world on impact of building in relation with energy and environment for the last few decades [1]. It is now well established that building is not just a place for accommodation, it has vast influence on its inhabitants and utility component (e.g. power). Developed countries are moving towards energy efficient building. However, in developing countries for example Bangladesh, buildings are designed without considering the climate in most cases. Features such as site location and geological condition, choice of building material, architectural consideration are often ignored which results in adverse indoor climate, consequently consuming more energy for lighting and cooling purpose. With current building technology it is possible to construct buildings that consume 25% of energy in compare to traditional building. In United States this 75% reduction in consumption of energy results in 25-35% reduction in total national energy use [2]. In developing countries the major reason for not adopting energy consideration in building design is the initial cost. In reality considerable population don't have adequate shelter, therefore, let alone an energy efficient home. Moreover, lack of accessible proper solution is another reason of not practicing the energy efficient building concept. It is evident that housing sector is one of the fast growing sectors in Bangladesh and which will much influence the power consumption in buildings. Importantly there are some existing facilities which are not very costly and are sustainable which can lessen the energy consumption in apartments and offices.

2. ENERGY IN BUILDING

Energy is related to building throughout its life from the very beginning of material production to the service life by the user. It can be classified into three categories;

1) Embodied energy.
2) Energy for transportation of material.
3) Energy for living purpose of the inhabitants.

The embodied energy of a building material is the total amount of primary energy that is required for the production of that material. This energy is principally related to production. This can also be counted for energy efficiency and savings in the industry. Energy for transportation is the amount of energy demanded by a raw material for transportation produced by burning of fuel. This energy requirement is related to various disciplines. This study does not overview the former two forms of energy rather deals with the third form; the energy consumed by the inhabitants throughout the service life of the structure. It can be consumed for cooling, heating and lighting purpose. Being situated in a tropical-monsoon climatic zone, buildings in Bangladesh generally do not count for energy for heating. Different

data sources used in this paper are not from similar climatic zone, but provides researched and reliable results.

2.1 Bangladesh Power Demand Overview

It's been long chase for Bangladesh to achieve self-dependence in the power sector. Though the production has increased but it was never able to neither face the growing demand fully nor even close to it. Power demand is mainly dependent to the domestic sector. The yearly consumption of different sectors is shown in the Fig. 1.

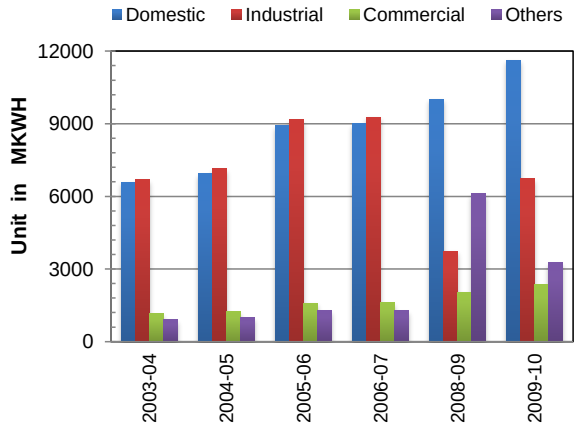

Fig.1: Electricity consumption in different sector [3]

Fig.1 shows that the domestic electricity demand is increasing rapidly with time. Growth of housing sector and increase in living standard will always accelerate the domestic electricity demand. Another important indication is that the commercial electricity demand is also increasing considerably due to excessive increase in use of Air conditioner and other artificial lighting equipment.

3. ENERGY EFFICIENT TECHNOLOGY

With the development of technology there has developed numerous techniques to keep building energy efficient. In hot climate zone the major source of heat energy is solar radiation from the sun. It can enter building through the windows, doors, walls and roof. The solar energy heats the building shell to a higher temperature throughout the day and also after the sunset by radiating the heat gained in the walls and roof during the day. This heat gain from radiation can be reduced by several insulation techniques for example heat reflective paint and coatings, radiant barriers, light colored roofing (cool roof). In addition the green roof system is widely tested and praised. Other techniques such as adequate shading from sun (passive design) simultaneously help in reduction of energy for artificial lighting.

3.1 Material Selection: Eco-friendly Material

One simple technique that can be widely applied in Building construction to compensate energy consumption is the choice of construction material. Considering a building that is constructed by using natural materials all through; designed to minimize heat gain during summer also provided with passive design to facilitate natural ventilation and maximize fresh air flow, such building will pave the way towards energy efficiency in the domestic and commercial sector. When this type of building reaches its lifetime or being demolished they will degrade in the soil making the soil more fertile. In this context such eco-friendly materials can be termed as materials that increase energy efficiency of building as well as reduce the impact on human being and surrounding environment. The techniques and application depends on some factor is shown in Fig. 2 [4]. Eco friendly materials are related to various components of building as follows.

