International Journal of Civil Engineering (IJCE)
ISSN: 2278-9987
Vol.1, Issue 1 Aug 2012 93-101

REVIEW OF BUILT ENVIRONMENT IMPACTS ON CLIMATE CHANGE, DESIGN STRATEGIES FOR REDUCTION

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ABSTRACT

As stated by United Nations Human Settlements Programme (UN-Habitat) in its "Global report on Human Settlements 2011", humanity is facing a very dangerous threat when the world enters the second decade in the new millennium. Fuelled by two powerful human-induced forces that have been unleashed by development and manipulation of the environment in the industrial age, the effects of urbanization and climate change are converging in dangerous ways which threaten to have unprecedented negative impacts upon quality of life, and economic and social stability. This statement clearly indicates the seriousness of the issue which was created by the excessive use of fossil fuels with dangerous consequences starting from rising of Sea levels to melting of glaciers causing disturbing effects on the human kind globally. Urban centers are the drivers of this situation emitting major part of Greenhouse Gases (GHG). In India, Construction industry has a very important role in its economy contributing on an average 6.5% of the GDP and it has direct impact on the environment with its consumption of energy both directly and embodied energy in the materials that it uses. Large amounts of energy is used for the production of the building materials in the construction phase and also to create the comfort conditions inside the buildings during the life cycle. The average annual electricity consumption for space conditioning and lighting in India is around 80 KWh/m2 and 160 KWh/m2 for residential and commercial buildings respectively. Buildings which are naturally ventilated by using passive design strategies, traditional building technologies/elements make a sound investments than those depending on the use of energy consumption to create human comfort.

KEYWORDS: Built Environment, Climate Change, Thermal Comfort

INTRODUCTION

Climate change is recognized both as a threat and a challenge. The impact of human activities on climate and climate systems is unequivocal. Climate has a significant role in the economic development of India as many sectors of the country are climate sensitive. Climate change has origins in anthropogenic activities and is engaging the attention of planners, governments, and politicians worldwide. It is no longer a scientific question as to whether the climate is changing, but the question is the timing and magnitude of Climate Change. The governments of the countries across the world are busy in working out the impacts and associated Vulnerabilities of their economies to impending projected climate change. In India, the potential climate change impacts are as follows:

1. Meteorological records indicate rise in the mean annual surface air temperature by 0.4°C with not much variations in absolute rainfall.
2. The tide gauge observations in the last four decades across the coast of India also indicate a rise in sea level at the rate of 1.06-1.25 mm/year.
3. Some preliminary assessments point towards a warmer climate in the future over India, with temperatures projected to rise by 2-4oC by 2050s.
4. Spatial pattern of the rainfall are likely to change, with rise in number and intensity of extreme rainfall events though there may not be any change in total quantity of rainfall expected.
5. The sea level is also projected to rise with cyclonic activities set to increase significantly with warmer oceans.

The continuous warming and the changing rainfall pattern over the Indian region may jeopardize India's development by adversely impacting the natural Resources such as water forests, coastal zones, and mountains on which more than 70% of the rural population is dependent. The physiographic features and the geographic location, which control the climate of the country, bestows it with great wealth of its natural resources, surface and ground water availability, forestry and vegetation. The region abounds in very rich collection of flora and fauna, and some of these locations exhibit a high degree of species endemism and constitute biodiversity hotspots of the world. There is an ever increasing recognition of the need for national level assessments which provides an opportunity to enhance our knowledge and understanding about the implication of both the current climate variability as well as the projected adverse impacts of climate change.

The main drivers of the GHG emissions in urban centres are

- Industries
- Built Environment
- Infrastructure
- Transportation

Only the buildings alone produce approximately 50% of the GHG emissions including from the manufacture of building materials and products, transport of construction materials.

The estimate of resources used in buildings Globally and World pollution attributed to Buildings are as follows

Resource	%
Energy	45-50
Water	50
Materials for Buildings& Roads	60
Agriculture land loss	80
Timber products	60
Coral reef destruction	50
Rain forest destruction	25

Pollution	%
Air quality in cities	23
Climate change gases	50
Water pollution	40
Land fill waste	50
Ozone depletion	50

(The Impacts of Construction and Built Environment,2010, Willmott Dixon)

The IPCC Fourth report also reiterates the necessity of taking appropriate efforts to bring down carbon emissions from the buildings sector. In its comparative study of the energy savings potential of the building sector with that of other economic sectors, it is observed that the building sector has the greatest potential among all sectors, in all countries, and at all cost levels. This holds true for India as well given the high growth rate in construction industry. The exponential increase in energy demand will be exacerbated further by the fact that buildings usually have a life above 50 years which will increase the pollution further.

