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Seminar on

"GREEN AND ENERGY EFFICIENT BUILDINGS"

August 18, 2021
New Delhi

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Mid-Term Session
and
National Seminar on

"Green and Energy Efficient Buildings"

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FOREWORD

In present scenario of fast pace of urbanization, globalization, rising cost of electricity, green house emission global warming, water shortage, deforestation, scarcity of raw material and development it is imminent to adopt green and energy efficient approach in planning, design, construction, operation and maintenance of energy efficient buildings. This is very true in context of India because green cover in India is depleting due to requirement of land for infrastructure and houses for population. The requirement of energy for India in next 20 years will be enormous.

Rational and innovative planning of site and buildings holds great bearing on making buildings green. Therefore, before taking up construction of any building project there is need of detailed study and analysis of site in terms of; location, orientation, wind direction, accessibility, size, shape, soil conditions, topography, vegetation, natural features, hydrology, precipitation, infrastructures etc.

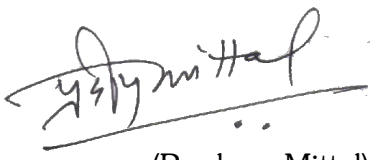
For making buildings least consumers of energy, resources and generators of waste, there is a need of paradigm shift on the part of Construction industry for redefining and changing the traditional approach to buildings. Resource conservation, an important component of Green Buildings should be implemented and enforced under the principle of "Reduce", "Recycle" and "Reuse".

For taking care of water shortage, effective water management should revolve around fourfold strategy; protecting water, conserving water, protecting water quality and reducing consumption. Options for minimizing water consumption shall involve; adopting water-efficient construction practices.

For taking care of rising demand of energy, thrust should be on conservation and generation of energy by way of non-conventional source of energy and by installation of equipment like solar water heating system, use of Biomass & Bio gas for heating and lighting etc, coupled with use of energy efficient light fixtures, fittings and appropriately sized energy efficient HVAC gadgets.

The idea of green and energy efficient buildings is a creative process that ultimately links the built environment with the human health and comfort, water, energy, biodiversity and other natural resources.

The Indian Buildings Congress has selected 'Green and Energy Efficient Buildings" as theme of this Mid Term Session and National Seminar to draw attention of all the stakeholders dealing with Built Environment. It is expected the useful recommendations shall emerge out of the deliberations, which will be of immense value to the professionals participating in the Seminar.



(Pradeep Mittal)
President, IBC

PREFACE

Building construction is an integral part of development activity. Be it residential accommodation, educational, industrial, commercial, entertainment complexes, socio-cultural centres or sport complexes all activities related to them involve creation of shelters. Provision of infrastructure facilities such as roads, bridges, jetties, harbours, airports, sports complexes, power plants etc. invariably involve building construction activities. The human beings have been witness to this activity right from its inception in the early ages when the human being required some sort of shelters to save from the vagaries of weather and subsequently to provide privacy and comforts of living.

Due to increased demand of shelter coupled with improved living environment and comfort, the building construction activity has undergone fast changes by way of improved and rapid construction technologies, innovation of new materials and non-conventional energy production techniques. All this has necessitated making provisions for various systems in the built environment. These are in the form of central air conditioning, fire detection and protection systems, security systems, automated Civil, Electrical & Mechanical services.

With its population ever increasing has led to greater demand of buildings and ancillary infrastructure activities and mechanisation, which in turn has led to environmental pollution, climate change, and more energy demand. To meet this challenge our country needs to focus on sustainable development. The increasing use of conventional building materials in the country needs to be halted at all costs to ensure that future generations are able to live a clean and healthy life in the country by reducing the risk of the catastrophic level of pollution. Over a period of time, hope is seen in Green buildings coupled with energy conservation and construction of energy efficient buildings. so as to cause least disturbance to the Mother Nature.

Ancient Indian Architectural literature provides enough evidence of concern for environment and nature. It has been integral part of planning and designing of built environment in ancient India. The symbolic image of 'Vastu Shastra' is a glaring example of finding oneness with the nature. Skills in establishing a unity with environment, and energy conservation have been demonstrated in huge temples of South India which remain remarkably well ventilated and are cool in the summer also and the grand structures like Hawa Mahal of Jaipur, Deewane-E-Aam built by King Akbar etc. which did not require any public address system.

The traditional buildings of the past have in-built thermal comfort property and were based on climate responsive integrated passive design approach. The Principles of good thermal design used in traditional buildings are still valid today. It would still be possible for modern designers, architects and engineers to incorporate these design principles in the buildings by optimum use of locally available building materials and good foresight in planning.

The Subject of 'Green and Energy efficient Buildings' is very much relevant in the present day scenario considering the acute necessity of conserving natural resources, conserving energy, production of energy through non-conventional modes like solar, wind, sea waves etc., use of energy efficient gadgets and in practising the principle of "Reduce", "Recycle" and "Reuse" so as to generate minimum residual waste. It is in this context that the Indian Buildings congress, having been connected with the Built Environment for almost three decades, decided to hold the Seminar on "Green and Energy Efficient Buildings" along with its Midterm session.

I am grateful to the enthusiastic response of the authors who have submitted very good quality papers on the Topic. The Papers will be presented and deliberated during the Seminar. The Important recommendations flowing from the deliberations will be presented in the Seminar and will also be sent to Government for consideration and implementation. It is hoped that the professionals connected with the built environment will adopt the recommendations for the benefit of mankind in general and the future generation in particular.

I express my sincere thanks to my colleagues in the Technical Committee, for their valuable support in screening and selection of papers. I also acknowledge the untiring efforts of Shri M.C.Bansal, Advisor (Tech.), IBC in bringing out this publication.

(Krishna Kant)
Chairman/ Convener Technical Committee &
Former UN Expert & CE CPWD

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TECHNICAL SESSION

"GREEN AND ENERGY EFFICIENT BUILDINGS"

STRATEGIES FOR MAKING BUILDINGS GREEN AND ENERGY EFFICIENT

JIT KUMAR GUPTA*

Abstract

Buildings, as definers of character and fabric of any city, are known for their positivities, negativities, dualities and contradictions. Consuming half of the global energy, majority of resources and generating 45% carbon emissions, buildings are largely responsible for climate change and global warming. Sustainable Development Goals enunciated by UNO also mandate the critical role of buildings in promoting global sustainability. However, majority of buildings are designed without any concern for energy, resources and environment. For making buildings least consumers of energy, resources and generators of waste, traditional approach to buildings has to be changed and redefined. In search for appropriate solutions paper looks at the options of rationalising pattern of designing buildings; relevance of site and orientation; options for energy and water efficiency; context of building materials and indoor air quality, to make buildings green and energy efficient.

INTRODUCTION

There exists two kind of environment on this planet earth, one created by nature called natural environment and other called built environment, made by human beings. Manmade environment is gradually gaining predominance over natural environment due to ever increasing number of human beings and their rising needs and demand for buildings. Known for concentration, cities house large number of people, buildings, activities and amenities in small space. Occupying only two percent of the earth's landmass, containing 50 percent of world population, cities consume 75 percent of world's resources and produce 75 percent of waste. Consumption of resources and generation of waste by urban settlements are the outcome of quality, quantity and typologies of buildings designed and built.

Buildings define both human history, growth and development besides future journey of mankind. Buildings remain vital for human growth because they are central to all human activities and are known to deeply impact the quality of life, because 80% of human life is spent within buildings. Modulating quality of life, buildings make human beings healthy/sick. As largest polluter of environment / ecology and generators of large carbon footprints, buildings remain responsible for climate change, global warming and modulators of sustainability.

Large consumption of resources and generation of waste can be attributed to the way buildings are designed, constructed, operated and maintained. Making buildings sustainable is essential for preserving, protecting and making value addition to resources, environment and ecology. Considering the contours of Indian urbanisation, McKinsey Global Institute, 'India Urban Awakening: Building Inclusive Cities -Report', states that 700-900 million sqmts. of uilt space would be required annually, to meet the needs of urban India. Considering the enormity of space and their implications as consumer of energy and resources, buildings need to be planned, constructed and operated with utmost care and caution, with focus on energy conservation, sustainability and resource efficiency

GREEN BUILDINGS

Buildings known for their positivities, negativities, dualities and contradictions, not only provide space for productive living for human beings, but are also anti-thesis to the environment and ecology. Buildings constitute a complex system of designing, construction, materials, resources and environment. Revolving around seven layers during its life-

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cycle (Siting, designing, construction, operation, maintenance, renovation and deconstruction); promoting consumption (energy, water, materials and natural resources); impacting environment (generating waste, air/water pollution, indoor pollution, heat islands, storm water runoff); buildings adversely impact human health, environment and precious resources as shown in Table-1.

Table 1: Impact of Built Environment

Aspects of Built Environment	Consumption	Environmental Effects	Ultimate Effects
•Sitting •Design •Construction •Operation •Maintenance •Renovation •Deconstruction	•Energy •**Water** •Materials •Natural Resources	•Waste •Air pollution •Water pollution •Indoor pollution •Heat islands •**Stormwater runoff** •Noise	•Harm to Human Health •Environment Degradation •Loss of Resources

According to World Energy Council Report, 2016, buildings consume over 45% global energy, 30% raw materials, 25% timber harvested, 16% fresh water withdrawal, 35% of world's CO_2 emission, 40% municipal solid waste and 50% ozone depleting CFC besides promoting 'sick building syndrome'. Considering life cycle cost and energy, only 10% cost & 17% energy goes into making of a building whereas remaining 90% cost/ 83% energy is used in their operation and maintenance, involving heating, cooling, lighting and ventilating. Thus buildings offer greatest opportunity to minimize energy consumption by merely changing the manner in which buildings are planned, constructed and operated.

Looking at the entire gamut of built environment, Green Buildings emerge as the best option to make buildings sustainable and least consumers of energy and resources. Green Buildings minimize use of water, optimize energy efficiency, conserve natural resources, generate less waste and provide healthier space for occupants as compared to conventional buildings. Green Buildings also save energy upto 50%; water consumption by 40%; reduce carbon emission by 35%; CO_2 by 8000-12000 tons and 3 MW of connected electric load / million Sqft building; besides reducing 70% construction and demolition waste. Green buildings not only reduce consumption of non-renewable resources but also fetch better returns from buildings. Such buildings provide financial, environmental and social benefits besides creating a win-win situation for both owners, occupants and users through improved productivity. Studies reveal that, 'Green Schools make learning easy and more meaningful'; 'Green Houses makes people happy and healthy'; Green Hospitals cures patients quickly and Green Shopping Malls can increase sale / profits'. Green building may cost more up-front, but save through lower operating costs over useful life of building. Cost savings is optimised when buildings is designed as green buildings at the conceptual design phase. Potential financial benefits of improving indoor environments exceed costs by a factor of 8 and 14. Green Building practices expands/ complements building design concerns of economy, utility, durability and comfort.

DESIGNING GREEN BUILDINGS

World Green Building Council has defined Green Building as a, Building that, in its design, construction or operation, reduces or eliminates negative impacts, can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources, improve quality of life. It includes following features;

- Using energy, water and other resources efficiently
- Using renewable energy including solar energy
- Reducing pollution and waste, involving re-use and recycling
- Promoting good indoor environmental air quality
- Using non-toxic waste based sustainable materials
- Valuing environment as integral part of design, construction and operation
- Ensuring quality of life for occupants

- Evolving design, that responds positively to changing environment

While principles for building green remain universal but designing green buildings will vary from region to region and within regions, depending upon prevailing climate, site conditions, cultures, traditions, available materials, construction practices and building typology besides environmental, economic and social priorities. Buildings shall continue to be consumers of energy but a green building not only minimise the use of such resources but also replaces the conventional resources with resources, which are available in abundance and remain regenerative universally. Basic approach to green buildings shall revolve around designing with nature, making optimum use of natural resources and adopting integrated approach to design. While Planning with nature would essentially involve, making optimum use of Panchbhutas-Prithvi (site), Agni(energy), Jal (water), Vayu (air) and Aakash (Space), for meeting the basic needs of energy and resources for buildings, Integrated approach to building design would essentially revolve around, respecting site, rationalising site planning, rationalising built form, lowering surface to volume ratio; promoting building efficiency, evolving efficient structural design; adopting solar passive techniques, using energy efficient equipment, controlling lighting, heating, ventilation; using solar energy/air movement, reducing transportation, minimising waste, using local materials in natural form, optimising landscaping etc.

Orientation will remain determinant for optimising nature and natural resources and accordingly, will be effectively leveraged in design solutions to modulate heat gain/loss and evolve energy efficient building envelop. Since requirements of building design would vary, accordingly, buildings with regard to climate, sun and wind will have to be oriented differently in different regions. For ensuring buildings to make best use of solar and wind energy, essential would be that majority of sites should have advantage of best orientation. Accordingly, town planner's role would be important role to ensure that maximum number of plots have best orientation, to enable Architects to evolve a sustainable and energy efficient design of building.

Rationalising site planning would involve that entire built up area shall have benefit of natural light during the day. This would be particularly critical in case of row housing, where plots have the option to draw light only from front and rear. For making buildings energy efficient, they must be designed to conform to the norms and standards defined by the GRIHA (Green Rating for Integrated Habitat Assessment) for green buildings. Thus designing Green buildings should be the outcome of;

- Designing with Nature
- Designing based on Climate
- Making optimum use of Orientation and wind direction
- Respecting Site, Optimizing site potential, making value addition to site
- Minimizing building footprints
- Making optimum use of Natural/Renewable Resources
- Finding balance between building and environment
- Preparing plans with energy, environment and resources as focus
- Safeguarding Environment
- Promoting, Processing indoor air-quality

Since designing green buildings remains a professional/team work, accordingly such projects shall invariably involve creating a dedicated teams of architects, engineers, landscape expert , consultants etc, having knowledge, expertise , understanding, experience of designing green buildings .

PLANNING FOR SITE AND BUILDING

Rational and innovative site planning and planning of building holds great bearing on making buildings green. Accordingly, context of site needs detailed study and analysis in terms of; location, orientation, wind direction, accessibility, size, shape, soil conditions, topography, vegetation, natural features, hydrology, precipitation, infrastructures etc. Based on the analysis, green building design shall

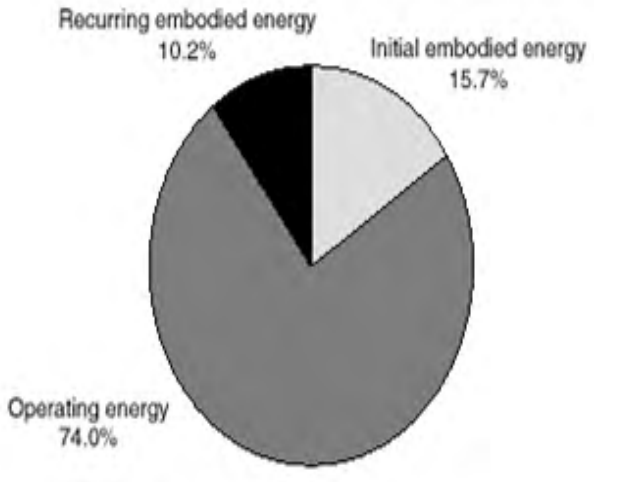
be the outcome of physical characteristics, slope, surrounding land uses/buildings, visual linkages etc. Principles governing the site planning shall involve; minimising footprints of buildings; maximising open spaces; minimising damage to site; designing with local culture; promoting pedestrianisation and using hierarchy of preservation, conservation and regeneration. In addition, placing of uses/spaces also holds great relevance in making buildings green and energy efficient. Accordingly, planning of building shall be based on making optimum use of site conditions; minimising wall to area ratio; achieving high building efficiency; making optimum use of orientation, flora and fauna; positioning all habitable rooms in the best orientation; optimizing air and ventilation within and around buildings. Design approach shall be to make buildings climate responsive. In hot regions, strategy shall be to minimize heat gain and promote heat loss. In case of cold climate, the approach shall be to optimize the heat gain and minimize heat loss. Accordingly north-south shall remain the best orientation in hot regions whereas north shall be invariably avoided while designing buildings in the cold regions. In hot regions, buildings shall be painted light to minimize heat gain besides using thick/hollow walls whereas in the case of cold climate buildings shall

Buildings in Cold Climate of Leh and Ladakh to optimize the heat gain and minimize heat loss

be painted with dark colours to absorb maximum heat. If typology of open buildings shall be used in hot regions, buildings shall be designed compact in cold regions. Further building envelop would also require careful designing for making buildings green. Designing building envelop shall be dictated by optimum solid-void relationship; careful positioning of openings, projections and shading devices; optimizing room size/building height, natural lighting and ventilations; green walls and green roof etc.

ENERGY CONSERVATION

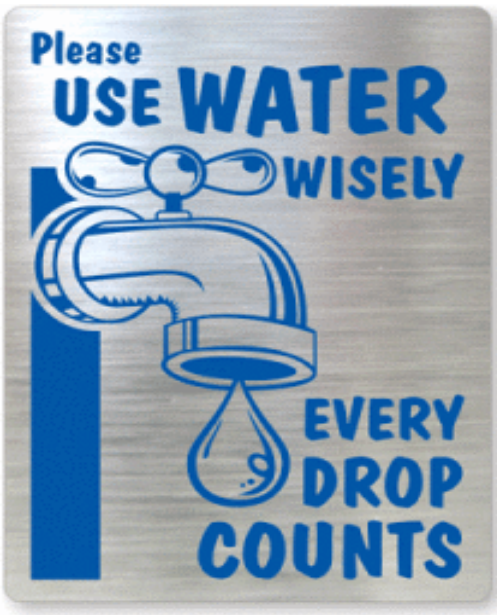
Considering the lifecycle operations, building consume two types of energy - embodied (which goes into their making) and energy used in various operations & maintenance (HVAC, lighting) during the useful existence of buildings. Only 16% energy is used during construction whereas O&M operations involve rest of 84% energy. Accordingly, for making buildings energy efficient, both embodied and operational energy components will need reduction. Reducing embodied energy will essentially require; optimizing various systems; reducing structural loads; using low-energy construction technologies; creating resilient and flexible structures; using local/natural/low energy materials, in natural form including debris etc. Using properly sized / energy-efficient and rated lighting/heating/ cooling systems in a thermally efficient building shell will be pre-requisite to make buildings green. In the past, strategy has been to make buildings energy efficient, which needs to be taken to the next level of zero energy buildings (SDGs) before achieving the ultimate objective of making buildings energy positive. This would need dual strategy of; minimizing energy consumption and making building net generator of on-site renewable energy



from natural resources (sun, wind, bio-mass, geo-thermal). It would also involve daylight harvesting; promoting operational / maintenance efficiency through BMS (Building Management System); smart metering besides computer modelling(for optimizing design of electrical/ mechanical systems and building shell), coupled with using advanced lighting controls-- motion sensors / dimmable lighting controls etc for making buildings smart and energy efficient.

WATER CONSERVATION

Having merely 4% of world's water resources for supporting 17.7% of world's population and 20% of world's livestock (500 millions-Gangwar 2013), India remains one of the most water stressed nation globally. Despite limited availability, India uses largest amount of ground-water (24 percent of global total), more than that of China and US combined. India is the third largest exploiter of groundwater-12 % (Water-Aid). India currently ranks 120 among 122 countries in the water quality index. According to NITI Aayog, "India is suffering from the worst water crisis in its history, and millions of lives and livelihoods are under threat." Critical issue of water is, demand on supplying aquifer/ sources exceeding ability to replenish it. Twenty-one Indian cities, including Delhi, are estimated to run out of groundwater, affecting million people by the next decade.



Known as elixir of life, water remains critical for both human living as well as for building construction. Buildings remain large consumers of water in its life-cycle including building operations, producing materials used in construction, curing and in their operations and maintenance. Building sector is estimated to consume 16% of total fresh water withdrawal globally. Green buildings remain highly water-efficient, reducing consumption upto 40%. Effective water management should revolve around fourfold strategy; protecting water, conserving water, protecting water quality and reducing consumption. Options for minimizing water consumption shall involve; adopting water-efficient construction practices. Pre-fabrication technology is known for its water efficiency which needs leveraging effectively. Strategy for multiple uses of water through dual plumbing; in-house sewage treatment; using phytometric solution for sewage treatment; using grey water for flushing and landscaping; using water rated/efficient fixtures-ultra-low flush toilets/urinals; rationalizing landscaping; using native flora & fauna; minimizing building footprints; providing large porous space can lower water consumption and increase ground water recharge. The intent is to reduce the generation of waste water and potable water demand. Slow the flow, breaking water flow, creating mist by mixing air with water, are other options to reduce water consumption. From water efficiency, there is need to graduate to zero-water buildings and ultimately water-positive buildings by promoting rainwater harvesting, ground water re-charging, air based cooling and reinventing sanitation system which is not simply water based.