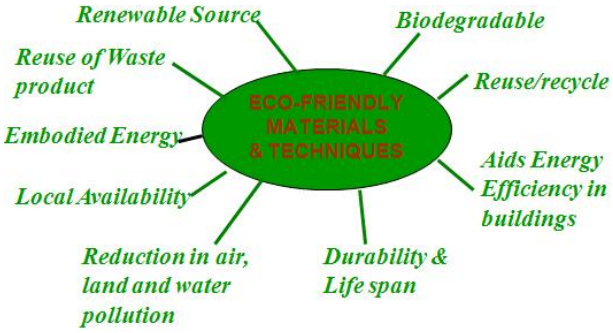

Fig.2: Eco-friendly materials facts [4]

In lieu of conventional cement, Pozzolana materials like fly ash, slag and calcinated clay materials could be used. Hollow or bricks produced from waste and byproducts like fly ash bricks and bricks from rice husk ash are such. Use of precast concrete blocks, panels that require less embodied energy. Primary energy required by some common materials is given in Table 1 [1].

Table 1: Primary energy requirement of different construction materials.

Materials	Primary energy requirement (GJ/ton)
Cement	5-8
Steel	30-60
Precast Concrete Blocks	1.5-8
Fly Ash Materials	<0.5
Clay Bricks and Tiles	2-7

In case of paints, low VOC paints should be used like cement paints for interior surface. Thus the right choice for construction of different components of buildings has to be made.

3.2 Cool Roof and Cool Color Technology

Cool roof and cool color technique is based on the principal of reflecting the solar radiation. Cool roof could save up to 15% annual air conditioning energy of a single story building [5]. Not only in Bangladesh but also throughout the world most of the roofs are dark colored. These roof (roofing surface material) absorb sunlight heavily consequently transmitting the hit in to building and thus increasing the indoor temperature. This might

help keeping buildings warm in a cold climatic zone. Light color e.g. white or other modified cool colored roof comparatively absorb less sunlight. This improves the indoor condition by lowering the temperature and requires less use of cooling systems. These cool roofs can be applied for new building roof alongside it can be applied for existing roofs for traditional roof material.

Fig.3: White colored Cool Roof in USA [5]

Some cool roof products used worldwide are elastomeric coatings, thermoplastic membrane, clay tile, concrete tile etc. The large scale benefit of cool roofing is that, it not only improves the building comfortness envelop but also increases the surrounding environment. For a large scale application in an urban city it will help in reducing Urban Heat Island effect [5]. Studies have shown that the reduction in this Urban Heat Island can reduce 20% energy demand for cooling purpose [6].

Though the concept of the light color is old one but the application of cool color is a recent development. These cool colors do not differ from standard colors aesthetically, but near the infrared range it got higher solar reflectance. Infrared is the component of sunlight carries maximum amount of sun's total energy. The main reason for this higher solar reflectance is the Infrared Blocking Pigments (IrBPs).A coating made of these pigments will have higher solar reflectance in compare to a coating made of conventional pigments. In US the study of US DOE [7] found 6-13% net annual energy savings using IrBPs coating. The saving depends on various factors such as climate condition, net solar heating on the location throughout the years, humidity, wind condition and other geological condition.

In Bangladesh the temperature during winter doesn't go beyond freezing and no heating energy is usually provided. Consequently no heating penalty requires for cool walls or roof in the winter. Therefore saving can be even more in case of Bangladesh. To evaluate solar reflectance of cool colors as well as cool roofs, several test methods are provided by ASTM. One of them is ASTM C1549, standard test method for "Determination of solar reflectance near ambient temperature using a portable solar reflectometer" [8]. Also the ASTM C1371, standard test method for "Determination of emittance of materials near room temperature using portable emissometers" [9] can provide valuable information.

3.3 Green Building and Green Roof Technology

Green Building is a technology paving the way to sustainability and creating environmentally sound building. Saving energy through this technology has also been under research. Moreover the technique can improve the indoor and outdoor surrounding air qualities in urban cities. Green roof, component of a green building technology sometimes used as an individual technology for energy efficient building. Alongside energy saving and sustainability it also help in storm water management and also in reducing CO_2 emission. Green roof decrease heat gain from sun about 70-90% in the summer and also reduce heat loss about 10-30% in the winter [10]. In a nutshell these techniques are utilized for natural resources to reduce the use of artificial resources. Depending upon features adopted and proper implementation it consumes 40-60% less energy than conventional buildings [11].