GREEN HOUSE GAS EMISSIONS FROM INDIA

The per capita emissions is increased to 1.51T in 2010 from 0.7T in 1990,(Global CO2 emissions from fossil fuel use and cement production per region,1990-2010). Though our contribution is small when compared to rich Countries like US,EU and Japan, as a developing nation these numbers will raise in coming years with 40 largest coal based thermal plants, 5 largest steel plant and 15 largest cement plants in India. If you look at the GHG emissions from India in 2007, buildings alone are contributing about 12.5% for creating the comfortable environment inside. If we consider the industries producing building materials like cement , steel and ceramics the contribution will be 20.2%,(India-Green House Gas Emissions, 2007 by Ministry of Environment and forests, Govt. of India.)

Sector	GHG gas emissions in Million tons	%
Energy	1100	57.8
Industries	412.55	21.6
Agriculture	334.41	17.56
Others	57.73	3.04
	1904	

Total GHG emissions in India in 2007

Energy Type	Commercial	Residential
Lighting	60%	28%
AC	-	7%
Fan, Coolers	-	38%
Refrigerators	-	13%
HVAC	32%	-
Others	8%	10%

GHG Emissions from Energy Sector in 2007

ENERGY CONSUMPTION IN BUILDINGS

The literature suggests that energy consumption for thermal comfort in building sector is 60% of the total energy consumption. Building designs do not start with climate as the prime parameter resulting in discomfort and recurring expenditure of energy to improve the comfort levels in the building, Debnath (1995) Kaushik (1988). Annual Electrical consumption in Residential & Commercial Buildings in India is as below.

Sector	GHG gas emissions in Million tons	%
Generation	719.31	65.39
Transport	142.04	12.9
Resi. /Com Bldngs	137.84	12.53
Others	100.87	9.17
	1100	

Inside the built envelop, many building materials, furnishes give off toxic byproducts causing to indoor air pollution, poorly designed lighting and ventilation causes health problems etc. An aesthetically pleasing and functionally active building is no longer a good Building design but it should be environmentally responsive too.

The climate sensitive design or Solar passive Architecture deals with the local climatic conditions and determine the basic internal space conditions like to the extent HVAC services are needed and the comfort levels of occupants.

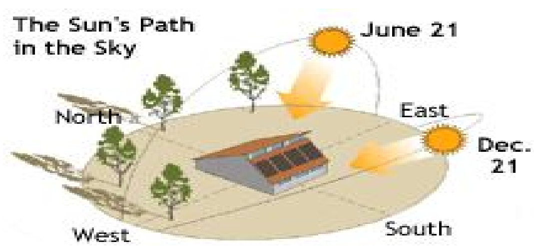
Thermal comfort in buildings deals with the heat flux in to the building envelop through the surfaces exposed to the climate. The factors that influence the thermal behavior of the buildings are

SOLAR SPACE CONDITIONING

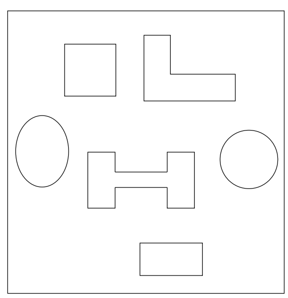
This can be achieved by Passive solar architecture or Design. These passive technologies maximize the indoor comfort levels by studying the micro and macro climate of the site and various bioclimatic concepts in terms of

ORIENTATION & SHAPE OF THE BUILDING

Building orientation is an important parameter of the design. In hot/cold climates the building needs to be oriented such that solar radiation is admitted as per the climatic condition.

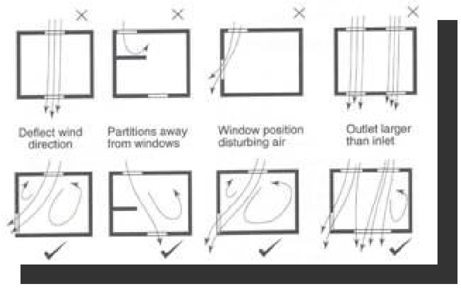


The plan form of a building affects the airflow around and through it. The perimeter to area ratio of the building is an important indicator of heat loss and gain. It, therefore plays a role in ventilation, heat loss and heat gain. This causes a new airflow pattern.



FENESTRATIONS

The pattern and configuration of openings such as windows forms important aspects of climatic design. These provide for the purpose of heat gain, day lighting and ventilation. Appropriate design of openings and shadings devices help to keep out sun and allow them in building. Ventilation lets in fresh air and exhausts hot air from room resulting in cooling of the space.



Thumb rules for fenestration configuration

BUILDING FABRIC

This is a major part of building envelope and receive large amount of direct radiation. Depending on whether the need for heating or cooling, variations in the thickness and material of the wall can be decided .The heat gain occurs more than 25% due to conduction by walls in warmer region. Hence control of heat through walls must be an important consideration for reducing cooling loads.

Passive solar heating techniques aim at promoting solar heat gain through direct or indirect means. The solar radiation falls on the external surfaces of the buildings is transmits to the internal surfaces and will be absorbed by them heating them up. Passive heating may be attained through

- Appropriate size & orientation of the building
- Minimizing conductive losses by reducing surfaces exposure on north side
- Minimizing external air flow by reducing pressure difference between two opposite sides.