GREEN MATERIALS AND TECHNOLOGIES

Buildings consume three billion tons of raw materials annually, constituting 40 percent of total materials used globally (Roodman and Lenssen, 1995). Materials remain major determinant of embodied energy, cost, quality and maintenance of buildings besides posing serious environmental issues associated with; extraction, transportation, processing, fabrication, installation, reuse, recycling and their disposal. Considering their major implications, materials used in buildings

should, promote conservation of non-renewable resources; ensure energy conservation; minimise maintenance/replacement costs,; create healthy indoor environment; lowering costs associated with making additions/alterations besides offering .greater design flexibility. Accordingly, materials used in buildings should essentially be resource efficient; natural, plentiful, renewable; energy/ water efficient; environment responsive; affordable; recyclable; locally available; easily salvaged, furbished and remanufactured; made from industrial/agro waste and durable. Further materials should be lightweight to reduce self- load of building, involving using fewer/more durable materials and generating less waste at the end. In addition, green buildings shall involve using state of art and innovative construction technology which are cost- effective, material efficient, speedier, energy/water efficient, safe, generators of minimum waste, using local resources, ensuring optimum use of materials, integrating renewable and low-carbon technologies.

INDOOR AIR QUALITY (IAQ)

With cost, quality and time becoming important, indoor air quality, despite its critical role and importance, remains the most neglected aspect of building design. Since human beings spent 80% of their life span within building, accordingly IAQ becomes critical for making people healthy/sick. Good IAQ remains essential element of Green Buildings because it ensures quality in workplaces; reduces fatigue/tiredness of occupants; fosters better health and improves their work performance. IAQ becomes critical when people themselves become major source of emission. Good IAQ is known to create optimum living conditions by avoiding CO_2 concentration. Poor IAQ is the product of materials/finishes used both in interior and exterior of buildings; poor ventilation; chemical emissions; lack of natural light; smoke/dust; moistures etc. As major determinant of IAQ, materials selected should be non-toxic; having minimal chemical emissions; involve low-VOC assembly: moisture resistant and easy to maintain besides using indoor plants. Promoting good IAQ would require temperature range of 21-24oC, relative humidity (RH) below70%; CO_2 levels < 1000ppm; exclude VOC with vapour pressures limited to restrict the fungal/ microbial/ pathogens growth. Natural daylight/ outside views/ good landscaping / efficient ventilation are known to improve the IAQ.

CONCLUSION

Using less water, energy or natural resources, Green buildings not only reduce/eliminate negative impacts of buildings, but also positively impact environment by generating their own energy and increased bio-diversity. Globally, green buildings have capacity to reduce greenhouse gas emissions by 84 $GtCO_2$; energy savings of 50% and limiting global temperature rises to 2°C by 2050 (UNEP). Green buildings offer numerous economic/ financial benefits--lower construction costs, higher property value; increased occupancy rates/ lower operating costs for building owner. Green buildings are known to command 7% increase in value over traditional buildings; workers in green offices recording 101% increase in cognitive scores (brain function), sleeping 46 minutes more per night with increased productivity of 8%. Green Buildings remain best option for achieving global SDGs; addressing climate change; creating sustainable/ thriving communities; driving economic growth ensuring environmental, economic and social benefits; minimising waste and maximising reuse ; promoting health and wellbeing and creating win-win situation for owners, occupants, communities and nations. Considering massive urbanisation and growing needs of built environment, India must immediately put in place an effective/efficient policy framework to retrofit the existing buildings and make all new buildings net-zero carbon by 2050, on the pattern suggested by World Green Building Council, to make "Sustainable India".

BIBLEOGRAPHY

1. World Green Buildings Council; What is a Green Buildings;https://www.worldgbc.org/what-green\
2. WoolliamsJessica; Planning, Design and Construction Strategies For Green Buildings; British Columbia Buildings CorporationMinistry of Finance and Corporate Relations; July, 2001, http://www.greenbuildingsbc.com
3. Sharpe Tim; The Role of Building Users in Achieving Sustainable Energy Futures; October 3,2012
4. https://www.indiatoday.in/science/story/world-water-day-2019-water-crisis-india-
5. Dick Greg; Green Building Materials;: https://www.calrecycle.ca.gov/GreenBuilding/ ; October 18, 2019
6. Asian Development Research Institute-India Water Facts-https://www.adriindia.org/adri/india_water_facts
7. McKinsey Global Institute (April 2010). India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth Report.
8. Government of India (2011).Census of India.
9. World Energy Council; World Energy Council Report and Financial Statement, Report, December, 2016
10. UN- HABITAT; Hot Cities Battle- ground Climate Change; Global Report on Climate Change,2011.
11. Indian Green Building council; IGBC Green New Buildings; Benefits;https://igbc.in/igbc/redirectHtml.htm?redVal=showGreenNewBuildingsnosign
12. Kant Amitabh;CEO NITI Aayog; Composite Water Index (CWMI); A National Tool for Water Measurement, Management & Improvement; June 14, 2018
13. World Green Building Council; The Benefits of Green Buildings;https://www.worldgbc.org/benefits-green-buildings
14. India Today; World Water Day; India third largest ground water exporter; March 22, 2019; https://www.indiatoday.in/science/story/world-water-day-2019-water-crisis-india-1483777-2019-03-22

COVID-19 AND THE CONCEPTS OF GREEN AND HYGIENIC BUILDINGS

A.K. JAIN*

Abstract

The Covid -19 pandemic has affected the life, health and livelihoods of millions, specially the poor, migrants and walking classes living in the slums. This necessitates to revisit the concepts of building and urban planning, and to focus on public health and hygiene, livelihoods, composite redevelopment of slums and shelter. The buildings by themselves should be able to detox the air, function as water capturer, energy generators, engage waste recycling and promote urban farming. The paper suggests a building resources pyramid, parametric and morphotectonic strategies for green and hygienic buildings.

INTRODUCTION

Covid-19 is once in a century pandemic. It has caused massive disruption to the economy and the livelihoods, especially of the working classes in slums. Their income sources have vanished and the lock down has been a cause of severe misery of women and children. Most of them live in slums, lack space, sun, air, clean water and sanitation. The Covid pandemic has exposed them to the epidemiological, transitional, health system, and other vulnerabilities. This calls for a systematic analysis and revisiting the building design, construction and urban sector towards creating a healthy, resilient and anti-frugal environment.

The urbanisation policy must link more closely with livelihoods, jobs and health. The location of living and workspaces and density should be accessible with the blurred divide between living and work. The space should be adequate to avoid transmission of the epidemic. The services viz. potable water, sanitation, electricity and recycling of wastes should be hygienic.

COVID 19 PANDEMIC

India's 7936 cities and towns, having a population of 377 million generate 60% of GDP and 70% of the jobs. According to 2011 census, 2613 cities have 1.39 crore slum households with a population of 6.54 crore. With diminishing returns from agriculture, people are migrating to urban areas for jobs, better facilities and livelihoods. However, they soon discover a stagnating job market, shortages of infrastructure services and housing, congested roads and poor educational, health and cultural facilities. The commuting distances keep on increasing due to indiscriminate urbanization. Most of the migrants work in the informal sector as domestic servants, labour, vendors, the construction sector and live in crowded, cramped and congested slums.

According to the National Sample Survey Office (NSSO) 76th round (2018) 80% rural houses and 62% urban houses in India have one room or less. 75% of rural households and 40% of urban households do not have access to tap water, 45% of rural and 9% of urban households are without washrooms/latrines. This means that norms of social distancing, self-isolation and regular hand washing are difficult to be observed by most households.

It is estimated that the Covid 19 pandemic has resulted in loss of 200 million jobs of daily wagers. The financial package of government may provide a temporary relief but cannot give regular jobs to these people. According to NSSO, there are 6.3 crore unregistered micro-enterprises. Due to Covid 19, these little businesses are shut down and workers are struggling to survive. Many have gone into debt and MSME packages announced by the government have not covered these enterprises. The impact of the lockdown is severe, and the surveys indicated income dropping by 57% on average.

During the lock down, from 25th March 2020 to 19th May 2020, while going towards home 162 migrants died due to exhaustion and accidents. With public transport shut down workers walked and cycled hundreds of kilometres or travelled in autos,

**Former Commissioner DDA, (Planning), New Delhi*

trucks, and even transit concrete mixers.

The Health Ministry has issued guidelines on management of Covid 19 in urban settlements. These delineate focus areas that require interventions from urban local bodies. 30 municipal areas have been identified which have contributed 80% of the total Covid 19 patients. Most of these areas are in the Old City, slums and high-density pockets of migrant workers. The Government of India in its relief package (16th May 2020) has announced creating industrial areas covering about 5 lakh hectares, which will be mapped and allotted fast.

This reminds of 1947 when about 20 million refugees crossed into partitioned India. The Government of India created the Ministry of Refugees (later Ministry of Rehabilitation) which provided immediate relief - food, shelter, medicines, water and sanitation facilities. Simultaneously, livelihoods - kiosks, shops, work sheds, small scale/household industries and homes were provided to the refugees. The refugees in Delhi were resettled in 36 Rehabilitation Colonies with about 70,000 plots of 60 to 80 sqm, besides 15,000 shops.

URBAN POLICY AND AFFORDABLE HOUSING

The urban policy should aim to make the cities more inclusive, safe, resilient and sustainable. The shelter must be adequate, healthy and affordable, along with rental option as the poor can't afford paying the EMI.

The Niti Aayog projects that per capita residential space in India will increase from 5.9 m_2 in 2012 to 35 sqm in 2047. This means a drastic revision of spatial standards of the houses of poor along with an optimally compact and dense urban pattern. This will enable reduction of construction cost and the length of service lines-water system, electricity, cables, sewerage, drains, roads and pathways. The passive design can make the building climatically comfortable and healthy.

Building regulations and urban planning are closely related to public health. After the industrial revolution, during the 18th and 19th century, the unhygienic conditions prevailed in the cities. As a result, the concepts of town planning, zoning, land use controls and building regulations were developed to safeguard public health, safety and convenience. Health had been a determining factor in the selection of the site of New Delhi, the new Capital of India. Earlier, in 1911 a site was selected at Kingsway Camp on the bank of river Yamuna, towards North of Civil Lines. It was dropped being malaria-prone, low lying and water-logged, and a new site at Raisina was selected for its better drainage and health conditions.

COMPACT, DENSE AND ACCESSIBLE URBAN PATTERN

London School of Economics in its study "Experiencing density living in a denser London" (March 2020) found that 'surprisingly residents' satisfaction with their housing has little relation with their aesthetic quality. The degree of density also does not corelate with how much they like their homes.

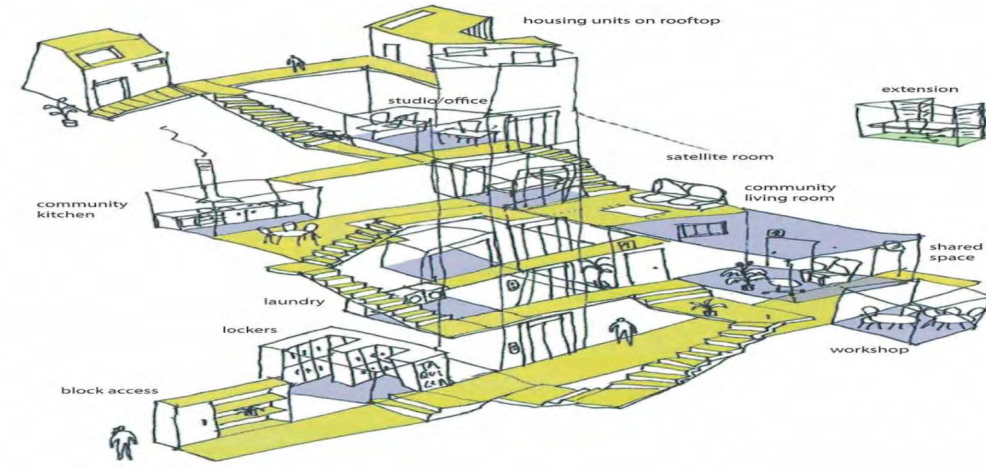


Fig. 1: Mixed Land Use for Work-Life Integration (Work from Home)

Rather, a building's internal design and comfort are most important. The study has redefined the density in terms of habitable rooms as below:

- High 100du/400 habitable rooms/Ha
- Super dense 150du/500 habitable rooms/Ha
- Hyper dense 350 du/1000 habitable rooms/ Ha

The optimum density is important for efficient use of land with minimum building footprint, especially for the projects of in-situ rehabilitation of slums. Prof. Richard Sennett of the MIT states that "on the whole density is a good thing; denser cities are more energy efficient."

Location is most important for the livelihoods of the informal sector workers who cannot afford to lose time and money in commuting. As a principle, the distance between work and living should be below 15 minutes by public transport, cycle or walk, that is 10 km, 3 km, and 1 km respectively. In view of recent corona lockdown, it may be mandatory to provide at least half of the built space for work-life integration and mixed land use as outlined in Fig.1. This will save the need to commute.

GREEN BUILDING

A green building is defined as the one which is environmentally responsible and resource-efficient through its design, construction, operation, maintenance, renovation and demolition. A green building integrates the following:

- Sustainable site planning
- Energy conservation, renewable energy and net-zero energy buildings
- Reduce air and water pollution
- Sustainable building materials with recycled and renewable contents and low emissions
- Healthy environment, thermal comfort and air quality with buildings free from Sick Building Syndrome (SBS) caused by microbial, allergy, toxins, dust and mites. The wall between work and life should be dismantled by composite and mixed land use.
- Building system design, HVAC (Heating, Ventilation and Air Conditioning), which destroys the covid virus and other bacteria. According to the Covid 19 Guidelines for Air-conditioning and Ventilation, issued by the CPWD (22.4.2020), low temperatures (7-8^{0}C) are optimal for airborne influenza virus survival, which decreases progressively at moderate temperature (20.5-24^0 C). It further decreases at 30^0 C and above. SARS-Covid 19 survives for 14 days at 4^0 C, one day at 37^0 C and 30 minutes at 56^0 C. As such, room temperature should be set at 24^0 to 30^0 C, humidity of 40% to 70% with fresh air flow to inactivate aerosol droplet virus. As AC ducts are potential careers of virus and bacteria, the system should be self-cleansing and sensor controlled.

The planning and design involve optimising the efficient and sustainable use of land and other resources. This need working out optimum density, minimising building footprint and adoption of mixed use.

PARAMETRIC AND MORPHOTECTONIC APPROACH

With the Information Technology (IT), the urbanisation and buildings have become information exchange system. Their spatial form is dynamic, functional and 5 dimensional, alongwith time and energy. It can be termed as symbiocity - Sym 'with' and biosis 'living',which means 'living together'. The buildings form a symbiotic and organic relationship with the elements of nature-earth, water, sun (energy), space and sky. The computation and big data analytics capture the complex multi-dimensional interaction of the elements of nature and evolve the solutions based on the urban issues and needs of the people.

In view of impending warming, air pollution and water shortage, it is time to conceive zero net-energy buildings, which use sustainable building materials and detox the air, work as bioreactors and energy generators. They provide water loops for its conservation and rainwater, provide space for pneumatic, underground scrapers for waste treatment. They multiply the space and promote urban agriculture, blurring the borders between urban and rural. The design of building adopts biomimicry, the emulation of nature's model, processes and systems, that is clean and organic. Like food pyramid, building materials pyramid can be a new way of building design, based on the use of materials with least environmental footprints.

BUILDING RESOURCES PYRAMID AND CIRCULAR CONSTRUCTION

In the up-cycle scenarios, the building materials have to be sustainable, local and affordable. This involves a new design thinking based on reversible solutions, the reuse and recycling of building components and wastes. Life Cycle Analysis (LCA) and Life Cycle Costs (LCCs) are the basis for absolute sustainability and green transition with the following principles:

- Prioritise renewable, bio-based materials over non-renewable materials
- Avoid environmentally harmful materials and construction processes
- Use green energy sources
- Ensure that such resources are included in the standards, specifications, technologies and biological circuits, and
- Incorporate the social and cultural dimensions of green transition.

CONSTRUCTION AND DEMOLITION WASTE RECYCLING

Construction involves generation of construction and demolition wastes. These need to be disposed of and recycled as per the Construction and Demolition Waste Management Rules, 2016.Recycled products reduce the demand for new materials. Such materials include reused brick, steel, concrete, gypsum, sulphur, wood alternatives, reconstituted wooden pallets, combination of straw, bamboo, lime tiles wood waste and cement for wall, roof and positions, insulating felts and boards, blocks, etc. The C&D waste as a resource and should be:

- Segregated at site and exclude the inert, chemical or hazardous wastes such as oil, paint, batteries and asbestos
- Recovery from recyclable wastes, such as plastics, timber, steel, aluminium, bricks, wood, concrete, etc.
- Energy production from organic, bio-degradable wastes.

BUILDINGS AS RESPIRATIONAL SYSTEM

With critical levels of air and water pollution in the cities, there is a need to revisit the concept of building services and examine whether these can be designed to detox the air, bioreactors and to harness electricity and for water transpiration. Buildings can be designed as huge air-purifiers, which transform the pollution and exhaust fumes into clean air by water algae and sea sponge. These contain organisms that convert pollution and exhaust fumes into oxygen.

- **Urban Nebulizer:** It is a device to aid breath for an asthmatic. It takes temperature inversion, smog and polluted air of atmosphere and diffuse it by smokestack, combined with water vapour. The structure also functions as a botanical garden, mostly with circular trees for air purification.
- **Detox Tower:** A green building designed as a detoxing tower cleans air through its outer skin and internal detox loop. The detox tube has three layers-the first is Voronoi/ aerodynamic adaptable structure, the next is a nano-hydrophobic membrane layer with venturi that uses lichen and algae for purification purposes. Finally, the air passes through layer three, which is comprised of a flexible aerogel.

  The building design based on the chimney effect, cools the air entering at its base and flows out at the top, cooling the whole structure. The building skin also collects energy.
- **Energy Bioreactor:** Bioreactor gathers CO_2 from the industry, burning of wastes and auto emissions. It runs on water, sunlight and algae. CO_2 produced by the process could also be run back through the system to energise the bioreactor, raw products, and to create biodiesel, hydrogen fuel, and animal feed besides hydrogen, water and oxygen. The building façade of the Algae Bioreactor can act as a zero-net energy building.

  Noise and heat insulating panels, made of carbon fibre and cyanobacteria can create a closed autonomous system of air circulation within a building, protecting it from outer pollution by

providing fresh ionized oxygen. The exterior should be able to open and close, blooming like a sunflower. Within these modules, the

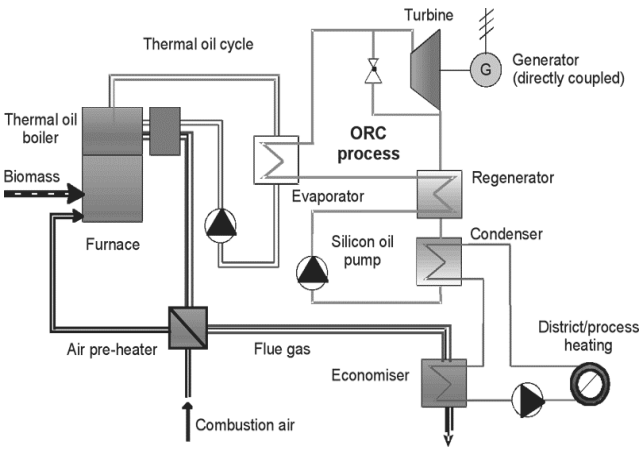


Fig.3 : Gasification Process: Electricity from Bio-mass

Source: Trashscraper, David Constable in Evolo Skyscrapers, 2012

cyanobacteria grow.The modules are filled with a 'special water solution' that reacts with carbon dioxide to produce oxygen by photosynthesis process.

- **Geothermal Wells:** It can connect the buildings via an underground pipe system as shown in Fig.3. Each geothermal system can generate energy between 200-300 megawatts. As this process is still evolving, the buildings are equipped with spherical solar cells to supplement their energy.

CONVERTING NOISE INTO ENERGY

The urban transducer captures airborne sound converting it into energy for the buildings by using acoustic panels that perceive frequencies and wavelengths to capture energy from noise. The urban transducer has ability to remember the frequencies and their locations. It can also be combined with the wind energy produce by miniature turbines. The acoustic panels that envelope urban transducers are made up of multiple metal bands with individual tuners and sensors that sense frequencies.