Fig.4: Green roof at Etherland [10]

The green building and roof generally consist of a layer of vegetation that covers the buildings outside periphery partially. Figure 5 shows idea of green technology could be adopted in a green building. The basic components and relevant design consideration for green buildings that generate energy from natural resources are as follows:

1) Installation of solar panel on roof top counts for efficient energy generation in high solar radiating zone like Bangladesh. This would be appreciable to use in high and low rise commercial buildings and apartment;

2) Installation of mini wind turbines on roof top and on walls will contribute to energy generation from natural resources;

3) Structural consideration for green roof is to be recognized. Usually additional weight for soil and vegetation in roof is about 15-30 psf [12].

4) Arrangement for collecting storm water from green roof system is to be provided. Therefore in the design of roof slab, the condition of full saturation of water should be considered.

5) Architectural consideration is to be made for proper orientation of the house for lighting and free

air entrainment. Additionally Architect has to make the building design such that the installation of these systems doesn't disturb the visual appearance of the building.

Researches on green building and energy efficiency are being carried out over the world. There is a subcommittee of ASTM E06.71 [14] on sustainability of green roof. This committee has developed several standards relating to green roof. Key contributions are as follows;

•ASTM E2396-11 [15]

•ASTM E2397-11 [16]

•ASTM E2398-11 [17]

•ASTM E2399-11[18] and

•ASTM E2400-06 [19].

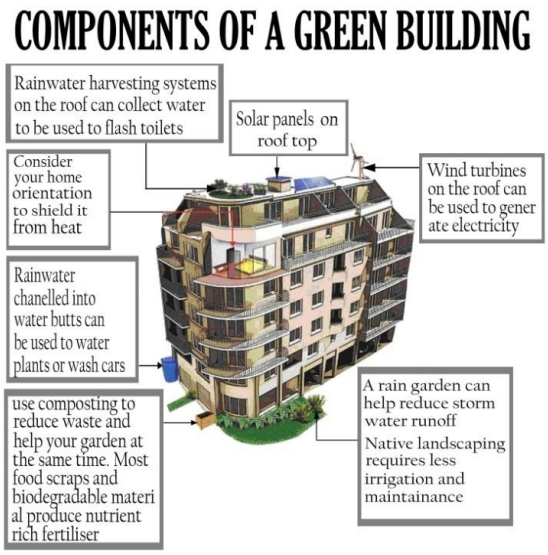

Fig.5: Schematic diagram of a green building [13]

3.4 Radiant Barriers

Radiant Barriers is a reflective insulation technique. It is generally a sheet made of Kraft paper, cardboard, plywood and air filtration material covered on one or both side by highly reflective material (e.g. aluminium). The emittance of the reflective material should be not more than 0.1 (ASTM C1313) [20].

Fig.6: Radiant barriers product (Louisiana Pacific) [21]

In commercial buildings RBs are attached in space between the suspended ceiling (provided for decorative purpose) and the roof. In residential building it is attached in attic space. The technique is capable of reducing sun's heat flow by 23-45% [20]. Though it doesn't represent direct saving in energy as ceiling heat gain represent 15-25% of the total cooling loads, therefore it can be accounted for 6-20% saving in cooling loads [20]. ASTM test methods available for RBs are as follows:

1) ASTM C1313/C1313M – 13 [22],

2) ASTM C1743-12 [23], and

3) ASTM C1744-12 [24]

4. CONCLUDING REMARKS

Self-reliance in energy sector is a cherished desire and controlling building energy can be a key part in achieving this for Bangladesh. Though initial investment for installation of the proper system is considerable, in course of time this will be recovered in terms of saving in energy. This will then contribute to the nationwide energy savings when applied in large scale for apartments and commercial buildings.

Finally for proper implementation Standard guidelines are required to put in Bangladesh National Building Code (BNBC). Engineers, Architects and the Owner will be interested only when these technologies will be available with proper guideline. This could be developed in collaboration with relevant authorities carrying out researches and implementing these technologies in different countries. For instance "American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)"; is such an organization that working on industrial buildings. For residential and commercial buildings ASTM guidelines and standards cited above will be helpful. Only then these technologies will be available in the market and consequently can be adopted on large scale on building sector. These will then contribute in building energy efficiency nationwide and proper energy management.

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6. NOMENCLATURE

Symbol	Meaning	Description
U.S.	United States	
DoE	Department of Energy	
IrBPs	Infrared Blocking Pigments	
ASTM	American Society for Testing And Materials	
FTA	Federal Technology Alert	
RBs	Radiant Barriers	
CO_2	Carbon DI Oxide	
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers	The society and its member focus on Building Systems, Energy Efficiency, Indoor Air Quality, Refrigeration and Sustainability within the Industry.
ORNL	OAK Ridge National Laboratory	A multi programmed Science and Technology Laboratory managed for U.S. Department of Energy by UT-Battelle, LLC.
BNBC	Bangladesh National Building Code	Building construction regulations for Bangladesh
BBS	Bangladesh Bureau of Statistics	
VOC	Volatile Organic Compound	