Passive cooling may be attained through

- Appropriate shading devises to reduce the direct solar heat gain
- Appropriate roof designs and by increasing roof height, conductance can be reduced.
- Orientation of the building as per the wind direction
- Green roofs

LANDSCAPING

Landscaping is an important element in changing the climate of a space. Proper planting of trees reduces the striking of direct Sun light and can alter the air flow patterns. The shades created by trees, shrubs and other plants reduces the air temperatures adjoining the buildings and provide evaporative cooling.

DAY LIGHTING AND VENTILATION

The day lighting design is not just how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects. Beyond adding windows or skylights to a space, it involves carefully balancing heat gain and loss, glare control, and variations in daylight availability. A building should orient to south-north for maximum day lighting. Deviation from due south should not exceed 15° in either direction for best solar access and ease of control.

A successful day lighting design shall make use of the exterior shading and control devices. In hot climates, exterior shading devices often work well to reduce head gain and diffuse natural light before entering the building. Examples of such devices include light shelves, overhangs, horizontal louvers, vertical louvers, and dynamic tracking of reflecting systems.

EMBODIED ENERGY THROUGH BUILDING MATERIALS

In building design processes, specifying materials of construction is one of the vital parameter. Large amounts of energy is spent on the manufacturing of the materials and for their transport. Conservation of energy through building materials is very important in limiting GHG emissions. Researches show that less energy intensive building materials like for various building components are as follows:

Roofing-Filler Slabs

Terracing-Mud Phuska

Super structure-Ashlar Masonry with cement mortar

Foundation-Fly ash bricks

Not only these but there are vernacular materials available locally which can prove not only cost effective but also less energy intensive

ENERGY EFFICIENT LIGHTING

Electric lighting is a major energy consumer. Using less electric lighting reduces heat gain thus saving air conditioning loads and improving thermal comfort. By installing new lighting technologies, buildings can reduce the electricity consumed. The following are few examples of energy saving opportunities with efficient lighting.

- Installation of CFL,s in place of Incandescent lamps
- Use of energy efficient Fluorescent lamps in place of conventional CFL,s
- Installation of LED,s in place of CFL,s in offices/show rooms
- Installation of sensors
- Adding lighting controls and photo sensors

In addition to daylight controls, other electric lighting control strategies should be incorporated where they are cost effective, including the use of:

Occupancy Controls: Using infrared, ultrasonic, or micro-wave technology, occupancy sensors respond to movement or object surface temperature and automatically turn off or dim down luminaries when rooms are left unoccupied. Typical savings have been reported to be in the 10% to 50% range depending on the application.

Timers: These devices are simply time clocks that are scheduled to turn lamps or lighting off on a set schedule. If spaces are known to be unoccupied during certain periods of time, timers are extremely cost-effective devices

It is proven by Siemens that every building on an average has the potential to improve the energy efficiency by 25-30%(www.simmons.com). This can be achieved by optimizing the Building management systems, lighting, heating , cooling systems and water and energy distribution system(Griggs,2009)

TRADITIONAL TECHNOLOGIES FOR SUSTAINABILITY

Rudofsky, in his architecture without architects, points out that "untutored builders fit their work in the environment and topography. They don't try to conquer nature." India's wide range of environments and topography assures equally wide range of responses. If you look at the roots, each rural builder adapts to environmental circumstances rather than confronting them. Traditional domestic architecture harmonizes with the local climate. In the plains where temperatures are high, walls and roofs were often massive to give insulation. Broad Chajjas project over external and courtyard walls shading them from the sun and safe guard the walls from the heavy rains. Windows are plentiful but unglazed to allow efficient ventilation done with wooden shutters. Certain bed rooms were partially or wholly open to sky cooling rapidly after the Sun has set. But the lung and the light of the house is the courtyard, protected by the rooms all round from the direct sunlight. Often roofs and terraces drain in to a tank under the courtyard providing water to the household. Jallis or lattice work screen were used to allow passage of air and light in hot climates. The design of built forms varies very much in India among its varied climates like hot-arid and tropical. Till now the architectural vocabulary is greatly dominated by the designs developed based on the influences of western world which are not a climate responsive for the Indian climatic conditions. In order to re orient architectural responses for India, we should look at the sources of inspiration from the traditional buildings from the past to make the built forms in the region more meaningful to the local climates by designing buildings which can breath and by reducing un necessary energy usage for comfort conditions inside.

CONCLUSIONS

An effective Climate change strategy must consider options for reducing the GHG emissions associated with buildings by looking at how they are constructed, used, and located. To reduce GHG emissions from the building sector, guidelines for sustainable buildings by ECBC, GRIHA and coordination between technical and policy solutions, have to be integrated with architectural design. A large part of building sustainably is about enhancing biodiversity, creating spaces that are healthy, economically viable and sensitive to social needs. Rather than constantly battling against the natural environment, we need to start respecting natural systems to create a better balance between human life with natural environment.

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