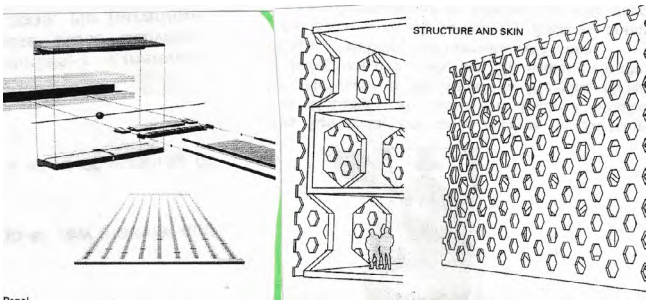


Fig. 4: Acoustic Panel and Urban Coral Reef Skin for Energy from Noise

Source: Ryan Browne, Nathaniel Dunn, Daniel Nelson & B. Scholten, Urban Transducer, and Amandine Quillent, F Zaini, Urban Coral Reef, in Evolo Skyscrapers, 2012

The acoustic panels on the exterior of the building contain multiple bands with tuners which resonate at a specific frequency. They can slide to the desired locations, changing the bands frequency. The bands change the magnetic field by electrostriction and transform noise into electrical current by a piezoelectric transducer. The schematic line drawing is shown in Fig. 4.

In this process, called electrostriction, the vibration of the band alters the magnetic field with a copper wrap magnetic rod that runs along each band. A piezoelectric transducer transforms the movement into an electric current and sends it to storage unit at the end of each band. The electricity is then transferred to main storage battery for use in the building.

THE CLOUD GENERATOR

The energy from lightening and its positive and negative currents can be harnessed by the cloud generators. These currents rise over one kilometre in the air. Every single lightening generates enough power to light 1,00,000 light bulbs for one hour and a metal lightening rod can generate 150 kilowatts of power.

WATER CONSERVATION AND EVA-TRANSPIRATION

With increasing urbanisation, pollution and loss of biodiversity, there is an increasing shortage of potable water. There is a need to adopt an ecosystem and watershed approach, including the water recycling, rainwater harvesting, desalination and purification of salty/brackish water, conservation of water sources/rivers and lakes, controlling extraction of groundwater, micro-irrigation, water efficient systems, plumbing and fixtures, and fiscal and management reforms.

Grey water treatment by root zone system using urban forestry and nutrients can produce evaporation-transpiration. The irrigation system is 1 m below ground to reduce evaporation losses, pollution and to prevent odour. The vegetation cools the environment. An adult beech (Fagus Sylvatica) has a cooling power of 1,000 mega-joules per day. Each litre of water evaporated by a tree produces 2,300 kilo joules (0.64 kwh) of cooling. By proper design, we can use this energy to cool buildings, in addition restoring the nature. The plant species for cooling should be suitable for suction of particulate, evapo-transpiration and waste water treatment.

Water reservoirs in the form of funnels and reed fields serve as a hydro-botanic treatment unit. A network of channels on the external surface of the building captures rainfall which is stored in a reservoir. This water can be used for flushing toilets, washing machines, watering plants, cleaning floors and other domestic applications.

BUILDINGS AS WASTE SCRAPERS

In view of the problem of growing solid waste and non-availability of landfills, it is necessary that every building/campus and housing cluster to have its own waste recycling. Every new construction should use at least 50 percent of recycled material. Large landfills in the cities create a myriad of environmental and space problems. Vertical waste scrapers can replace them. The waste scraper is a system of reorganisation, automated waste collection and recycling. The modular structure can be compressed like an accordion and can be quickly erected into movable waste containers. These can also be used for slum rehabilitation, emergency shelter and essential facilities like police and fire station.

GIANT RECYCLING WHEEL

For 2010 Commonwealth Games in Delhi, a proposal for building an iconic giant wheel like a London Eye (about 150-200 m dimension) was mooted, however, this could not be finalised. In view of overflowing landfill sites and environmental hazards, it is time to revive the giant wheel project comprising waste infill modules, which can be built from recycled materials. This can also act as a green filter, air purifier, a tourist attraction and an amusement park together with mineralisation baths, O2 enrichment, exhaust filters, biofuel production, carbonate and SPM recycling. The giant wheel by itself can be a turbine. The greenery around the giant wheel through photosynthesis would enhance oxygen synthesis, regulate heat, filter air and reduce the noise.

The waste collection modules automatically separate the leachate and are lifted for treatment, recycling and composting. Apart from recycling wheel, the waste scrapers will have a programmed skin with a gasifier. The gasification process uses an oxygen starved high pressure and high temperature environment to kill the virus and germs and to remove impurities before full combustion. An interpretation centre is located at the base of the structure. The conceptual basis of the project is recycling of waste, least impact on environment, and providing amenities to the local community. The wastes are filtered and processed separately. The decomposition and formation of organic wastes produces methane gas, which can be used as fuel.

Composting reduces transportation costs and emissions as well as providing valuable compost for local needs. Containerised processing allows emission free composting on site. With pre-sorting, the recyclates can be containerised and sent to processing facilities.

URBAN AGRICULTURE

For urban agriculture multi-level platforms can be created along with micro-irrigation and humidifying mechanisms. Methanisation of organic wastes, air supply and photovoltaic systems provide supports to the idea of the artificial urban biotope. This can help in availability of organic produce locally, reduce haulage and wastage of agriculture produce and bring greenery amid concrete jungle.

CONCLUSION

In the present scenario of the Covid 19 pandemic, the idea of green building needs to go beyond using the energy, water, building resources and materials more efficiently. The building should be not only smart and sustainable but also healthy

and hygienic. It acts as an urban nebulisers and transducer, detoxes the air, functions as a bioreactor and energy generator. It integrates parametric and morphotectonic strategies and building resources pyramid.

REFERENCES

1. Aiello, Carlo (ed) et al (2012)Evolo Skyscrapers, Vol. 1 & 2, Evolo Inc., Los Angeles, USA
2. Burry, Jane & Mark (2012) The New Mathematics of Architecture, Thames and Hudson, London
3. Central PWD & ISHARE (2020) Covid 19 Guidelines for Air -Conditioning and Ventilation, New Delhi
4. CINARK, KDAK (2019) Circular Construction Materials, Architecture and Tectonics, Unwelt, Udgivet, Copenhagen, Denmark
5. Hamzah TR & Yeang, Ken (2001), Ecology of the Skyscrapers, Images Publishing, Victoria
6. Indo-Global Social Service Society (2020) Seeking Justice for Informal Sector During Covid 19 Lock Down, IGSSS, New Delhi
7. Jain, A.K. (2015) The Idea of Green Building, Khanna Publishers, New Delhi.
8. Jain, A.K. (2015) Smart Cities: Vision and Action, Discovery Publishing House, New Delhi,
9. Jain, A.K. (2016) Building 20 Million Homes, Discovery Publishing House, New Delhi.
10. Jain, A.K. (2020) Tall Buildings and Vertical Urbanism, Discovery Publishing House, New Delhi
11. Jain, A K. (2020) Housing and Community Planning, Discovery Publishing House, New Delhi.
12. Ministry of Health and Family Welfare (2020) Preparedness and Responses to Covid 19 in Urban Settlements, Government of India, New Delhi
13. UN Habitat& NIUA (2020) Can Covid 19 Fill the Void of City Governance for Urban Transformation, New Delhi

UTILISATION OF GREEN BUILDING MATERIALS FOR SUSTAINABLE DEVELOPMENT IN INDIA

Dr. J. Bhattacharjee*

Abstract

This paper deals with basic concept of Green Buildings and Green Materials, present scenario in India and in other countries regarding use of Green materials. The paper also brings out advantages of Green Materials and Green Building practices including measures required for saving energy by using green materials to reduce overall impact of the built environment on human health & natural environment by efficiently using energy, water & other resources; protecting occupant health & improving employee productivity and reducing waste, pollution & environmental degradation. In this paper, it is highlighted that by using green materials we can take the advantage of renewable resources, reduced energy use & reduced wastes etc. It is evident that the concept of utilizing Green Buildings using Green Materials has lot of Potential for sustainable development in our country. For saving energy, alternative sources of materials particularly local materials like wood/bamboo etc in construction have been brought in details in the paper, with an aim for improvement in level of sustainable Development in built environment for long term. The use of wood/ Bamboo which is renewable like crop has tremendous potential in India for our civil engineering application, has been dealt in depth with reasoning in the paper. In fact, our survival on this planet will mainly depend on how innovatively way and efficiently we can use more & more Green Materials in our various construction works.

INTRODUCTION

Sustainable development has become the challenge for humanity particularly with the rapid growth of urbanization. Critical issue is to provide food, shelter and other basic needs to rapidly growing world population and save natural resources on which the very existence of population depends. The challenge becomes more serious to developing country like India, where growth of population is alarming and probably uncontrollable so far. In a society, Engineers are the backbone of the country for development process. Therefore, we must respond to sustainable development, before it becomes too late. We have got wide variation in the Perception of responsibility to future generations and ethical issue. There is an urgent need for the professionals to understand and implement cleaner production and sustainable development objectives at all level of responsibility. The buildings in which we live, work, and play protect us from Nature's extremes. Yet they also affect our health and environment in countless ways. The design, construction, operation, maintenance, and removal of buildings takes enormous amounts of energy, water and materials, and generates large quantities of waste, air and water pollution. As the environmental impact of buildings becomes more apparent, a concept called green building is gaining momentum.

Green or sustainable building is the practice of creating healthier and more resource efficient models of construction, renovation, operation, maintenance, and demolition. Research and experience increasingly demonstrate that when buildings are designed and operated with their lifecycle impacts in mind, they can provide great

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environmental, economic, and social benefits. It is worth noticing that most of us talk about energy consumption and pollution because of industry and transport, when at least 40% of the total energy produced is consumed by buildings only.

PRESENT SCENARIO IN INDIA

The construction industry in India is the largest sector after agriculture, contributing around 7% of India's GDP Growth. The sector is likely to grow at a rate of about 10 % per annum, against the world average of 5.5% & construction industry in India is gradually heading for a greatest employer of the Country. The development of Indian economy is creating demand for residential and non-residential construction, as consumers demand more houses, commercial spaces, shopping malls, hotels, other facilities and modern amenities. However, due to overall slowing down of economic activity world - wide, the process may be delayed slightly. Green buildings are steadily increasing their footprint in India with gradual increase every year. Today a variety of green building projects are coming up in the country–residential complexes, exhibition centers, hospitals, educational institutions, laboratories, IT parks, airports, government buildings and corporate offices.

India, which has an estimated about 19 years of the domestic oil reserve to last and 86% of its oil consumption being imported, has taken a leading role in promoting green buildings coming close behind to US, Australia and Canada. Green buildings utilize designs and materials that are environment friendly. They ensure pollution-free environment and reduction in energy bills through application of smart energy management, building management, application of solar photovoltaic system, high performance windows and heat resistant paints among others, which are being used in India now. There are many energy efficient buildings in India, situated in a variety of climatic zone. One of these is RMZ Millenia Park, Chennai, India's largest LEED gold-rated Core & Shell green building.

CII-IGBC announced sometime back that Shree Ram Urban Infrastructure – a developer – is attempting the first ever LEED Platinum rating (Core & Shell) in India and will be the first ever residential building in the world to do so. Entitled 'Palais Royale', the building is being built in Worli, Mumbai with an estimated height of over 300 m. However, our effort of utilizing green materials so far is limited only, which has to be increased manifold for our long-term survival on this planet.

SCENARIO IN ADVANCE COUNTRIES

Green building practices aim to reduce the environmental impact of buildings. Buildings account for a large amount of land use, energy and water consumption, and air and atmosphere alteration. In the United States, more than 2,000,000 acres (8,100 Km^2) of open space, wildlife habitat and wetlands are developed each year.

As per estimate, buildings used 40% of the total energy consumed in both the US and European Union. In the US, 54% of that percentage was consumed by residential buildings and 46% by commercial buildings. In 2002, buildings used approximately 68% of the total electricity consumed in the United States with 51% for residential use and 49% for commercial use. 38% of total amount of carbon dioxide in USA is attributed to buildings, 21% from homes and 17.5% from commercial uses. Buildings account for 12.2% of the total amount of water consumed per day in the United States. Considering these statistics, reducing the amount of natural resources buildings consume and the amount of pollution given off is seen as crucial for future sustainability. The awareness in advance countries is much higher and thereby the concept of Green buildings and green materials is being utilized judiciously.

ADVANTAGE OF GREEN BUILDING CONCEPT

It is estimated that 40% of energy consumption in a building is on account of heating, ventilating, and air-conditioning, or HVAC. Green buildings have provision for solar protection to prevent heat gain in the premises during the day. This helps in putting less of load on air-conditioning system to maintain ambient temperature within the premises.

Weather sensors help in optimizing the benefits offered by automated solar protection system. In winters, the natural heat can be allowed in the

premises using the same solar shades and for controlling those, depending on the sun effect and heat coming inside the building, thereby helping the heating system perform better. The downsizing of active temperature management systems (air-conditioning and heating) in the green buildings reduces the overall building costs.

As per estimates, 76% of the electricity generated by all power plants is consumed by buildings and 35% of the energy consumed in a building is because of use of light in the daytime. So, the big question is how to reduce the consumption of this energy? The simple answer to this question is the solar protection mechanism in green building. It ensures the usage of natural light to the maximum and that results in the reduction in the consumption of electricity used for lighting. It helps in curbing the recurring energy consumption costs like lightning using natural lights. Indian climate provides us natural light for quite a longer duration and if the luminosity coming in can be controlled, then this will be huge source for energy. The mechanism also protects the premises from the glare and heat of harsh Sun in the summers and maintains the warmth of Sun during the winters. This helps in the increase in the comfort level of users, as it enables natural ventilation, natural light and climate control in a natural way. So, the overall experience in such buildings is quite soothing.

GREEN BUILDING PRACTICES

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, for reduction of rainwater run-off. Effective green buildings are more than just a random collection of environmentally friendly technologies. However, they require careful, systemic attention to the full life cycle impacts of the resources embodied in the building and to the resource consumption and pollution emissions over the building's complete life cycle.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable building: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy. Building materials typically considered to be 'green' include rapidly renewable plant materials like bamboo and straw, lumber from forests certified to be sustainable managed, dimension stone, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable, and / or recyclable. The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects. Building materials should be extracted and manufactured locally to the building site to minimize the energy embedded in their transportation.

Every year grain farmers battle with the remains of their harvest, straw. Straw does not decompose very rapidly and becomes burden for the farmers, and the burning of straw produces CO_2 as well as CO which has an adverse impact on the environment. Thus the use of straw bale in building will not only solve the problem of straw as waste but also will help in building houses having significantly low impact on the environment without scarifying the most of comforts accustomed to be having. Straw is a renewable material offering good thermal insulation properties and a much lower environmental impact than many current mainstream construction materials. It can be promising building alternative that meets housing needs and energy efficient goals of India. So, choosing straw bale construction has many advantages for people and the planet.

Bamboo is basically like a grass. India has second largest bamboo reserves in the world. It is fastest growing species on the planet. It takes only 7 to 8 years for a seeding to grow into a mature clump. Considerable environmental degradation is taking place in India through declining forest cover and carbon emissions. It is possible to cultivate bamboo on degraded land also. Bamboo can lower

light intensity and protect against ultraviolet rays. Bamboo conserves the moisture in the soil and protects against drought. Bamboo stands release 35% more oxygen than equivalent stands of other trees, thus helps in reducing carbon dioxide gasses, blamed for global warming. Thus, utilization of bamboo is multifold and has great potential in developing economy, but in India, so far not much attention is paid in these lines. In India, NBM (National Bamboo Mission) has been set up under the Ministry of Food and Agriculture in 2005, with the following objectives: -

- Use bamboo development as an instrument of poverty alleviation and employment generation particularly in the rural sector.
- Diversify, modernize and expand bamboo-based industries through the application of modern technology and financial support and;
- Use of bamboo as a means to achieve ecological security through plantation of quality species needed by the industry and the handicrafts sector.

The progress on ground is slow. The utilization of bamboo has great potential in developing economy. However, with the involvement of traditional bamboo crafts sector it is expected that the Mission will be able to fulfill its objectives. The following measures as described below can give lot of advantage in reducing the requirement of energy.

i) Reduced Energy Use

Green building often includes measures to reduce energy use. To increase the efficiency of the building envelope (barrier between conditioned and unconditioned space), they may use high-efficiency windows and insulation in walls, ceilings, and floors. Another strategy, passive solar building design is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement (day lighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy loads. Finally, on site generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.

ii) Reduced Waste

Green architecture also seeks to reduce waste of energy, water and materials used during construction. For example, in California nearly 60% of the state's waste comes from commercial buildings. During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills. To reduce the impact on wells or water treatment plants, several options exist. "Grey water" wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars. Rainwater collectors are used for similar purposes.

Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission. Producing artificial fertilizer is also more costly in energy than this process.

iii) Energy Saving Measures in Homes

Energy can be saved in homes by adopting the following measures:

- Using renewable energy devices / system such as solar water heaters, solar cookers, solar

lanterns, solar home systems, solar generators, and other devices.

- Retrofitting some components of solar passive architecture, for example, sunshades, double glazed windows, smart glazing, window overhangs, roof treatments, ventilation, evaporative cooling, and day lighting, depending on the climatic zone where the house is constructed.
- Adopting energy conservation devices, for example, LEDs (Light-Emitting Diodes) CFLs (Compact Fluorescent Lights) instead of incandescent bulbs, electronics chokes and fan regulators, sensors for automatically switching lights on or off, automatic speed regulating fans / motors, energy – efficient electrical appliances such as fans, refrigerators, air conditioners, coolers, room heaters, and water pumps among others.

GREEN BUILDING MATERIALS

Eco – Friendly Building Materials and Resources:

- Select materials such that a major portion of the building material is recyclable during renovation and re-construction.
- Use materials having longer life which ultimately can reduce environmental impact in materials manufacturing and transporting (woods, flooring, paneling, cabinet, doors, frames, brick, light, fixtures etc.).
- Use locally available materials for construction, thereby reducing environmental impact resulting from transportation and supporting to the site area.
- After construction of the building, recycle or salvage at least 50 to 75% (by weight) of construction, demolition and land clearing waste.
- Allocate separate space for sorting and storing waste disposals (e.g. Newspaper, organic substances, dry waste etc.)
- Design waste bin, which allows for easy cleaning and thereby avoid health hazards.

Properties of Eco-friendly Materials:

- It is biodegradable and can be reused / recycled.
- It aids energy efficiency in buildings.
- It is durable and has longer life span.
- It helps in reduction in air, land and water pollution.
- Normally locally available.
- Reuse of waste product is possible.
- It is generated from renewable source.

The Source of Material is given below:

- Renewable Source
  - Rapidly renewable sources e.g. wood from certified forests.
- Reuse of Waste
  - Salvaged products – e.g. old plumbing, door frames.
- Recycled contents
  - Agriculture / industrial waste

Conventional Eco-friendly Materials

The major eco-friendly materials or green materials are listed below:

- Bamboo, bamboo based particle board & ply board, bamboo matting.
- Brick sun dried, precast cement concrete blocks, hollow concrete block.
- Calcined phosphor gypsum wall panels, calcium silicate boards and tiles, clay roofing tiles, marble mosaic tiles.
- Cellular light weight concrete blocks, insulated blocks.
- Cement paint.
- Water polyurethane and acrylic based chemical admixtures for corrosion removal, rust prevention, water proofing.
- Epoxy resin system, flooring, sealants, adhesives and admixtures.
- Ferro-cement boards for door and window shutters, ferro cement roofing channels.

- Fly-ash sand lime bricks and paver blocks, stone dust.
- Gypsum board, tiles, plaster, blocks, gypsum plaster fiber jute / sisal and glass fiber composites.
- Laminated wood plastic components.
- MDF Boards and mouldings, particle boards.
- Micro concrete roofing tiles,
- Polymerized waterproof compound.
- Portland pozzolona cement, Portland slag cement.
- RCC door frames.
- Ready mix cements concrete.
- Rubber wood finger joint board.
- Waterproof compound, adhesive, polymer, powder.

CONCLUSION

The idea of green building is a creative process that links the built environment with the human health and comfort, water, energy, biodiversity and other natural resources. The endeavour is to create sustainable buildings, which use less energy and water, generate less green house gases, use materials more efficiently, and produce fewer wastes than conventional building over their life cycle. The building design responds to the changing micro-climate and varying conditions of natural ventilation and light. The design obviates outdoor and indoor pollution, avoids use of materials with high energy demand and makes best use of space. It provides for water conservation, rainwater harvesting, recycling of wastes, explore sources of renewable energy, and use of intelligent and bionic systems. Green Building is the practice of increasing the efficiency with which buildings use resources – energy, water, and materials while reducing building impacts on human health and the environment during the building's life cycle, through better sitting, design, construction, operation, maintenance, and removal. Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources.
- Protecting occupant health and improving employee productivity.
- Reducing waste, pollution and environmental degradation.

As brought in the paper, our long-term sustainable development depends mainly on how innovative way and efficiently we can use our more and more Green materials in our various construction works.

REFERENCES

1. S.C.Joshi and Pankaj Aggarwal (2013) "Issues in cultivation and utilization of Bamboo" in paper published on National Seminar organized by Amity University, Noida on 13-14 Feb 2013, pp-107-113.
2. A.K.Jain, former Commissioner Planning,(2013), " The Genesis of Green Building" in Article published by Amity University.
3. Times of India news item published on 21st March2010.
4. J.Bhattacharjee (2009) "Green building concept & its various applications" in seminar organized by MES,Bareilly on 23rd Jan2009, pp-108-11.

RECENT TRENDS IN PLANNING, DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF GREEN AND ENERGY EFFICIENT BUILDINGS

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Abstract

Buildings consume one sixth of world's fresh water, withdraw one fourth of wood harvest and two fifth energy and material flow. In buildings wastage of energy is 50 to 90%. With increasing degradation of environment due to high-energy consumption, it has become necessary to design, construct, operate and maintain energy efficient buildings with green approach. This will result in reduction of greenhouse gases, energy consumption, environmental degradation, water and air pollution, generation of waste and water consumption.

An optimum level of energy efficiency can be achieved when all aspects of the building planning, design, construction, operation, and maintenance (O&M) are integrated with each other in a coordinated manner to take full advantage of the opportunities that such synergies offer. For energy security, future growth, clean air, water, easy transport management, sanitation, solid waste management, generation of employment in India sustainable building and services is the best option.

This paper basically focuses on design, construction, (O&M) of energy efficient building with green approach, important concepts and techniques for design of energy efficient buildings, use of non-conventional energy for energy efficiency of buildings and services, and green building construction practices. In order to go for green buildings in services, appropriate techniques, strategies and technologies based on design, climatic and physical data, to be selected. Energy efficiency of the buildings has to be ensured by adopting proper strategies at all levels of green buildings design, construction, operation, and maintenance.

INTRODUCTION

There is close connection between energy use in buildings and environmental damage which arises because energy-intensive solutions sought to construct a building and meet its demands for heating, cooling, ventilation, and lighting. The concept of energy efficiency should be considered from the beginning of the lifecycle of a building. Green approach of planning, design, construction, O&M is the art of development, which complies, with the principles of economic, social, and ecological sustainability. Global warming, unprecedented changes in climate, shortage of energy, environmental degradation, shortage of building material has necessitated alternate technology and methods of construction like green buildings. A green building is one that incorporates design, construction, O&M practices that significantly reduce or eliminate the negative impact of development on the environment and occupants with strategies for addressing energy efficiency, greenhouse gas emission abatement, water conservation, waste avoidance, reuse and recycling, pollution prevention, enhanced biodiversity, reduced natural resource consumption, productive and healthier environment, flexible and adaptable spaces. A design should be conforming to environmentally sound principle of building material and energy use. Strategy for designing green buildings should make use of solar panels, skylights; recycled buildings materials water conservation fittings, high efficiency toilets, tankless water heaters, green roof etc.

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ENERGY EFFICIENT BUILDINGS

Green approach in planning, design, construction, O&M makes building more energy efficient. An energy-efficient building balances various aspects of energy use in a building – lighting, space-conditioning, and ventilation–by providing an optimized mix of passive solar design strategies, energy efficient equipment, and renewable sources of energy. Use of materials with low embodied energy also forms a major component in energy efficient building designs.

Buildings should be planned, constructed, operated and maintained to meet the occupant's need for thermal and visual comfort at reduced levels of energy and resources consumption. Energy resource efficiency in new constructions can be affected by adopting an integrated green approach to building design. The main steps in integrated green approach to building design are as under:-

- Incorporation of solar passive techniques in a building design to minimize load on conventional systems.
- Design energy-efficient lighting and HVAC like heating, ventilation, and air-conditioning systems.
- Use of renewable energy systems like solar photovoltaic systems/solar water heating systems to meet a part of building load.
- Use of low energy materials and methods of construction and reduce transportation energy

Architecture

India is divided in six climatic zones. Knowledge of climate at a given location can help in the design of solar passive buildings that eliminate the adverse effects of climate, yet simultaneously take advantage of effects that are beneficial. For example in a place like Mumbai, a building can be designed in such a way that appropriate shading prevents solar radiation and adequate ventilation reduces humidity and in a place like Shimla, where the climate is cold and cloudy, a building can be designed to make maximum use of sunlight, and thereby keep its interiors warm. The various climatic factors that affect the solar passive design are wind velocity, ambient temperature, relative humidity and solar radiation

IMPORTANT CONCEPTS AND TECHNIQUES FOR DESIGN OF ENERGY EFFICIENT BUILDINGS

Some of important concepts and techniques used in design of energy-efficient buildings are described below.

- **Direct Heat Gain:** This technique is suitable for cold climates. As per this concept sunlight is admitted into the living spaces through openings or glazed windows to heat walls, floors, and inside air. The glazed windows are located facing south to receive maximum sunlight during winter. Windows are usually double-glazed, with insulating curtains to reduce heat loss during the night. In daytime, heat is stored in walls and floors; it is released during the night to warm the interior.
- **Thermal Storage Walls:** In this approach, a thermal storage wall is constructed between the living space and the glazing. This wall prevents solar radiation from directly entering the living space. The radiation is absorbed by the storage wall, and then transferred into the living space. Thermal storage walls include Trombe walls, water walls, transwalls, etc.
- **Evaporative Cooling:** This is a passive cooling technique, generally employed in hot and dry climates. Evaporative cooling works on the principle that when warm air is used to evaporate water, the air itself becomes cool, and in turn cools the living space of a building.
- **Passive Desiccant Cooling:** This method is effective in a warm and humid climate. Natural cooling of the human body through sweating does not occur in highly humid conditions. To decrease the humidity level of the surroundings, desiccant salts or mechanical de-humidifiers are used.
- **Induced Ventilation:** Passive cooling by induced ventilation can be most effective in hot and humid climates as well as in hot and dry climates. Induced ventilation method involves the heating of air in a restricted area through

solar radiation, thus creating a temperature difference and causing air movements or drafts. The drafts cause hot air to rise and escape from the interior, drawing in cooler air and thereby effecting cooling.

- **Earth Berming:** This technique is used for both passive cooling and heating of buildings. It is based on the fact that the earth acts like a massive heat sink. Thus, underground or partially sunk buildings would provide both cooling in summer and heating in winter to the living spaces within. In addition to the above concepts, there are many other solar passive techniques such as wind towers, earth air tunnels, curved roofs, and air vents, which can be incorporated according to the requirements of the buildings.

USE OF NON-CONVENTIONAL ENERGY FOR BUILDING AND SERVICES

Energy efficiency of buildings is enhanced by use of appropriate non-conventional energy techniques. Some important non-conventional energy techniques are as under:-

Building Integrated PV Systems: Integration of photovoltaic panels in the roof and facades of the building is increasing worldwide. The panels function as building mat and also generate electricity in daytime, which is used to meet a part of the electrical energy needs of the building. The environment friendly application is commonly referred to as building integrated photovoltaic (BIPV) This concept is very useful to construct energy efficient and aesthetically appealing buildings.

Solar Energy: Technology for solar energy for common use in buildings are Quantum Solar-Boosted Heat Pump Water Heater, Solar Steam Generating System for Cooking Application, Box Solar Cooker, Community Solar Cooker for Indoor Cooking, Dish Solar Cooker, Solar Cooking, Solar Drying Systems, Crystalline Solar Cells, Standards for SPV, Solar Home Light System, Solar Street Light, Solar Photovoltaic Pump, Solar PV Power Plant, Solar Generators, SPV-based Information Display Systems, Stand-alone SPV Power Plant, Wind-solar Hybrid Systems.

Wind Energy for Water Pumping and Off-grid Power Generation: Water-pumping windmills, aero generators and wind-solar hybrid systems are very useful for meeting water-pumping and small-power requirements in a decentralized mode in rural and remote windy areas of the country. The MNES is implementing a programme on 'Small Wind Energy and Hybrid Systems' to promote utilization of water-pumping wind mills, aero generators, and wind-solar hybrid systems for water pumping and power generation.

Biogas Plant:-

- Provides a non-polluting and renewable source of energy
- Efficient way of energy conversion
- Saves women and children from drudgery of collection and carrying of firewood, exposure to smoke in the kitchen, and time consumed for cooking and cleaning of utensils
- Produces enriched organic manure, which can supplement chemical fertilizers
- Leads to improvement in the environment, sanitation and hygiene
- Provides a source for decentralized power generation
- Leads to employment generation in the rural areas

Wind Power Generation: Generation of electricity has emerged as the most important application of wind energy world-wide. As per this concept flowing wind rotates the blades of a turbine, and causes electricity to be produced in generator unit. The blades and generator are mounted at the top of a tower. India's wind power potential has been assessed at 45000 MW. The current technical potential is estimated at about 13000 MW, assuming 20% grid penetration, which would increase with the augmentation of grid capacity in potential states.

Heating and Air-conditioning by Facades with Built-in Radiators: The feeling of comfort in a dwelling depends upon the radiation of heat and cold by the various parts of its structure.

Transfer of heat by means of a heat absorbing liquid makes it possible both to heat and to air-condition private houses as well as industrial buildings. The concept using facades with low energy built-in radiators will revolutionise present-day heating and air-conditioning. The technology is environment friendly, costs very little and operates at low temperatures. It is built into all the facades during their prefabrication, thus ensuring a very large total radiating surface.

Power Generation from Waste: In this technique waste incinerators are used for power generation. The incinerators are being made less harmful to the environment and a new subsidy system for local governments may also be established to help prevent global warming. The Government should promote the improvement and development of human waste disposal, as all such disposal into the sea is to be forbidden by February 2007.

DESIGN APPROACH FOR GREEN BUILDINGS

Modern green initiatives call for an integrated and synergetic design to both new construction and retrofitting in existing construction. This approach integrates the building lifecycle with each green practice employed by design purpose to create a synergetic amongst the practices used. Building should be designed for energy efficiency; it should be a healthy practice and should have very low impact on environment. In order to achieve the benefits of green buildings the design approach should be, whole building design approach. In whole building design approach, all the components are considered during the design phase. Whole building design approach integrates all the subsystems and parts of the buildings to work together. The design team should be fully integrated from beginning of the process of design. The design team should consist of architects, structural and other engineers, building occupants, owners, specialists in air indoors quality, energy use, and material. Whole building design approach takes into consideration the building system as a whole and examines how these system works together to save energy and reduce environmental impact and give comfort to occupants.

Key Attributes for Green Buildings - In whole building approach following aspects are very vital-

- Site conditions- Site conditions should be suited to take advantage of mass transit, protect and retain existing landscaping and natural resources, effective use of nature and soil erosion control.
- Water-Select plants that have low water and pesticides needs, and generate minimum plant trimming. Use compost and mulches this will save water and time.
- Energy – Use energy efficient fittings, passive design strategies, equipments, and natural lighting.
- Materials- Reuse such type of materials which can be recycled. Recycled content paving materials, furnishings, and mulches help close the recycling loop. Minimize wastage, pollution, and environmental degradation.
- Indoor environment.
- Acoustics.
- Natural resources.
- O&M optimization.
- Generate onsite renewable energy. Geothermal/ groundwater , Surface water, Wind, Solar, District heating/cooling, Cogeneration, Thermal storage, Fuel cell power

Green Building Materials: In design of green buildings, energy efficient materials, and products should be considered. Design for green buildings should be adaptable having harmony with natural features and resources surrounding the site. Some green building materials are appended as under.

- Use of cellular light weight concrete blocks in construction.
- Use of fly ash cement.
- ICF wall system.
- Green roof.
- Use of recycled material.
- Use of pervious concrete.
- Use of reflective tiles on roof.

- Use of big window.
- Use glass of low thermal conductivity.
- Advance passive techniques, such as wind tower roof, evaporating cooling.
- Use light colour on roofings.
- Use of recycled aggregates and lightweight aggregates for some concrete applications.
- Anticorrosion agents such as epoxy coating extend the life of steel reinforcement, especially for applications such as parking slabs where salt is used in winter.
- Using low-waste formwork is a final step in resource conservation.

Design Aspects of Green Buildings: Important aspects related to design of green buildings are listed as under

- Dual plumbing should be considered in design so that recycled water could be used for toilet flushing or gray water system that recovers rainwater or other non-potable use for site irrigation.
- Minimize wastewater by reusing ultra-low-flush toilets, low–flow shower heads, and other water conserving fittings.
- For centralized hot water distribution recirculating system should be used.
- For distant locations point-of-use hot water heating system should be used.
- Use dimensional planning and other material efficiency strategies.
- Reuse and recycle of construction and demolition materials should be considered at the design stage itself.
- For adequate ventilation and high efficiency, induct filtration system should be provided.
- For improvement of indoor air quality, heating and cooling system that ensures adequate ventilation and proper filtration should be used.
- For prevention of indoor microbial contamination, microbial growth resistant material should be selected and proper drainage should be provided to all components of green buildings.

CONSTRUCTION OF GREEN BUILDINGS

Basically construction of green buildings involves incorporation of green building materials for reduced maintenance/replacement cost over the life cycle of the building, energy consumption health and productivity, grater design flexibility and lower cost. A sustainable building encompasses design, building materials, and construction techniques. Its success depends on the active participation of everyone who has a hand in the process. While constructing green buildings on site generation of renewable energy, like solar power, wind power, hydropower or bioenergy should be opted.

CRITERIA FOR SELECTION OF GREEN BUILDING MATERIALS

Green building materials should have following properties.

- Renewal.
- Environmentally responsible.
- Energy efficient.

The selection of green building material is carried out based on following criteria-

- Resource efficiency- recycled content, natural, plentiful, renewable, resource efficient manufacturing process, local availability, reusable or recyclable, durable.
- Indoors air quality – low or non toxic, minimal chemical emission, low-VOC assembly, moisture content, healthfully maintained system or equipments.
- Energy efficiency-embodied energy should be lowest.
- Water conservation.
- Affordability-lifecycle costing.

For incorporation of product in construction of green buildings, there are three basic steps research, evaluation, and selection

Research: Research consists of Materials data sheet, Indoors air quality data, Product warrantees,

Source material characteristics, Recycled material, Environmental statement, Durability information, Building codes, Governmental regulations, Building industry articles, Model green building product and Specification.

Evaluation: This consist confirmation of the technical information as well as filing in information gaps. A Life Cycle Assessment (LCA) is an evaluation of the relative greenness of building materials and product. LCA addresses the impacts of a product through all its life stages.

Selection: Evaluation matrix is involved in this step for scoring the project specific criteria. The total score of each product evaluation will indicate the product with the highest environmental attributes.

OPERATION AND MAINTENANCE (O&M) OF GREEN BUILDINGS

Building operations and maintenance (O&M) significantly impact a building owner's costs, and affect the internal and external building environment. Building O&M plays several important roles. It should maintain proper building temperature and humidity; promote the ventilation, dilution, and removal of airborne contaminants; and provide other important environmental conditions, such as appropriate lighting and acoustics. It should also ensure the safety and cleanliness of building systems so that they do not generate pollutants and hazards. A ventilation system must sufficiently exhaust and dilute contaminants. It must also be kept clean and free from excessive moisture so as not to generate contamination. O&M practices are shaped by professional standards, facility characteristics, and an organization's general management policy. Every aspect of green building is integrated into the O&M phase of building's life. At the O&M phase green practices such as recycling and air quality enhancement take place. Green buildings will save on operating costs such as energy (30 to 40%) for life cycle of the building. Green buildings cannot achieve their objectives unless they perform as intended. A manual for O&M is very useful for operation of green buildings. An O&M manual should contain product and system information, warrantees, contact information and other information required for effective O&M. It also should have instruction for the staff/users about O&M of equipments, fittings, and buildings components. While designing and constructing the green building its O&M aspects should be kept in mind and green-buildings materials should be selected accordingly. During the O&M of green buildings attention should be given towards continued improvement of energy efficiency of the buildings and its components. Proper O&M ensures that a green building continues to perform as designed, constructed and commissioned. Over time, the performance of the green building can be assured through regular maintenance, upgradation, measurements, and adjustments. Preference should be given to green building materials for repair replacement of building components, fittings and finishes.

CONCLUSION

In present scenario of fast pace of urbanization, globalization, rising cost of electricity, green house emission global warming, water shortage, deforestation, scarcity of raw material and development it is imminent to adopt green approach in planning, design, construction, O&M of energy efficient buildings. This is very true in context of India because forest cover in India is depleting due to requirement of land for infrastructure and houses for population. The requirement of energy for India in next 20 years will be enormous and design, construction, O&M green buildings for energy security, environmental protection, and occupant's health can ensure preservation of resources. This has necessitated need of, design, construction, and O&M for green buildings for overall sustainable development.

REFERENCES

1. Green buildings by Debajit Palit, TERI, WEEA.
2. DM Roodmen and N Lenseen A building revolution: How Ecology and Health Concerns are transforming Construction.
3. Sustainable buildings and construction for India: Policies, practices and Performance- TERI background paper

CPWD GREEN RATING MANUAL - 2019 AND ITS PROVISIONS

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Abstract

CPWD has brought out its own rating manual in 2019 applicable for all residential, non residential and institutional buildings. It includes general criteria adopted by other rating agencies like IGBC and GRIHA council and also includes quality and safety measures, timely completion of work, welfare measures, and different energy efficiency measures incorporating the provisions of net zero and net plus energy buildings.

In the present paper, the provisions of the Manual are presented and discussed.

INTRODUCTION

CPWD is the government of India construction agency and has been bringing out various technical publications. CPWD has brought out CPWD Green Rating Manual - 2019, the provisions of which incorporate green building and sustainable development concepts.

Green building concept generally includes architectural design for energy efficiency, energy conservation, water efficiency, comforts level and energy generation from non conventional sources. For green building concept, efficient architectural design, use of green building materials, energy efficient equipments, water conservation measures, recycling of waste and measures to improve indoor air quality are adopted. For sustainable development, quality and safety of the structure, green construction processes, timely completion of projects, waste management, public welfare measures, mitigation of air pollution, conserving natural resources and well being of people and citizens are included. As the government is committed for improving quality of life of citizens, policies related to their welfare are also included in the rating system.

Rating in the manual are divided under 9 broad criteria as Architectural Planning and Design, Quality and Safety, Sustainable Building Materials, Green Construction Measures, Water Conservation Measures, Energy Efficiency and Conservation, Waste Management, Welfare Measures, and Landscape and Horticulture and evaluated out of maximum 100 marks. The buildings/projects are to be rated as Green, Green plus and Super green based on the score awarded to the buildings.

RATING PROCEDURE AND RATINGS

The Engineer-in-Charge is required to register the project online for its rating. The buildings may be residential, office or institutional buildings. A team of officers drawn from Architects, E & M Engineers and Civil Engineers are required to visit the site for evaluation.

The rating will be awarded once the building is complete, occupied and operational. It is assumed that once a green and sustainable building is planned and constructed, it will remain so during its life cycle. Rating criteria include steps to be taken during pre construction, execution and post construction stage by the architects and engineers. The rating is to be awarded within 3 months of the occupancy. Advantage of such ratings would be that the building will get certificate immediately after its occupation.

Approval from local bodies like Municipal corporations, fire and environment or as applicable is the prerequisite for award of green rating. Since no building can be constructed without mandatory requirements, no marks have been kept for such approvals in the ratings.

Some rating criteria include marks for site accessibility from various transport modes.

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Since, government buildings are to be designed and constructed according to the site available irrespective of facilities developed at that particular time, such criterion has not been included in the rating.

Rating grades are divided in three groups as Green, Green Plus and Super Green based on qualifying marks, given in Table 1. In case a building scores less than minimum marks required for "Green" certification, no rating will be awarded. Marks are to be given in whole numbers and not in decimals. Idea of three groups is that all the government buildings should be constructed as green and sustainable possessing minimum "Green" rating.

Table 1: Ratings

Certification	Qualifying marks
Green	55-70
Green Plus	71-85
Super Green	86-100

The buildings are to be rated under the following criteria as given in Table 2.

Table 2: The Criteria for Ratings of Buildings

Criterion Subhead	Criterion No.	Criterion name	Weightage	Maximum Marks
1.Architectural Planning & Design	1.1	Passive architectural design strategy	16	4
	1.2	Accessibility in built environment		2
	1.3	Availability of integrated Civil, E&M, and landscape drawings before invitation of bids		5
	1.4	Layout/ site planning		3
	1.5	New and innovative approach		2
2.Quality and Safety	2.1	Availability of safety plan before invitation of bids	12	4
	2.2	Availability of quality assurance plan before award of work		4
	2.3	Availability of Structural drawings before award of work		4
3.Sustainable Building Materials	3.1	Use of flyash based/recycled C&D waste products	16	2
	3.2	Use of waste products/alternatives to natural timber in woodwork		2
	3.3	Use of cement manufactured from waste products		2
	3.4	Use of local materials		2
	3.5	Use of recycled materials		3
	3.6	Adherence to Make in India Policy		2
	3.7	Use of non toxic and non hazardous materials		3

4.Green Construction Measures	4.1	Air pollution and noise control measures	14	2
	4.2	Trenches for integrated services		2
	4.3	New construction technologies for green construction		3
	4.4	Use of equipment to avoid generation of C&D waste		3
	4.5	New construction technologies for speedy construction		4
5.Water Conservation Measures	5.1	Recycling water	7	3
	5.2	Rain water harvesting		2
	5.3	Use of water efficient fixtures		2
6.Energy efficiency and conservation	6.1	Energy efficient building envelope	22	4
	6.2	Energy efficient lighting, fans, air conditioners and controls		4
	6.3	Energy efficient pumps, lifts and other equipments		2
	6.4	Integration of controls with IBMS and sensors for lighting fixtures		3
	6.5	Generation of renewable energy		8
	6.6	Innovation in energy efficiency		1
7.Waste Management	7.1	Waste management policy	4	1
	7.2	Organic waste converter/compost pits		2
	7.3	Waste segregation facilities		1
8.Welfare Measures	8.1	Toilet facilities during construction	4	2
	8.2	Welfare measures during construction		2
9.Landscape and horticulture	9.1	Trees protection and transplantation	5	3
	9.2	Irrigation features		1
	9.3	Reuse of excavated soil		1

Criterion 1: Architectural Planning and Design (16 marks) is for adopting architectural planning and design strategy based on sustainable and life cycle energy efficiency concept by way of adoption of passive architecture, landscaped but minimised hard areas, preserving existing sustainable site features, design according to existing topography and micro climate, with adequate shafts for better and effective maintenance, and integrated services conforming to accessible norms giving regard to its aesthetics and innovation. Criterion 1.1 is for passive architectural design strategy having 4 marks. 2 marks are for orientation of building and WWR (window to wall ratio) including design of openings / fenestration. Design as per zoning and massing according to solar path analysis and prevailing wind direction is awarded 1 mark, and other climate responsive passive architecture design strategy 1 mark. Criterion 1.2 for barrier free built environment has 2 marks and to be awarded in case all the norms of barrier free built environment are followed however for following more than 60% (physical not to be measured in financial terms) norms only 1 mark is to be awarded. Criterion 1.3 is for availability of integrated Civil, E&M, Services and landscape drawings before invitation of bids. If all the drawings are available, 5 marks are awarded, in case only building drawings available without

services and detailing 2 marks and for availability of only architectural drawings without detailing 1 mark is awarded. Criterion 1.4 is for layout/site planning in which design with minimum roads and hard area; 1 mark, segregation of pedestrian and vehicular traffic 1 mark and for minimum disturbance to land/ site topography 1 mark is given. Criterion 1.5 for innovation in architectural planning and design has maximum 2 marks.

Criterion 2 is for quality and safety being part of sustainability approach. It includes availability of plans and their implementation. Availability of plans ensures implementation as such the provision has been kept for preparation of quality and safety assurance plans. Further timely availability of structural drawings are essential for timely correlating with architectural drawings, preparation of better detailed estimate and curtailment of delays in completion of project. Criterion 2.1 is for safety plan having 4 marks. Criterion 2.2 is for quality assurance having 4 marks. If quality assurance plans are available before commencement of work - 2 marks, if available after commencement of work - 1 mark and if quality assurance plan not prepared, no mark is given. Further if 100% execution/implementation of quality assurance plan as prepared is done, 2 marks are awarded. If safety assurance plan is available before commencement of work - 2 marks, and if available or made available after commencement of work - 1 mark is awarded. Further if implementation of safety plan is done as per the policy of the Department - 2 marks otherwise for part implementation of safety plan or not being implemented, no mark is awarded. Criterion no. 2.3 is for structural drawings. In case, all structural designs and drawings are available before commencement of work in EPC contracts and before award of work in other contracts - full 4 marks, partly available but before commencement of activities causing no hindrance leading to delay in completion of work - 2 marks and in case any hindrance is noted due to structural drawings leading to delay in completion of work - no mark is awarded.

Criterion 3 of sustainable building materials has 16 marks and is based on sustainable use of waste, locally available, non toxic and non hazardous materials and "Make in India" products. Criterion no. 3.1 is for use of recycled waste products in masonry work. For use of flyash bricks/AAC blocks or recycled C&D waste blocks in full brick/block masonry all 2 marks are awarded. In case they are used in more than half brick/block masonry work but not full, only 1 mark is awarded. Criterion no. 3.2 is for use of waste products/alternatives to natural timber in wood work. Use of alternate materials of natural timber in full wood work - 2 marks and if used in more than half, 1 mark is awarded. Criterion no. 3.3 is for use of cement manufactured from waste products like flyash in 100% cement concrete with OPC or PPC in cement concrete and PPC/blended cements in all other works: 2 marks and for 50 to 100% - 1 mark is awarded. Criterion 3.4 relates to use of local materials. In case local material/items which are available within 100 kms are used to the extent of minimum 5% or more of the cost of construction, 2 marks and for use of minimum 2 to 5% - 1 mark is awarded. Provision of recycled materials is in criterion 3.5 vide which use of minimum 25% recycled sand, aggregates or manufactured sand of total quantity used -1 mark, for use of recycled materials in flooring and false ceiling - 1 mark and for use of recycled materials in landscape/art works - 1 mark is awarded. For adherence to Make in India Policy for civil, E&M and all other products, maximum 2 marks have been kept under criterion 3.6. In Criterion no. 3.7, 2 marks are awarded for use of low VOC primer and paint (less than 50 grams/litre) in 100% applications and for following hazardous waste management Rules/policy during construction and operation - 1 mark.

Criterion 4 for green construction measures having 14 marks includes green methods, equipments and technologies adopted during construction. Under criterion No.4.1 of Air Pollution and Noise Control Measures, use of air pollution control measures like washing tyres of vehicles, sprinkling of water and other measures to reduce air pollution - 1 mark, and for use of barricading of minimum 3 m height and as per the norms of the local body - 1 mark is awarded. In criterion No.4.2 of Trenches for Integrated Services, full 2 marks are awarded for construction of trenches for integrated utility services

like fire, water supply, air conditioning, telephones, electric cabling etc. and only 1 mark for trenches constructed for part utility services. Criterion No.4.3 is for New Construction Technologies for Green Construction. It stipulates 3 marks for adoption of green construction technologies for building/roadwork, flooring, plastering, tile work, laying utility services (trenchless technologies) etc. For part adoption, marks are awarded between 1 and 3. In Criterion No.4.4 for use of equipment/ techniques to avoid generation of C&D wastage, maximum 3 marks are stipulated. 1 mark for use of small equipments to make chases and 1 mark for use of equipment or avoiding breakage by chiselling for water supply lines, 1 mark for laying electrical conduits and avoiding chiselling in walls and 1 mark for use of small equipments to drill holes and avoiding chiselling/hammering to take out other services is awarded. Criterion no. 4.5 is for adoption of New Construction Technologies for Speedy Construction. For completion of work as per schedule period mentioned in Preliminary Estimate – 2 marks, before $1/16^{th}$ period - 3 marks, and before $1/8^{th}$ period - 4 marks are awarded.

Criterion 5 of Water Conservation Measures has provisions of water efficient fixtures, rain water harvesting, recycling of waste water and conservation of treated water. In Criterion No.5.1 of Recycling water, recycling to the extent of 80% water or above and its reuse - 3 marks, to the extent of 50-80 % water - 2 marks and for less than 50% but more than 20% - 1 mark is awarded. In Criterion 5.2: Rain Water Harvesting, use of rain water harvesting to the extent of 50% of the rainfall on the rooftop of the building (s) - 2 marks and for 20 to less than 50% - 1 mark is awarded. Criterion 5.3 is for Use of Water Efficient Fixtures in which 1 mark is awarded for use of low flow water supply fixtures and 1 mark for use of low flow/waterless flushing fixtures/urinals.

Criterion 6 Energy Efficiency Measures having 22 marks is for energy efficiency and reduction of carbon emissions during construction and thereafter during maintenance stage. In case a building is designed and constructed as net zero with100% onsite energy generation, it is written in the Manual that full 16 marks will be awarded without any further analysis in this criterion. In case, net plus (to the extent of 20% or more) onsite energy efficient building is constructed, additional 4 marks will be awarded (Total 20 marks). This needs revision as, "In case of net plus to the extent of 20% or more onsite energy efficient building, additional 4 marks will be awarded i.e. 12 marks against 8.

In Criterion No.6.1 of Energy Efficient Building Envelope, Super ECBC compliant buildings are awarded 4 marks, ECBC+ compliant - 3 marks and ECBC compliant - 2 marks. Criterion 6.2 is for Energy Efficient Lighting, Fans, and Air conditioners with Controls. Use of 100% LED lights (indoor and outdoor) - 2 marks, and of 75 to 100% - 1 mark is awarded. Use of all energy efficient 5 star fans and unitary ACs - 2 marks and of 75-100% - 1 mark is awarded. In case of HVAC/VRV system; Energy efficient 5 star fans and unitary ACs (if provided) and for HVAC/VRV system, minimum COP and IPLV as per ECBC norms - 2 marks are awarded. In case of only energy efficient HVAC/ VRV system as above but not fans and unitary ACs - 1 mark is awarded. Under Criterion 6.3 of Energy efficient Pumps, Lifts and other Equipments, 1 mark is awarded for providing energy efficient pumps and DG set and 1 mark for energy efficient/ regenerative lifts. In Criterion 6.4: Integration of controls with IBMS and sensors for lighting fixtures, integration of IBMS is awarded 2 marks and sensors for lighting fixtures 1 mark. Criterion 6.5: Generation of Renewable Energy has 8 marks for onsite solar power or other non conventional power generation. For 10% generation of required power for operation of the building/equipment provided in the building - 2 marks and for 100% generation i.e. net zero or positive energy building - 8 marks are awarded while for other conditions marks are to be given on pro-rata basis between 2 and 8. For Innovation in Energy Efficiency, 1 mark has been kept under criterion 6.6 for which assessment is to be made by the team making the assessment.

Criterion 7 is for Waste Management during construction, and occupancy of the building. Criterion 7.1 is for Waste Management Policy in which for availability of waste management plan conforming to Solid Waste Management (SWM) Rules/policy before award of work is given 1 mark and 2 marks for providing organic waste converter while only 1 mark for compost pit under criterion

7.2. In Criterion 7.3 of Waste segregation, if segregation facilities for C&D waste, wet waste and dry waste are provided, 1 mark is awarded.

Criterion 8 is for Welfare Measures having 4 marks to improve the quality of life of present and future generations which includes welfare measures of workers, engineers and other personnel working at construction site. Criterion 8.1 is for Toilet Facilities during construction. In case toilets for workers and staff as per norms at site with signage are provided, 1 mark and if separate toilet facilities for ladies (workers and staff) are provided as per norms and signage, additional 1 mark is awarded. Under Criterion 8.2, 1 mark for welfare measures for workers, staff and their children like shelter, canteen, crиches etc with proper signage and 1 mark for construction of office, conference room and display arrangements for architects, engineers and other staff with signage are awarded.

Criterion 9 is for landscape and horticulture as proper landscape and horticulture helps in environmental protection, bringing down the surrounding temperature around building leading to reduction in energy requirements during summer, reduction in air pollution, ground water recharging and in improving indoor air quality. Criterion 9.1 is for trees protection and transplantation. If concept of no cutting (felling) of trees is implemented, 3 marks, if 100% transplantation of existing trees - 2 marks and if 60% transplantation of existing trees and plantation of double of trees felled down subject to minimum 5% of native species, 1 mark is awarded. Criterion 9.2 is for Irrigation System in which efficient irrigation system like micro, drip or sprinkler irrigation is awarded 1 mark and under criterion 9.3 of reuse of Excavated Soil, 1 mark is awarded for 100% reuse of excavated soil at the site itself.

In case, any specific criterion is not applicable, the same will not be considered and the marks will be proportioned based on total marks excluding the marks of such criterion/criterion for 100 marks and rating adopted. For example, if after excluding a particular criterion, total marks works out to be 95 and marks obtained out of 95 are 65, the same will be proportioned as 65*100/95 = 68.42 rounded off to next full number i.e. 69.

SUGGESTIONS

The following suggestions are made for improvement in manual provisions:

- The marking provisions for net zero/net plus energy buildings need modifications as suggested above. Net zero/net plus criterion relates only to generation of non conventional energy and as such other provisions of energy efficiency are also essential.
- Since there are no sub mandatory criteria, the buildings may be rated as green without even conforming to some of the criteria. Hence, buildings should get qualifying marks individually in 9 criteria also i.e. for "Green" rating a building has to score minimum 55 marks in each of 9 criteria and then overall also.
- Detailed procedure of registration, fees, and inspection stages should be included in the Manual.
- Rating should be made mandatory for government buildings being executed by the CPWD.
- A review mechanism should also be developed in case of disputes.

CONCLUSION

The provisions of CPWD Green Rating Manual 2019 are brought out and discussed in brief. The manual provides for rating of buildings as Green, Green Plus and Super Green based on green and sustainable development concepts. CPWD needs to commence rating of buildings so that it is adopted by Central and State Governments at the earliest.

REFERENCES

1. CPWD Green Rating Manual 2019, published by Director General, Central Public Works Department, New Delhi.

STUDY OF FEATURES AND FUTURE PROSPECTS OF NET ZERO ENERGY BUILDING - A CASE STUDY

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HARPUNEET SINGH RAINA**

Abstract

Due to ever increasing energy demand, there is an immense pressure on the natural resources. Among the various sectors buildings are the major consumer of the energy. Need of the hour is to design building in such a way that they can generate the equal amount of energy as they consume. Net Zero Energy Buildings is a revolutionary concept which will help in reducing the energy consumption of building sector from external grid. This study suggests the various approaches and retrofits which can be used to reduce the energy consumption of Administrative Block of Punjab Engineering College, Chandigarh and also suggest the techniques which could be used for generation of an equal amount of energy per year as it consumes. This paper depicts the case study of a building in Chandigarh and it may be inferred that the building has been made energy positive building which has capacity to generate more energy than it consumes per year.

INTRODUCTION

Punjab Engineering College (PEC) Administrative Block is a three storied office building with a East-West orientation. The building has the main entrance from the east direction with the main entrance point on the first floor rather than ground floor. The building has the office space for various functionaries such as Director's office, Estate office, Student and account section. From the present study it may be inferred that the building has been made energy positive building which has capacity to generate more energy than it consumes per year. The results of this study can be helpful in developing approaches for other existing buildings in a sustainable manner.

CASE STUDY OF PEC ADMINISTRATIVE BLOCK

The building has three floors. The building has ground coverage of about 11000 sq.ft. and has square form of 105 ft X 105 ft. The total floor area is about 33000 sq.ft. Most of the space on the ground floor is non air-conditioned with the lobby area being naturally ventilated. The first floor has most of the area air conditioned by using standard window air-conditioner or split air-conditioner. The lobby area on the first floor which also includes the reception area is non-air-conditioned and is naturally ventilated. The roof area of the building is 11000 sq.ft. This study has given various techniques through which the energy consumption of Administrative Block of PEC, Chandigarh was first proposed to be reduced to great extent and then an equivalent energy generation capacity was provided through solar roof tops. The building has a paved parking area of about 7000 sq.ft. to its right and has gardens to its left and font. The front view of the building is shown in Fig.1. The details of various electrical appliances and estimated electrical loads are given in Table 1 and 2 respectively.

Fig. 1: Front Façade of Administration Block PEC University of Technology

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Table 1: Inventory of Various Electrical Appliances in PEC Administration Block

S. No.	Location	Lighting point	Fan point	Exhaust fan	3 pin 5A	3Pin 15 A	Computer Point	Printer Point	AC point	Photostat	Aqua +water cooler	LED	
Second floor													
1	Estate office	9	5				4		3	1			
2	Estate office Pantry	4	1		5	4							
3	Hall	6	4										
4	Dean Sponsored Research	10	4		2	4	3	1	2				
5	Dy. Director Office	10	2		1	3	2		1				
6	Dean Office	4	2		3	1	2		1				
7	Director office	6	5		8	3			3	1			1
8	Director's P.A office	4	2		6	2	2		1				
9	Committee Room	4	2		2	3	1 screen		1				
10	Conference Room	36	10		3	2	3 screens		6				
11	Toilet	3		2	1	1					1		
First floor													
1	Gallery	18	8		1	2							
2	Account office	1	3		19	5			1				12
3	Registrar office		3		20	2			3	1			12
4	Section office		1		2	1	2		1	1			5
5	Section office	1 2	1 1		7 7	1 1	2	1	1				4
6	Account office	25	9		4	1	8		3	1			
7	Establishment office	21	9		10	3	10		3				

								20							56
1												1			3
															9
				2	1			6			2				63
															13
				5				2			8				60
1				5	1			3	3		2	1			59
2								5			7	1			126
												2			4
3		6	3	7		12			1		6				101
		6		9	1	25			2		26	3		6	239
2															
	Ground floor	Toilet	Gallery	Account section	Store	Student Section	outdoor	Registrar office	pantry	JAC	Toilet		Roof	Flood Lights	Total
8		1	2	3	4	5	6	7	8	9					

Table 2: Estimated Electric Load of Administration Block

S. No	Point Name	Number of particular points	Load (Watts)	Total Load (Watts)
1.	Light point	239	45	10755
2.	Fan Point	101	70	7070
3.	Computer + Printer point	60	150	9000
4.	Air Conditioner	43	2000	86000
5.	Photostat	9	750	6750
6.	Water Purifier	3	100	300
7.	LED Lights	54	13	702
8.	3 Pin 5A Socket	126/3	100	4200
9.	Exhaust fans	4	200	800
10.	Water cooler	3	1500	4500
Total				129882
Note: The numbers of 3 Pin 5A sockets are divided by 3 as in general only one-third of these are used at a time.				

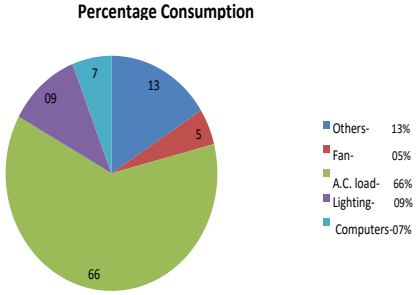

Fig. 2: Percentage Electric Consumption by Various Equipment

Table 3: Actual Electricity Consumption of PEC Administration Building Based on the Electricity Bills from April 2015-March 2016

Months	Energy Consumption (Electricity Consumption) In kWh
Apr-May	58980
June-July	68360
Aug-Sept	78290
Oct-Nov	50940
Dec-Jan	62540
Feb-Mar	46370
Total	365480

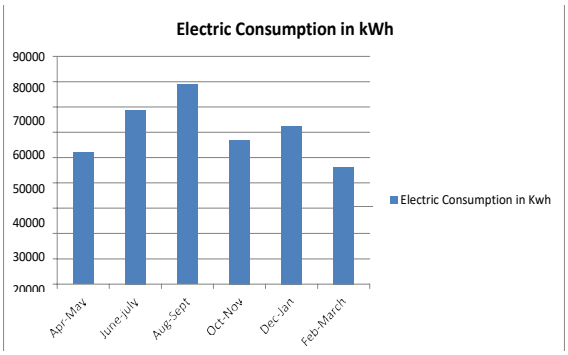

Fig.3: Electric Consumption in kWh of PEC Administration Block

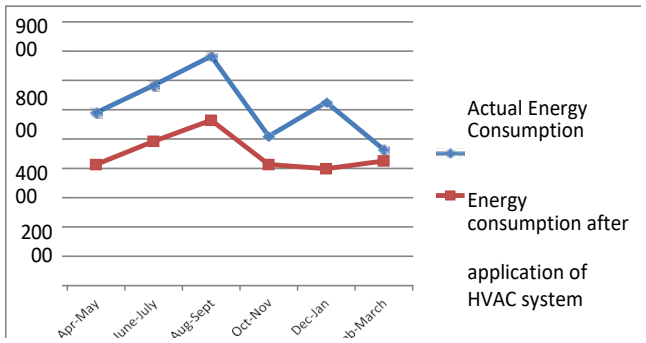

Fig. 4: Reduction in the Energy Consumption of Building

Table 4 : Energy Performance Index

Climate Zone	EPI range for buildings having more than 50% occupied area as air conditioned(kWh/m^2 /year)	EPI range for buildings having less than 50% of occupied area as air conditioned (kWh/m^2/year)
Composite	190-165	80-70
Warm & Humid	200-175	85-75
Hot & Dry; Temperate	180-155	75-65

Fig. 5: Variation in Internal and External Temperature at 5% Threshold

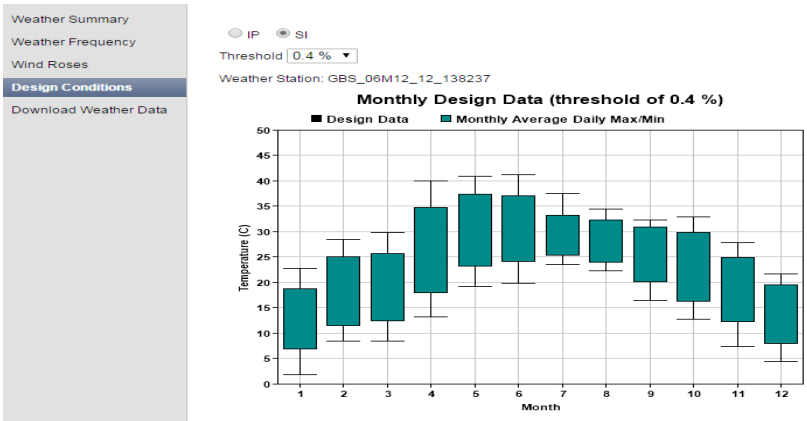

Fig. 6: Variation in Internal and External Temperature at 0.4% Threshold

Weather Summary

Weather Frequency

Wind Roses

Design Conditions

Download Weather Data

Weather Station: GBS_06M12_12_138237
Distance to your project 3.9 mi (6.3 km)
Latitude = 30.6500 , Longitude = 76.7667

Cooling Degree Day		Heating Degree Day	
Threshold	Value	Threshold	Value
18.3 °C	2088	18.3 °C	373
21.1 °C	1414	15.6 °C	157
23.9 °C	856	12.8 °C	35
26.7 °C	397	10 °C	3

○ IP ◉ SI

Annual Design Conditions				
Threshold	Cooling		Heating	
	Dry Bulb(°C)	MCWB(°C)	Dry Bulb(°C)	MCWB(°C)
0.1 %	40.9	21.1	3.3	1.9
0.2 %	40.8	20.9	4.1	2.4
0.4 %	40.1	20.2	4.6	2.4
0.5 %	39.9	20.4	4.8	2.7
1 %	38.9	20.7	5.9	3.7
2 %	37.7	22.0	7.3	4.1
2.5 %	37.3	21.5	7.6	4.4
5 %	35.2	20.8	9.3	6.0

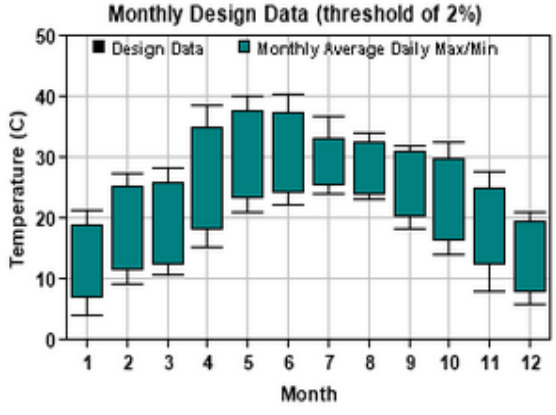

Fig. 7: Variation in Internal and External Temperature at 2% Threshold and Weather Summary

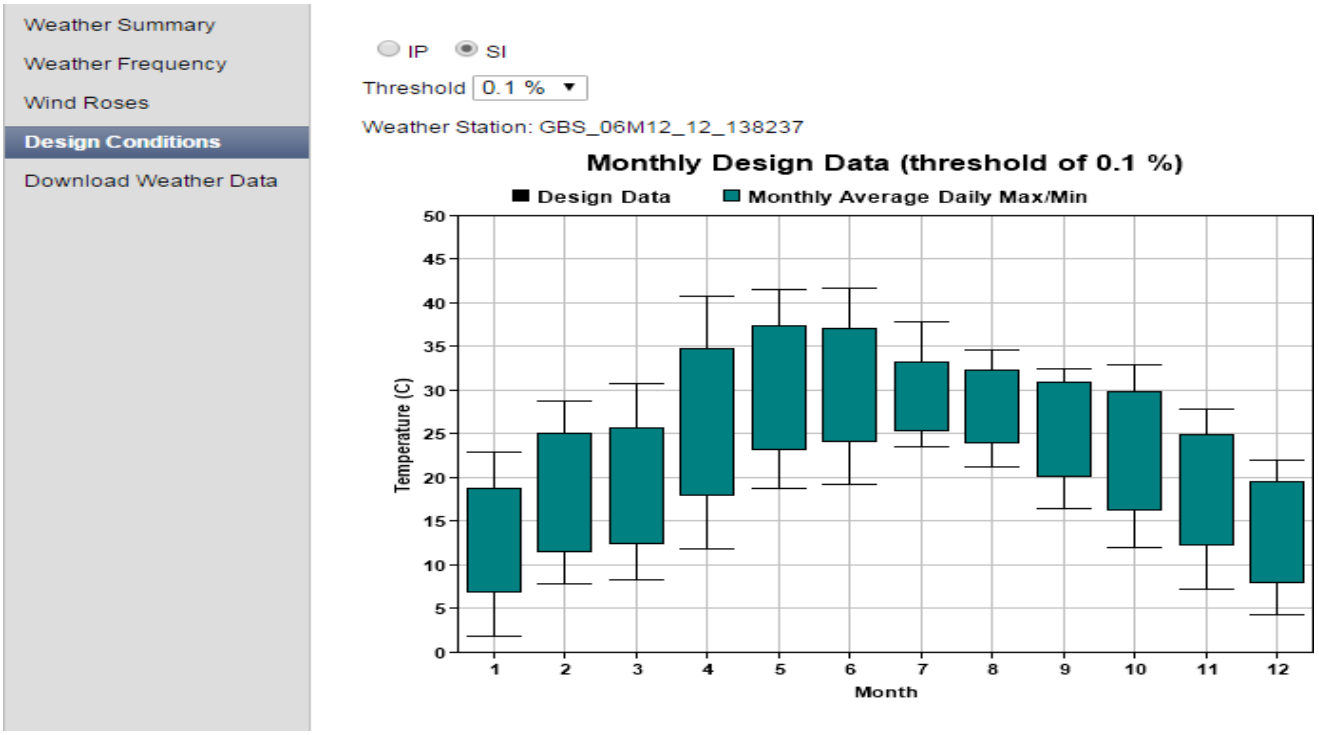

Fig. 8: Variation in Internal and External Temperature at 5% Threshold

Table 5: Energy Saved in kWh/year by various modifications

S. No	Description	Energy Saved in kWh/year
1	Controlled HVAC	92560
2	Lighting Controls with LEDs	30000
3	Insulation with Low coating, roof shades and green facade	30000

Fig. 9: Solar Power Plant Calculator by CREST

Table 6: Summary of Energy Consumption, Reduction and Generation

Actual Energy Consumption of the Building Based on its Bills	365480 kWh/year
Energy which can be saved by modification in design, HVAC installation and other systems suggested	152560 kWh/year
Energy Consumption of Building After Modifications	212920 kWh/year
Total energy Generation Capacity by Installing Solar PV on roof-tops and parking area.	213153 kWh/year
Total Difference in Energy Consumption and Generation	233 kWh/year

ANALYSIS

From energy efficiency point of view the building has certain short comings but in certain aspects it has some energy conserving design features. The East-West facade of the building results in more energy gain in the building which results in excess load on the cooling systems to maintain the thermal comfort zone especially in summers. It also reduces the potential of natural lighting and thus increases the level of electricity consumption for lighting. CFLs and tube lights are used for lighting which put a pressure on the electric bills. The building has a high window to wall ratio and the metal framed single glass without low emissive coating which increases the sun heat gain in summers and heat loss in winters. Conventional air-conditioning is used in the building instead of HVAC. From energy conservation point of view the gallery and corridor area is naturally ventilated and the open spaces in the slab on 1st and 2nd floor increases the cross-air flow which results in the thermal comfort.

CONCLUSION

NZEB is a novel concept which has a potential to decrease the energy consumption of building sector by a huge amount. With the latest initiatives by GOI like "Make in India" and construction of Smart Cities in India, the NZEBs will play an important role. Not only they can reduce the building energy consumption but can also make itself sustainable by production of equivalent amount of energy by means of Solar PVs and other means. India is much behind the developed countries in this regard where most of the new buildings are designed keeping in view the NZEB concept. This dissertation provided an approach through which existing buildings which have huge parking space can be made self-sustainable. This study has given various techniques through which the energy consumption of Administration Block of PEC University of Technology, Chandigarh was first proposed to be reduced to great extent and then an equivalent energy generation capacity was provided through solar roof tops. From the present study it may be inferred that the building has been made energy positive building which has capacity to generate more energy than it consumes per year.

REFERENCES

1. Attia S. and Carlucci S., 2015, Impact of different thermal comfort models on zero energy residential buildings in hot climate. Energy and Buildings 102 (2015)117–128]
2. Berggrena B., Hall M. and Walla M., 2013, LCE analysis of buildings – Taking the step towards Net Zero Energy Buildings. Energy and Buildings 62 (2013)381–391]
3. Colker R. M., Hewitt D. and Henderson J., 2011, Developing Effective Codes and Standards for Net-Zero Energy Buildings. BUILDING DESIGN CONSTRUCTION Chapter 5 March2011.
4. Raina Harpuneet Singh., (2016), . "Study of Features and Future Prospects of Net Zero Energy Building - A Case Study". M.Tech Thesis. Punjab Engineering College, Chandigarh.
5. Scognamiglio A., Garde F. and Rıılstvik H.N.,

2014 b, How Net Zero Energy Buildings and cities might look like? New challenges for passive design and renewables design. Energy Procedia 61 pg. 1163 –1166
6. Torcellini P., Pless S., Deru M. and Crawley, D., 2006, Zero Energy Buildings: A Critical Look at the Definition. ACEEE Summer Study on Energy Efficiency in Buildings, August 2006, Pacific Grove, CA. Golden, CO: National Renewable Energy Laboratory, 16 pp.
7. World Energy Outlook2015,OECD/IEA Special Report
8. www.crestchd.org.in/[Accessed 15 March 2015]
9. www.enob.info/en/net-zero-energy-buildings/net-zero-energy-buildings-as-built-reality/[Accessed 16 September 2015]
10. www.greentechmedia.com/green-light/post/bivpvsbapv-1345[Accessed20 September 2015]
11. www.insulation.org/articles.cfm/id=10090302[Accessed 15 October2015]
12. www.Indiraparyavaranbhawan.com[Accessed 15 November 2015]
13. www.moef.nic.in/ipb/home1.htm[Accessed 15 November2015]
14. www.riigiteataja.ee/en/eli/520102014002/[Accessed 15 March 2015]

GREEN & ENERGY EFFICIENT TALL BUILDINGS

Dr. Mutyala R. Prakash* And Sai Harshita T.**

Abstract

The Tall Buildings admeasuring 150 meter high and above is gaining importance in contemporary building technologies all over World. The Tall Buildings are known for saving the utilization of precious land in urban areas and cost effectiveness in the spectrum of modern construction. One of the significant cost savings are from the ever increasing cost of energy units, no matter, they are being generated from fossil fuel, wind, hydro or solar sources. In the present paper an attempt is being made to compare the energy consumption, in case of different kinds of buildings based on their height and occupancy ratio. In pursuing this analysis the paper intends to bring out the technologies involved, in saving the energy consumption, arguing that such an attempt would enable the Tall Buildings to secure the approval and qualification of being the Green Building. On pre review it is noticed that a scanty number of Tall Buildings until now got the approval of being the green buildings from the accreditation agencies. The paper further argues for adding in buildings regulations a Clause or two, that becomes mandatory to obtain the accreditation of Green Buildings Agency and Planning Permission to construct Tall Buildings anywhere in the World.

INTRODUCTION

The Tall Buildings, Skyscrapers, and High Rise Buildings are the different connotations used for the same family of buildings which are supposed to have reached a minimum 150 meters or more height. The concepts relevant to Tall Buildings, their features, economic viability, pricing pattern, structural changes over time, 3D printing applications, new technologies in construction management and application, green skyscrapers and energy profiles, parking conundrum, and status of important tall buildings constructed and under construction stage, are discussed at length[1]. The issues related to Greenfield Townships to accommodate Tall Buildings as exclusive zone or cluster was elaborated[2] . The present paper focuses on Green and Energy Efficient Tall Buildings. The energy inputs in Tall Buildings are required for cleaning, heating, cooling, water supply, lifts operation, lighting, recycling of waste water, ventilation, communication, etc.

Every unit of energy produced impact atmosphere directly or indirectly depending upon the type of energy production chosen. The most known pollution element is CO_2 and radiation.

CONCEPT OF GREEN ENERGY

The green energy is the one available and naturally replenished on a human scale, such as sunlight, wind, rain, tides, waves, and geothermal heat[3]. This is known as Non Conventional Energy source while compared to the fossil fuel known as Conventional Energy. However the unit cost of non conventional energy is higher than the conventional energy, as the processing cost of the non conventional energy is cumbersome. Its production time and reliability is relatively uncertain.

CONCEPT OF ENERGY EFFICIENCY

The efficiency is generally measured on axis of time and cost of production, assuming other things being constant. The cost of production includes, cost of capital, land, labour, and organizations. Efficient energy use, sometimes simply called energy efficiency, is the goal to reduce the amount of energy required to provide products and services. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature[4].

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TECHNOLOGIES RELEVANT TO ENERGY EFFICIENCY IN TALL BUILDINGS

Most of the Tall Buildings since last decade were equipped with technologies known as HVAC (Heating, Ventilation, Air conditioning) and UFAD (Under Floor Air Design). The agencies assessing the buildings to certify them as Green, evaluate the HVAC and UFAD in a building as major criterion to award certificate. There are plethora of companies marketing the HVAC and UFAD system with varied degrees of success. Due to the limitation of length of paper we will not elaborate the innovation of HVAC and UFAD of those are in place as on today.

ENGINEERING AND ARCHITECTURAL CONTRIBUTION IN ENERGY EFFICIENCY

Construction of a Tall Building is highly complex right from the stages of excavation to the finishing of Faзade stage of the Building. While the Architects endeavor to beautify the buildings, the structural engineers play the pivotal role in optimizing the energy cost with appropriate building materials. One would come across several challenges in construction of Tall Buildings, both manmade and natural catastrophe. The Damper Technology[5] attained its prominence, as most of the Tall Buildings are vulnerable to incidence of earth quakes. So as to conceal the Damper, the architects tend to create attractive facades and these facades have direct impact on energy use in a building.

ZONING REGULATIONS 1916[6]

Prior to the Zoning Regulations 1916, the measurement of the Tall Building were carried out by adding pieces of the structures in and outside Tall Building Structure while calculating its area and to estimate the energy requirement. However the promulgation of Zoning Regulations 1916 have changed the method of calculation which has impacted the Tall Buildings' calculation of area both in and outside the structure.

ESTIMATION OF ENERGY IN HIGH RISE BUILDINGS

The estimate of energy requirement is different in the case of non High Rise Buildings. In case of High Rise Buildings, the calculation is carried out by using the 'Envelope Surface Area' methodology after promulgation of Zoning Regulations 1916. The Envelope Surface Area Calculation system was adopted in calculating the 'facade' and total area of the Skyscrapers. Philip Oldfield et. al[7] calculated the envelope surface area of a high rise building as per the model given below.

$$AVr = \frac{SA}{V} \left(\frac{m^2}{m^3}\right) \quad \text{.....(1)}$$

Where SA is the envelope surface area of the building and V is its volume. m^2 and m^3 are units of SA and V respectively.

AVr ratio is used as the multiplier for the various estimates such as energy consumption, taxation and various other purposes.

ENERGY EFFICIENCY OF SKYSCRAPERS BUILDINGS

In this paper, for the purpose of analysis the Skyscraper is assumed, of those buildings having 150 meters and above . A building is qualified and accredited as Green if such building comply with the standards of energy production and consumption. The energy production primarily originates from fossil fuel leaving the carbon emission in to the atmosphere. The other forms of energy production is insignificant even though they are safe in production. They contribute much less as compared to the conventional source of energy. Such forms of energy are known as energy generated from, solar, wind, waste, tides, hydro, and biogas. In this paper the authors attempted to focus on energy savings in Skyscraper believing in the concept of , 'energy saved is energy produced'. Besides this authors are concerned about the safety of the people where ever these Tall Buildings are constructed.

Suppose if anyone attempts to produce the

energy form Skyscraper by fixing some additional outfitting, such as solar plates, wind propellers, turbines, and any other systems, they might endanger the safety of the lives and goods around the Skyscrapers as the things might fall from such height, as well, will be influenced by gravitational force to cause maximum damages to lives, goods and equipment around the skyscraper. Therefore utmost care is required in fixing the energy generation equipment so as to harness energy resources from the High Rise buildings.

For instance, Bank of America Tower (Manhattan) which was certified by LEEDS had some three incidents which are worth noticing.

- October 17, 2007: A construction container fell from a crane around 1 p.m., causing damage to the tower and injuring eight people on the sidewalk[8]. The container broke windows on several floors of the building, spraying debris that rained down on the streets below. Eight people suffered cuts and bruises. The Buildings Department temporarily stopped construction at the site.
- August 12, 2008: A 1,500 pound (680 kg) glass panel fell onto a sidewalk. Two people suffered minor injuries[9].
- September 17, 2008: A debris container fell, shattered a panel of glass fa3ade, and caused several pieces of glass to fall from the 50th floor to the sidewalk and street (West 42nd and Avenue of the Americas) at around 3.00 pm. No one was injured[10.]

There can be several instances of these nature which could happen from the skyscrapers. The present paper does not investigate such incidents as the subject matter is outside the purview of this paper. However the paper brings to the limelight that any attempt to create assets or equipment to generate energy within the Skyscrapers might add to the energy efficiency in Skyscrapers. Instead it is worthy to examine the energy saving in Skyscraper by adopting various new technologies and innovations in building technology and materials.

A REVIEW OF ENERGY SAVING TECHNOLOGIES RELEVANT TO HIGH RISE BUILDINGS

One of the potential areas to achieve economic viability of Tall Buildings exist in management of energy consumption right from the design stage to the end use stage. A typical Skyscraper provides business to parking, cargo handling, hotels logistics, subway station entrance, shops, restaurants, sightseeing, office lobby, hotel lobbies, ball room, boutique office lobby, conference centres, office space, sky lobby, swimming pool, sky lounge, bar, sky garden, hotel rooms, fitness centre, vip business centre, observation deck, exhibition hall, tuned mass damper display, concert hall, and mechanical systems services. An appropriate power loads are to be calculated and stable power supply is to be in place, so as to provide uninterrupted power supply to the users.

However it is possible to device energy savings systems right at the design and construction stage of the buildings. For the purpose of understanding the energy savings due to the design of the skyscraper and its evolution over decades, it is worthy and interesting to refer the article published by Philip Oldfield, Dario Trabucco & Antony Wood (pages 591-613)[11]. According to them, five categories of energy generations of tall buildings identified such as

- First Energy Generation: From the birth of tall buildings in the year 1916 to the year 1985 Zoning Law.
- The Second Energy Generation : From the year 1916 Zoning Law to the development of the glazed curtain wall 1951
- The Third Energy Generation : From the development of glazed wall 1951 to the year 1973 energy crisis
- Fourth Energy Generation : From the energy crisis 1973 to the present day
- Fifth Energy Generation : From the rise of an environmental consciousness 1997 to the present.

CONCEPT OF GREEN BUILDINGS (GB) & RELEVANCE TO SKYSCRAPERS

A Green Building is supposed to be the one which has lowest CO_2 emission, limit to the Zero which is highly utopian and improbable; occurring due to its functioning or utilization. The Evaluation of the Green Buildings include several factors attributed to the Earth, Water, Air, Noise, Radiation,

and other discharges both in terms of, gases, fluids or non fluids or both[12] .

In case of Green Skyscraper the description of criterion mentioned in the above paragraph holds good. However the accreditation process for securing certification from competent agency is enumerated in the following paragraph.

BODIES /ASSESSORS INVOLVED IN ACCREDITING SABS (STATE OF ART BUILDINGS) AND GREEN TALL BUILDINGS

Ever since the Green Buildings and State of Art Building have become interdependent on each other in seeking popularity and repute, the Builders and Architects have resorted to work in achieving highest credits against their built units, and call them as GBSABs (Green Building cum State of Art Buildings). So as to attain those credentials, most of them seek the involvement of evaluator/ certifiers. Following are the well known assessors and evaluators of buildings who perform their duties based on their 'in-house developed index or scaling criterion'[12].

- BREEAM (the U.K): Building Research Establishment for Environmental Assessment Method.
- LEED (U.S.A) : Leadership in Energy and Environment Design.
- CASBEE (Japan): Comprehensive Assessment System for Built Environment Efficiency.
- IGBC : Indian Green Building Council.

The important distinction of World reputed agencies like BREEAM and LEED are compared in the following Table 1 who enjoys the acceptance by the leading investors, in the World:

Table 1: Significant Comparison of BREEAM Versus LEED[12]

BREEAM	LEED
• Legislation /Best Practices-Base	• Optional StandardBase
• Quantitative Threshold Base	• % Threshold Base
• Based on CO_2	• Based on US Dollars
• Main Application in the U.K	• Niche Application in the U.K
• Assessor Involvement	• Team Involvement

Table 2: Most Famous LEED Certified Buildings of Mixed Heights in the World Including Tall Buildings[13]

S. No	Certification year	Name of Building	Features Relevant to Energy Paradigm
01	N.A (Not Available)	Soldier Field, Chicago	First LEED-EB Certified Stadium. Recycles every thing including dirt
02	2018	Salt Lake City Library, UT	High indoor environmental quality and energy and atmosphere
03	N.A	One Bryant Park, NY	High Rise Building –LEED Platinum Rating. Reuse rain water, recycle grey water . 4.6 megawatt cogeneration
04	2015	Shanghai Tower, China	Second tallest building in World. LEED Platinum Certificate
05	2012	Manitoba Hydro Place, Winnipeg, Canada	Uses 70% less energy, and saving USD 500,000 per year
06	2013	Kingkey 100Tower, Shenzhen, China	One of tallest in World. LEED Gold CS. Reduces 40% water use and generation of waste water by 50%. Energy saver.
07	2013	Jin Mao Tower, Shanghai, China	Chinese Longest running Building following retrofit. LEED Certified
08	N.A	Two International Finance Centre, Hong Kong, China	LEED Gold Certificate . Increase in natural light and reduce solar hear
09	N.A	Facebook HQ, Menlo Park, CA	Energy needs are met through 3.6 megawatt rooftop solar panels. Backwater treatment plant to support landscaping needs and toilets. LEED Certified

10	2010	Yale School of Forestry & Environmental Studies, New Heaven, CT	LEED Platinum Certificate. Provides energy efficient thermal comfort , reducing environmental impact
11	N.A	Willis Tower, Chicago, IL	LEED Gold Certificate . Efficient Lighting System.
12	2010 & 2014	Wells Fargo Tower, Los Angeles, CA	Overall efficient energy management. LEEDS Gold Certificate
13	2012	Taikoo Hui Guangzhou Towers, China	LEEDS Gold Certificate. Resource conservation system on-site. Gray water recycling system and CO^2 sensors to Optimise HVAC system
14	N.A	Andeavor Corporate HQ, San Antonio, TX	LEED Silver Certificate. Indoor environmental quality and energy efficiency.
15	2014	The Crystal, London, Uk	LEED Platinum Certificate. Uses only renewable energy to power and its operation
16	N.A	1800 Larimer Street-Xcel Energy HQ. Denver, CO	LEED Platinum Certificate. The building generates energy cost savings of USD 212,000 every year
17	N.A	Sabaru of America HQ. Camden, Nj	Zero landfill which means that none of its waste will ever be sent to landfill
18	N.A	San Francisco International Airport Terminal 2, CA	First airport terminal in US to attain LEED Gold Certificate. Year long retrofit and renovation program of an existing facility.
19	2010 & 2017	Vancouver Convention Centre- Canada	LEED Platinum certificate. Updating the energy efficiency rigorously adhering to the best energy efficiency LEED v4 Platinum standards
20	2011	TAIPEI, Taiwan	World's tallest LEED certified building. LEED Platinum certificate. Sustainability measures to gear up slashing energy consumption by 33.41 kWh and saving 28 millions liters of potable water each year. Built to withstand natural disaster with innovative Damper Technology.

With regard to the CASBEE (Japan), it is popular and used in Japan widely or they conduct this technique on those projects which are being financed by Japan no matter where they are being set up. As far as IGBC is concerned, the technique is popular in India and it plays advisory role to the Ministry of Environment, Government of India and to those private builder who might be interested to get their projects evaluated for Government of India funding. It may be noted that these assessors and evaluators perform as advisory bodies and not as regulators.

Unfortunately India has very insignificant number of High Rise buildings of the category of 150 meter and above. So, the experience of IBGC is limited to that effect. LEEDS has accredited several famous buildings out of which Twenty of them are described in the Table 2.

CONCLUSION

1. Until now the High Rise Buildings had free run in construction and management which is evident from the list of accreditation awarded to such buildings which were constructed and under operation.
2. Since the promulgation of Zoning Regulations are vested as the sovereign power of independent nations on our globe, none can force any country to adopt the Zoning Regulations similar to the USA.
3. India is yet to open its account to construct Green High Rise Buildings therefore, it might be appropriate to promulgate the zoning regulations before some one seeks Planning Permission from the Department of Town Planning Departments or Urban Development Authorities.

4. The Envelope Surface Area methodology be adopted by India, so as to allow the construction of Skyscrapers abandoning the old system of surface area calculation for all the buildings.
5. The investors in Skyscrapers' Equities must be alerted to seek the certificate from the institutions such as LEED and IGBC as mandatory.
6. The onslaught of COVID-19 flipped the Global System in to unknown state of affairs, and we must be prepared for evolution of The Sixth Energy Generation: From environment consciousness 1997 to the COVID-19 era .
7. It is important to assess the impact of COVID-19 on Green & Energy Efficient Tall Buildings and other buildings.

REFERENCES

1. Mutyala Prakash, Anara, and Gurinder, Modern Technologies and Construction Management Tools in Construction of Tall Buildings of the World The Journal of Indian Buildings Congress (June 2019).
2. Mutyla Prakash, Guridner, An Impact of Modern Greenfield Townships- Conflicts and Solutions Compared to the Traditional Brownfield Townships, The Journal of Indian Buildings Congress (January 2020)
3. Wikipedia
4. Wikipedia
5. A tuned mass damper, also known as harmonic absorbers or seismic damper, is a device mounted in structures to reduce the amplitude of mechanical vibrations. Their application can prevent discomfort, damage, or outright structural failure. They are frequently used in power transmission, automobiles, and buildings. Wikipedia.
6. The **1916 Zoning** Resolution in New York City was the first citywide **zoning** code in the United States. Wikipedia
7. Philip Oldfield, Dario Trabucco & Antony Wood, Five energy generations of tall buildings: an historical analysis of energy consumption in high-rise buildings The Journal of Architecture , Vol 14, 2009 –Issue 5
8. Crane Bucket Falls 53 Stories in Midtown. WNBC October 17, 2007.
9. Hauser, Christine (August 12, 2008) "At a Midtown Intersection, Another Sheet of Glass Falls". The New York Times .
10. Glass Falls 50 Floors From Midtown Building . Ny1, September 17,2008
11. Philip Oldfield, Dario Trabucco & Antony Woodd, The Journal of Architecture Volume 14, 2009-issue 5
12. Mutyla R. Prakash, et al,. STATE –OF- ART BUILDING TECHNOLOGY INNOVATIVE TECHNIQUES & TECHNOLOGIES, Journal of Indian Buildings Congress (2013)
13. The summary of the technologies adopted by the builders in energy saving, generation, and safeguards are enumerated

GREEN & ENERGY EFFICIENT BUILDINGS: A CASE STUDY OF SUZLON ONE EARTH, PUNE

Dr. Deepak Sundrani*

Abstract

Suzlon is a well-known Wind Turbine manufacturer in India. Since their business is about renewable energy, it was considered apt to make their headquarters green and energy efficient. Their headquarters named "Suzlon One Earth" is located in Hadapsar in Pune. The area of the campus of Suzlon One Earth is about 4 hectares. The campus is fully powered by renewable sources of energy such as hybrid wind turbines, solar panels and photo-voltaic cells. Suzlon One Earth is a LEED Platinum and GRIHA-5 star certified building. It is divided into 5 inter-connected, individual buildings named after elements of nature Sun, Aqua, Sky, Tree and Sea. To reduce its operating expenses, it also utilises rain-water harvesting, on-site conversion and an "office in Garden" design to maximise daylight use. This case study gives the details of the building.

INTRODUCTION

Suzlon was formed in 1995. It is a vertically integrated wind power company. It makes and installs wind turbines, and manufactures blades, generators, panels, and towers in-house. It also delivers turnkey projects through its project management and installation consultancy, and operations & maintenance services. Suzlon has offices, R&D and technology centres, manufacturing facilities and service support centres spread across the globe, with its head office in Pune. Suzlon has cumulatively added over 11000 megawatts of wind power capacity for over 1,700 customers in India across 40 sites in eight States. Suzlon accounts for nearly one-third of the country's total wind installations.

There is a saying: Practice what you preach. Since the Company's arena is renewable energy, when the company wanted to construct their new office building, it was considered apt to make it a green and energy-efficient building. This would give their clients confidence that if the manufacturer has a green and energy efficient building, they would be more competent to give to clients efficient solutions for their needs of renewable energy. The building would also demonstrate the commitment of the manufacturer towards renewable energy and would be an effective marketing tool.

Suzlon Energy Limited, together with the architect Christopher Charles Benninger, pledged to create the greenest office in India. Living the motto of the company, 'powering a greener tomorrow', the architect relied exclusively on non-toxic and recycled materials. The Suzlon One Earth campus is the corporate headquarters of Suzlon. It is located in Hadapsar, Pune, India. The climate in Pune is dry and tropical where the temperature ranges from 25 to 40 degrees Celsius from winter to summer. The place was conceived with a business and functional need to bring all business verticals and corporate services under one roof, which although linked to each other would be independent enough to be able to perform as per their respective needs and requirements. It is one of the greenest corporate campuses in the world. It is divided into five interconnected, individual buildings that are aptly named after the elements of nature – Sun, Aqua, Sky, Tree and Sea.

DESCRIPTION

It was designed in 2005, and completed in October 2009. A million square feet of ground plus two levels in a 10.4 acre urban setting achieved a LEED Platinum level certification standard (56 out of 57 points) and TERI GRIHA 5 Star certification with 8% of its annual energy generated on-site

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through photovoltaic panels and windmills with a total incremental cost of about 11%. While 154 KW of electricity is produced on site (80% wind and 20% photovoltaic), all other energy (4MW) is produced in Suzlon's wind mill farms. Thus, this project is self-sufficient in terms of energy requirement.

Through sustainable practices like rainwater harvesting, on-site waste conversion and an 'Office in Garden' design to maximise daylight use, Suzlon One Earth successfully reduces its operating cost by 35%.

Drawing clues from vernacular architecture, while respecting nature and culture, this sustainable and efficient design provides 75% of the work stations with daylight and external views, allowing inhabitants to enjoy seasons, weather conditions and to connect with the time of the day. During the design process, the needs of Suzlon were growing and changing almost from week to week. Hence the Architect decided that there was a need to create a transformational system that by its very nature was less specific and more general.That led to the creation of a simple arrangement of Server Spaces and Served Spaces. The Served Spaces cover the major portion of the campus where people work. These are flexible and adaptive cold shells that can accommodate modular walls and furniture systems. These are served by more rigid cores that house wet areas, utility shafts, ducts, fire stairs, elevators, entry and reception areas that will not change over time. "Modules" like the silo fire stairs; the benchmark glass cylinders and the 8.4 metre by 8.4 metre modules that can be used like a Lego Set and moved about in one's mind to create internal and external spaces.

The design process started with a premise of creating a central gathering space, or Brahmasthan, with the sky as its ceiling. It was conceived as a "secret internal garden" that gifts an exclusive and unique feel to the campus. There is visual access to the large central gardens from everywhere. There is a sense of connection between the various kinds of spaces right from the underground entries vide the sunlight that descends there from the Sky Courts and the Glass Cylinders and the vegetation that flows from these elements, up through the cylinders into the main circulation nodes of the building. They act as visual connectors between all floors and allow aeration of the basement parking area.

In ancient Indian temples, such as the Meenakshi Amman temple of Madurai, there would be a deep-stambha and usually a water-body such as a pool too. Drawing inspiration from that concept, in this project, the Deepa Stambh is set in the centre of the Suzlon reflecting pool. The pool rests at the basement level, wherein all of the cafeteria and the dining room open onto the water. In the background, these see a cascade of water falls, flying down three levels of tiers, with traditional step-like objects giving rhythm to the backdrop. A long water basin feeds the water falls through a pumping system. The lineal basin links the Brahmasthal to a fountain toward the east. These auspicious components protect the campus from unwanted influences and create a central focus and landmark. They bring very Indian features within a very global, high-tech ambiance. Large water body in the central court helps in improving the air quality and for evaporative cooling. All the external landscape areas are brought into the indoors along the perimeter of the building bringing fresh air, nature and natural light into the work areas so as to improve productivity of occupants. This central garden plaza encourages communication, interaction and innovation among the 2300 colleagues and provides a stunning aesthetic presentation for visitors.

In the Wind Lounge, there is a very traditional Indian Chowk here, with kund-like steps leading into a water pool shaded by photovoltaic panels allowing filtered light in, as if through an ancient jaali. Aluminum louvers act as a protective skin allowing daylight and cross ventilation. All areas have operable fenestration allowing natural air and ventilation when possible. These strategies resulted in lower, thinner and longer building shapes that increase the ratio of fenestration to volume, enhancing natural light and ventilation in hot and dry climatic conditions. The building employs a complex building management system. Lighting of individual offices is controlled by combined daylight and occupancy sensors. Sixty five percent of energy is saved by use of LED outdoor light systems in comparison to conventional scheme. Thirty to 40% reduction in operating cost, due to energy savings and water savings at 30%.

A photograph of the Suzlon One Earth Campus

I) Project Performance Targets – Energy

a) Carbon Neutral (through on site + off site energy)

– Zero Net Energy for Lighting (through On-Site generation)

i. PV systems integrated in design
ii. Micro Wind
iii. Biomass (Kitchen waste + STP output + landscape Waste)

b) Positive Life Cycle cost of all investments

Energy Systems (Except renewable to have a pay-back to be less than 5 years)

II) Building Performance Targets

a) Envelope Performance
   i. Minimal Heat Gain (40% better than ASHRAE 90.1 2007 and ECBC envelope Standards), due to use of cavity walls
   ii. 100% shaded Glazing during summer
   iii. Natural ventilation potential in transition spaces – Daylighting (more than 90% Daylit spaces)

b) Illuminance Levels
   i. As per NBC 350 Lux average – Lighting Load (less than 0.8W/square feet)
   ii. Suspended direct indirect light fittings
   iii Desk and furniture mounted task light

III) Energy end use

a) Optimized building design to reduce the conventional energy demand

b) Optimized the energy performance of the building within specified comfort limits

IV) The Envelope consists of high-performance glazing (with cavity):

a) The exposed glass is 4mm clear Annealed + 0.76 mm Polyvinyl butyral (PVB) + 6mm KT 455 + 12 mm air gap = 6 mm Clear Heat-Strengthened

b) Thermal transmittance (U-value) of 0.32 BTU/hr square feet^{0}F and Solar Heat Gain Coefficient (SHGC) of 0.26 which is less than 0.3 prescribed by Energy Conservation Building Code (ECBC) for moderate climate zones. Thus, no additional shading required for these.

More than 75% of Regularly occupied spaces are day lit with a Daylighting Factor more than 2.5%

V)Efficient Lighting Design

a) Dimmable ballasts in conjunction with daylight sensors are used throughout the Open Office space.

b) General Lighting at 350 Lux.

c) The Artificial Lights - dimmed up & dimmed down from 0% to 100% depending on the adequacy of available daylight to meet the 350 lux requirement.

d) The Task Lights have an Intelligent Built-in Occupancy sensor in conjunction with a Continuous dimmer.

e) Lighting of individual offices is controlled by combined daylight and occupancy sensors.

f) 90 % of the Luminaries in the Office space are with dimmable ballasts & are either connected to Occulux sensors, daylight sensors or OccuSwitch sensors.

g) The installed lighting of office spaces has been designed at 0.8 W/sq. ft., 0.75W/Sq.ft. for cores, 0.23W/ sq. ft. for basement parking. Overall Lighting Power Density (L.P.D.) by whole building area method is 0.8 W/ sq. ft.

VI) Energy Efficient Heating Ventilation Air Conditioning (HVAC) System

a) System flexibility of variable refrigerant volume system

The indoor unit's cooling operation can be controlled to maintain desired temperature in any location in the premises according to end user's needs and preferences.

b) Pre-cooling and heat recovery at Treated Fresh Air Units (T.F.A.s)
A sensible heat exchanger is used as pre-cooler to sink the temperature of incoming air (say 38.4°C Dry Bulb temperature (DBT) approximately) to approximately 27.66°C.

c) Direct-indirect evaporative cooling
1) Sensible cooling of approximately 130% of fresh air in an efficient heat exchanger, using pre-cooled water.
2) Further cooling of air, and simultaneous coing of water in indirect evaporative cooling section of the unit. Air required for cooling tower part this section is drawn from the outlet of the same section. (This is the excess 30% quantity which has been cooled in the first and the second sections). This air is termed commonly as "scavenge air".
3) Direct evaporative cooling of 100% air in the final section.

VII) Energy Performance
Energy savings are 42% over Benchmark Energy Consumption recommended by GRIHA

VIII) Energy: Embodied and Construction

a) Utilization of fly-ash (15% replacement of cement with fly-ash by weight) in the building structure

b) Reducing volume, weight. and time of construction by adopting efficient technology (Low Energy Technology/materials in structural application by use of Post-tensioned(PT) Slaband Low Energy Technology/materials in non-structural application by use of Autoclaved Aerated Blocks(from a factory located a few kilometres away)

c) Using low-energy material (Recycled, local/ regional materials, rapidly renewable, low emitting materials)in the interiors

IX) Renewable Energy

- Utilization of Renewable energy Building integrated photovoltaics (BIPV), solar panels and windmills
- Hot water system based on Renewable energy (100% Hot water requirement met by Solar Water Heating System installed on the site)

X) Water

a) Reduce landscape water requirement by following methods
i. Selection of species
ii. All permanent planting is of native species
iii. Minimization of high maintenance lawn area
iv. Placements of trees along with shrubs
v. Planting of shrubs and ground cover on all exposed soil surfaces
vi. Use of mulching is done to aid plant growth, and retain soil fertility and moisture
vii. Seasonal maintenance plan
viii. Integrated pest control plan
ix. Innovative ways to control wastage of water
x. Use of water from non-potable sources

b) Reduce building water use by following methods
i. Water Closets: Dual flush – Full (6 litres per flush) and half (3 litres per flush)
ii. Sensor Based urinals
iii. Efficient flow and plumbing fixtures: Pressure reducing device and water conserving shower heads

c) Efficient water use during construction by following methods:
i. Use of Ready-Mix concrete
ii. Efficient curing system
iii. Chemical curing

d) Use of Recycled Water for various construction processes, such as:
i. For tile cutting
ii. For cleaning Batching plant

e) Recycle, recharge and reuse of water

i. Waste water treatment
- WTP2 – Water Treatment Plant for Raw Water
- RO - Water Treatment Plant using RO Technology – Max 200LPH
- WTP1 - Water Treatment Plant for Rain Water Harvesting System (Recycle and reuse)
- STP – Sewage Treatment Plant (Recycle and reuse

ii. Water recycle and reuse: Annual reuse of water : 58.33 % average (with maximum upto 87 % during the rainy season)

XI) Waste Management

a) Reduction in waste during construction
b) Efficient waste segregation
c) Storage and disposal of waste
d) Resource recovery from waste

XII) Health and well-being of occupants

a) Use of low volatile organic compounds (VOC) paints/adhesives/sealants
b) Minimize ozone-depleting substances
c) Ensure water quality
d) Acceptable outdoor and indoor noise levels
e) Tobacco and smoke control
f) Provide the minimum level of accessibility for persons with disabilities.

XIII) Other energy efficient measures

a) Car-pooling: Car-pooling is encouraged by providing 5% of total vehicle parking capacity on site as dedicated parking for carpooling.
b) E-charging points: Electrical charging points to serve 97 vehicles (16.9% of Total Vehicle Parking capacity) at one time.
c) Environmental education
d) Offsite green power producing more than 50% of the energy requirement of the campus
e) Zero waste management policy
f) Construction on renewable energy

XIV) Practices to reduce air pollution during construction

a) Trucks carrying building materials were covered with tarpaulin
b) Batching plant was enclosed with tin sheets to reduce spread of particulate matter
c) Awareness programmes: the labourers were made aware of methods to reduce air pollution such as dust, by supervisors.
d) No smoking policy on site during construction
e) Water spraying to reduce dust from flying here and there

Net Impact of the above methods

Performance Metric	Impact/Savings
Energy use	Approximately 47%
GHG impact	Approximately 50%
Water use	Approximately 60%
Material use	Approximately 40% offset by recycled and renewable
Cost (incremental)	Approximately 10%
Pay-back period	Approximately 2 years

CONCLUSION

It has become the need of the hour for global corporations to have sensitively designed buildings which reflect their values, concerns for environment and the image of the new age. It calls for designing buildings in India with sensitivity towards climate. The Suzlon One Earth is an example worth imitating.

REFERENCES

1. www.suzlon.com
2. www.archdaily.com: Suzlon One Earth Global Corporate Headquarters/ Christopher Benninger
3. www.mgsarchitecture.in: Suzlon One Earth, Pune
4. worldarchitecture.org: Suzlon One Earth
5. Jain K.D. (EDS), Suzlon One Earth

CONSTRUCTION OF BUDDHA SAMYAK DARSHAN SANGRAHALAYA AND SMRITI STUPA AT VAISHALI, USING GREEN AND SUSTAINABLE CONSTRUCTION TECHNIQUES

Ram Babu Prasad* And Anupam Sunil**

Abstract

The construction methodology of the project is based on sustainable green and efficient building design principles, as such Stupa construction is going to be done first time in modern history of India completely through Stone masonry wherein the hollow dome structure will preserve relics of Buddha and help in spreading historical glory of Bihar to whole world. The programmatic requirements, orientation, and restrained materials palette were thoroughly evaluated and considered in order to reduce the buildings energy use, maintenance and provide a sustainable outcome.

INTRODUCTION

Buddha Smriti Stupa and Buddha Samyak Darshan Sangrahalaya at Vaishali (Bihar) is a proposed museum and stupa to house the Lord Budha's original holy relics which were found in a bamboo basket during archeological excavation. The Main Stupa will be constructed completely through Stone masonry wherein the hollow dome structure will preserve relics of Buddha and help in spreading historical glory of Bihar to whole world. This unique Budha Stupa structure built through stone masonry construction is going to be built first time in modern history of India. The design and construction of the project is done keeping the local environment in mind with the key concepts of creating an energy efficient, environmentally friendly structure.

Being an important pilgrimage place and a land with rich archaeological remains, ancient Vasihali city site, today attracts many tourists and pilgrims. Buddha Memorial (Smriti) Stupa and Theme Museum, i.e. Buddha Samyak Darshan Sangrahalaya, at Vaishali is designed to re-create the Heritage site into a Buddhist centre of world eminence. This project will be going to provide remarkable contribution to the Buddhist Circuit as visioned by Hon'ble Chief Minister Bihar, Shri Nitish Kumar.

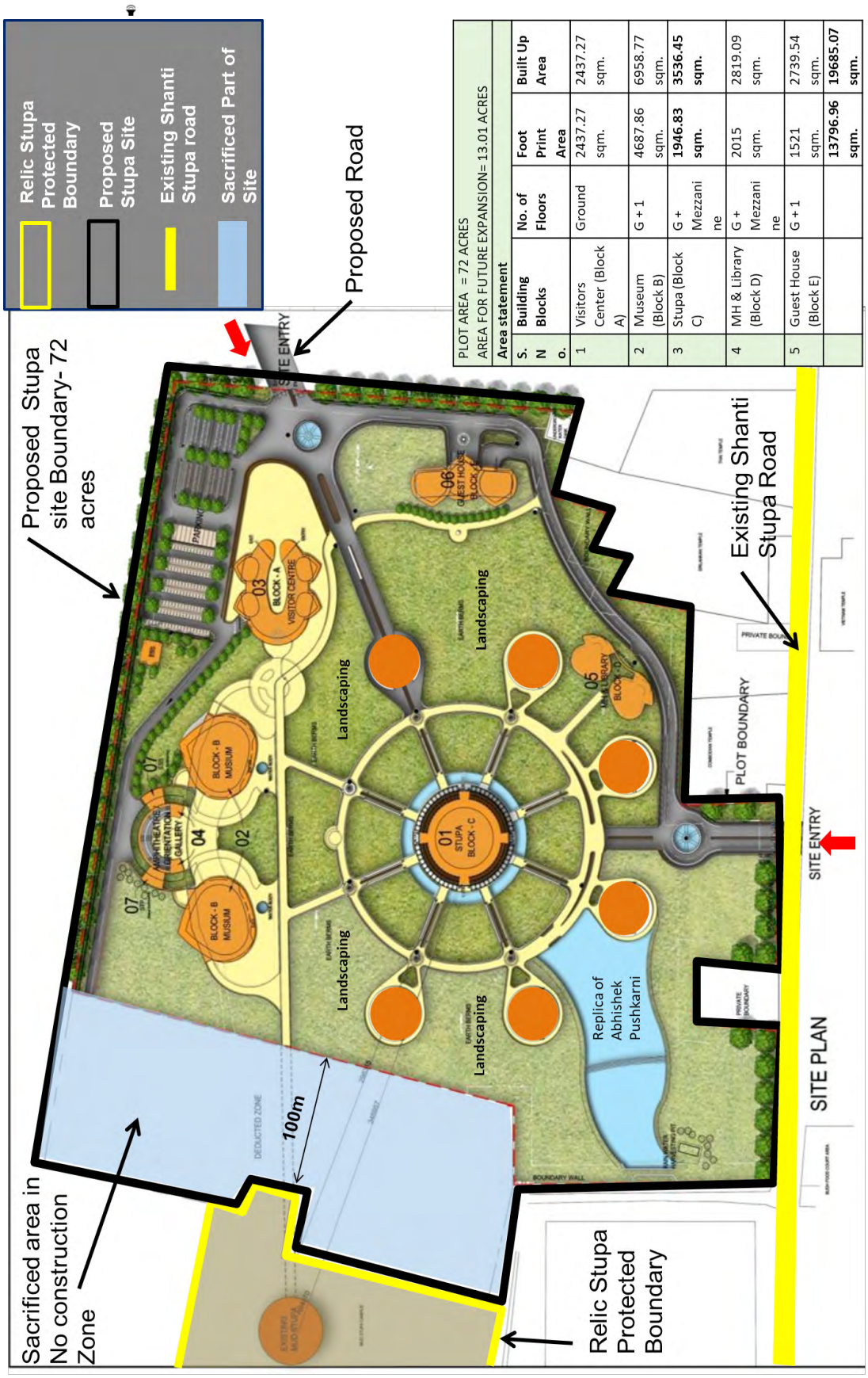
SALIENT FEATURES OF THE PROJECT

The master plan of site integrates with the surrounding as two approach roads have direct view of stupa and also axial linkages to shanti stupa, and surrounding monasteries of different countries of the world that follow Buddhism. A seamless connectivity between building blocks of different usage ensures crowd management during peak visitor traffic. The museum block is the core design component of project and its necessity in giving the visitors an insight in Buddha's life & Vaishali importance can't be ignored. The visual connectivity from visitor's point of view has been kept as prime objective of site layout design which has following built structures:-

Buddha Smirti Stupa

- This has been planned as a unique semi spherical hollow dome, to be constructed in dry stone masonry to replicate the heritage and to maintain the vernacular architecture of the sites of Bihar.
- The internal Diameter of stupa is 44.0 m (144.32ft), and the height including Chattra is 43.50m (142.68ft) so that it can accommodate up to 2000 visitors at a time.
- Dome will be constructed with 40,000 nos.

Executive Engineer, BCD Bihar &Project Architect, Urban Planner, BCD, Bihar*



PLOT AREA = 72 ACRES
AREA FOR FUTURE EXPANSION= 13.01 ACRES

Area statement

S. No.	Building Blocks	No. of Floors	Foot Print Area	Built Up Area
1	Visitors Center (Block A)	Ground	2437.27 sqm.	2437.27 sqm.
2	Museum (Block B)	G + 1	4687.86 sqm.	6958.77 sqm.
3	Stupa (Block C)	G + Mezzanine	**1946.83 sqm.**	**3536.45 sqm.**
4	MH & Library (Block D)	G + Mezzanine	2015 sqm.	2819.09 sqm.
5	Guest House (Block E)	G + 1	1521 sqm.	2739.54 sqm.
			13796.96 sqm.	**19685.07 sqm.**

Proposed Master Plan of Project

(approx.) Rajasthan Dhaulpur Sand Stone (Bansi Paharpur and Bharra stone blocks.)

- The Stupa follows Buddhist architecture elements consisting of four Nos. Torana (Gate), Chhatra at the top, Pradkshina path, Vedica (railing) and semi spherical dome.
- Considering the large volume of dome, cutouts and small openings is provided for natural ventilation and diffuse light thus creating healthy environment inside the stupa for meditation & enlightenment of visitors.
- Indian Buddhist architecture style in stupa has been followed with major reference towards Sanchi stupa along with integration of modern style by providing niche on uter surface at four directions for display of Lord Buddha Statues.

Theme Museum (Buddha Samyak Darshan Sangrahalya)

- Museum has been planned in two blocks (Hall 1 and Hall 2) with petal shaped roof design symbolic to nature and has built-up area of approx. 5200 sq.mt.
- The 2 blocks of museum will be connected by Orientation Gallery, Amphitheater & Information Center for smooth flow of visitors.
- The Hall 1 is dedicated to Buddha's life, his vision, preaching and teachings.
- The Hall 2 is an exposure to give visitor an insight of Buddhism journey from past to present and various historical and contemporary art styles of Buddhism.
- Orientation gallery will help to understand conceptual organization of Exhibit, Brief overview of the major components & how they are interrelated to one another to form a coherent view of project.

Buddhist Library and Meditation Hall

- Designed as a centre for learning, these two blocks have low height single storied halls with petal shaped roof above. Each having an area of approx. 630 sqm and are oriented towards stupa for clear vision &linkage from inside space.
- Meditation hall will provide serenity to the visitors and worshipers of Buddhism whereas Library will enrich visitor's knowledge about Lord Buddha & Buddhism.

Visitor Center

- Being located close to the site entry, having petal shaped roof and connected through pagodas, it is divided in four blocks to be used for reception, ticket counter, visitor information, merchandising and food court.
- A theme courtyard has been provided in the center of this block for creating an insight of the various space of the site.

Amphitheater

- An Amphitheatre to be used for recreational activity has been provided between the two halls of Museum for exposure of visitors towards the stupa.

Guest House

- A two storied building with petal shaped roof to accommodate visiting VIP'S & other public having 5-VIP units and 150 bedded dormitory.

SUSTAINABLE & GREEN ARCHITECTURE PRACTICE

The design and construction of the project is done keeping the local environment in mind with the key concepts of creating an energy efficient, environmentally friendly structure. The programmatic requirements, orientation, and restrained materials palette were thoroughly evaluated and considered in order to reduce the buildings energy use, maintenance and provide a sustainable outcome.

Sustainable Architecture Design

The project components which will give a sustainable outcome are:

- The proposed stupa will help to gain the sense of old stupa as it is being built in traditional stone masonry and an idea to recreate past. Visual integrity of existing Mud stupa (an ASI protected site) is done with new proposal and axial visual linkage to nearby monasteries with focus on landscape development. The existing mud stupa where original Buddha relic was found in archeological excavation is about 2 feet above ground in dilapidated condition.
- The proposed Stupa will rely on natural ventila-

tion for cooling as the hot air will move over the water body surrounding the stupa and further enter in the structure through multiple openings at lower level. Being a spherical dome structure the hot air on upper portion will move out through small opening located at 25m above ground while the cool air coming from lower openings will take its place. The use of natural ventilation through correlated movement of hot and cool air will save electricity and maintenance charges for the main stupa. The stupa is positioned centrally to the site with water bodies and landscaped corridor along it to create a green environment.

- Keeping Stupa in the center of the site, five circular gardens are projected out including a sixth focal point as meditation centre block which depicts Buddha's six senses. The sense gardens are built to create a link between visitors and nature through landscape elements. Gardens of senses appear to unite towards Stupa along with support buildings thus creating a focal point for the main structure.
- Large land parcels have been kept free on exterior portions of site in all directions to create harmony with the rural context of the site. Green landscape and tree plantation is proposed on the western side in the buffer zone between the old and new stupa to create a transition zone.
- The landscaping in the site is merged with the elevated pathway for the pedestrian movement with earth berm on either side. These earthen berms will connect the green landscape and built form thus diminishing the boundary between built and unbuilt. The pedestrian Ramp takes through the journey of Buddhism (Past, Present & Future) wherein Past through Museum, Present through Relic stupa and Future through proposed Buddha Smriti Stupa

Green and Energy Efficient Building Design

The most important element of green building design for this project is energy efficiency which is achieved through orientation of buildings on site, non-displacement of the existing soil, Energy efficiency through use of stone masonry and Landscaping work towards achieving green environment. Higher levels of energy efficiency reduce carbon emissions from project's own energy systems and the project is aiming for GRIHA rating going through following design strategy:

- **Location, Size and Building Design**
  Green building starts with environmentally-sensitive land use by going for smaller building footprint as it uses less energy and fewer construction materials. The smart building form maximizes solar benefits and day-lighting while reducing energy use via efficient landscaping and shading. The ground coverage of buildings is about 6% of total site area which results into emergence of site as a green estate where buildings are part of landscape without disturbing the site endurance.
- **Green Building Materials and Waste Reduction**
  Specific materials have been used which include non-toxic materials and furnishings, recycled-content or salvaged materials, and materials from renewable sources such as sandstone. Using green building materials will help to ensure a healthy indoor environment while reducing the project's overall environmental impact. Careful design and planning has helped to reduce construction waste that would otherwise need to be disposed of, often in landfills or by burning. The pathways have been designed in multiple levels with juxtaposition of landscape elements thus creating visual pleasure for visitors from different angles with the focal point as stupa. The excavated soil during foundation activity is effectively used on site for landscape without disposing off out of site.

- **Water Efficiency**
  The design help to conserve one of our most vital resources - water. Features like water-conserving irrigation systems, reduced lot size and low-water-use landscaping, water-efficient indoor fixtures all contribute to overall water efficiency. Water bodies in lower part of the site will function as natural rainwater harvesting pits where the entire site drainage is oriented which further links onwards to ancient "abhishek pushkarni" pond near the site.

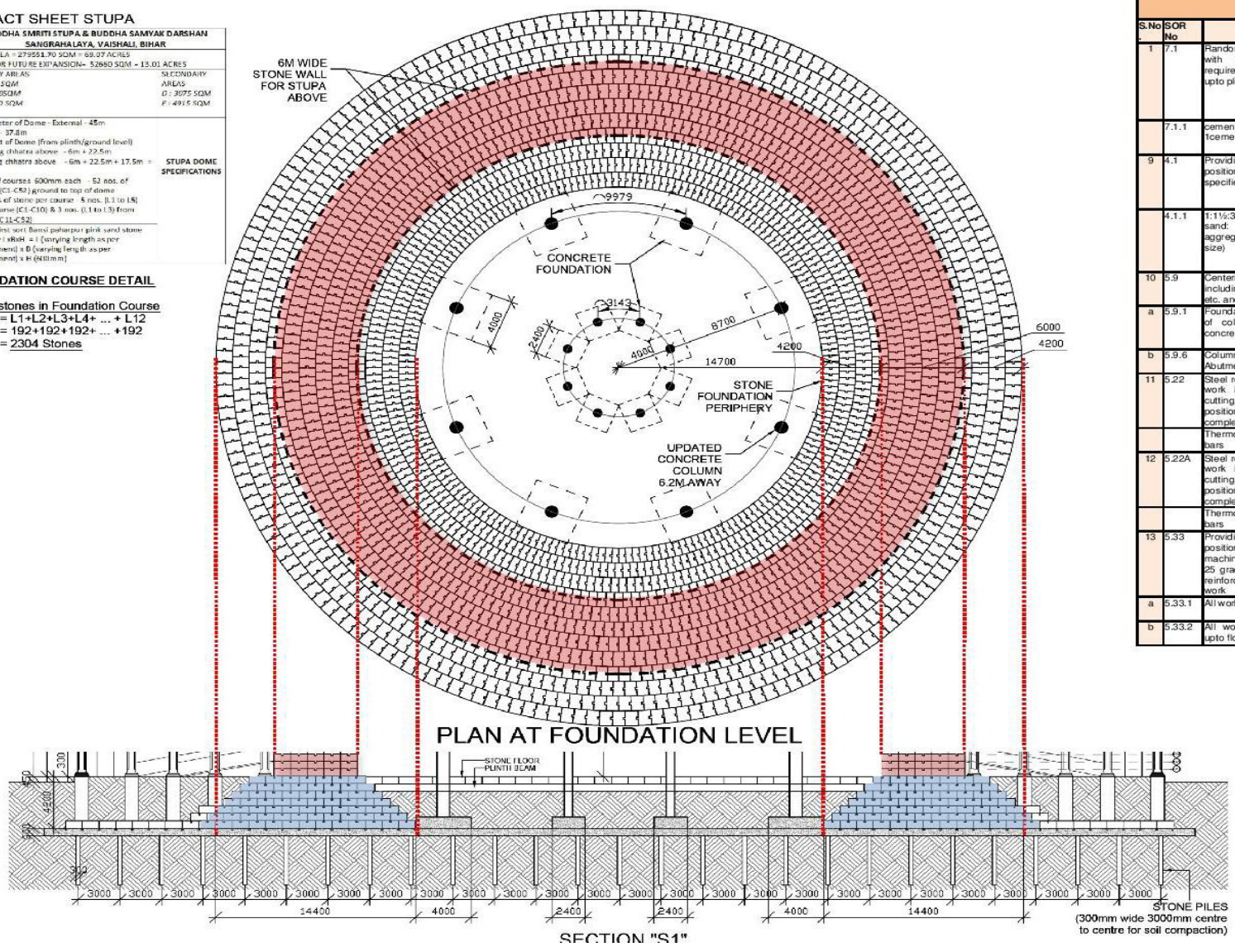
PLAN AT FOUNDATION LEVEL

FACT SHEET STUPA

BUDDHA SMRITI STUPA & BUDDHA SAMYAK DARSHAN SANGRAHALAYA, VAISHALI, BIHAR	
PLOT ARLA = 279551.70 SQM = 69.07 ACRES	
AREA FOR FUTURE EXPANSION= 52680 SQM = 13.01 ACRES	
PRIMARY AREAS	SECONDARY AREAS
A : 5480 SQM	D : 3075 SQM
B : 39300SQM	E : 4915 SQM
C : 19910 SQM	
1) Diameter of Dome - External - 45m Internal - 37.8m	
2) Height of Dome (from plinth/ground level) Excluding chhatra above - 6m + 22.5m Including chhatra above - 6m + 22.5m + 17.5m = 46.0m	STUPA DOME SPECIFICATIONS
3) No. of courses 600mm each - 52 nos. of courses (C1-C52) ground to top of dome	
4) Layers of stone per course - 5 nos. (L1 to L5) from Course (C1-C10) & 3 nos. (L1 to L3) from Course (C11-C52)	
Note- First sort Bansi pahalpur pink sand stone with size (aBxH = (varying length as per requirement) x b (varying length as per requirement) x H (600mm)	

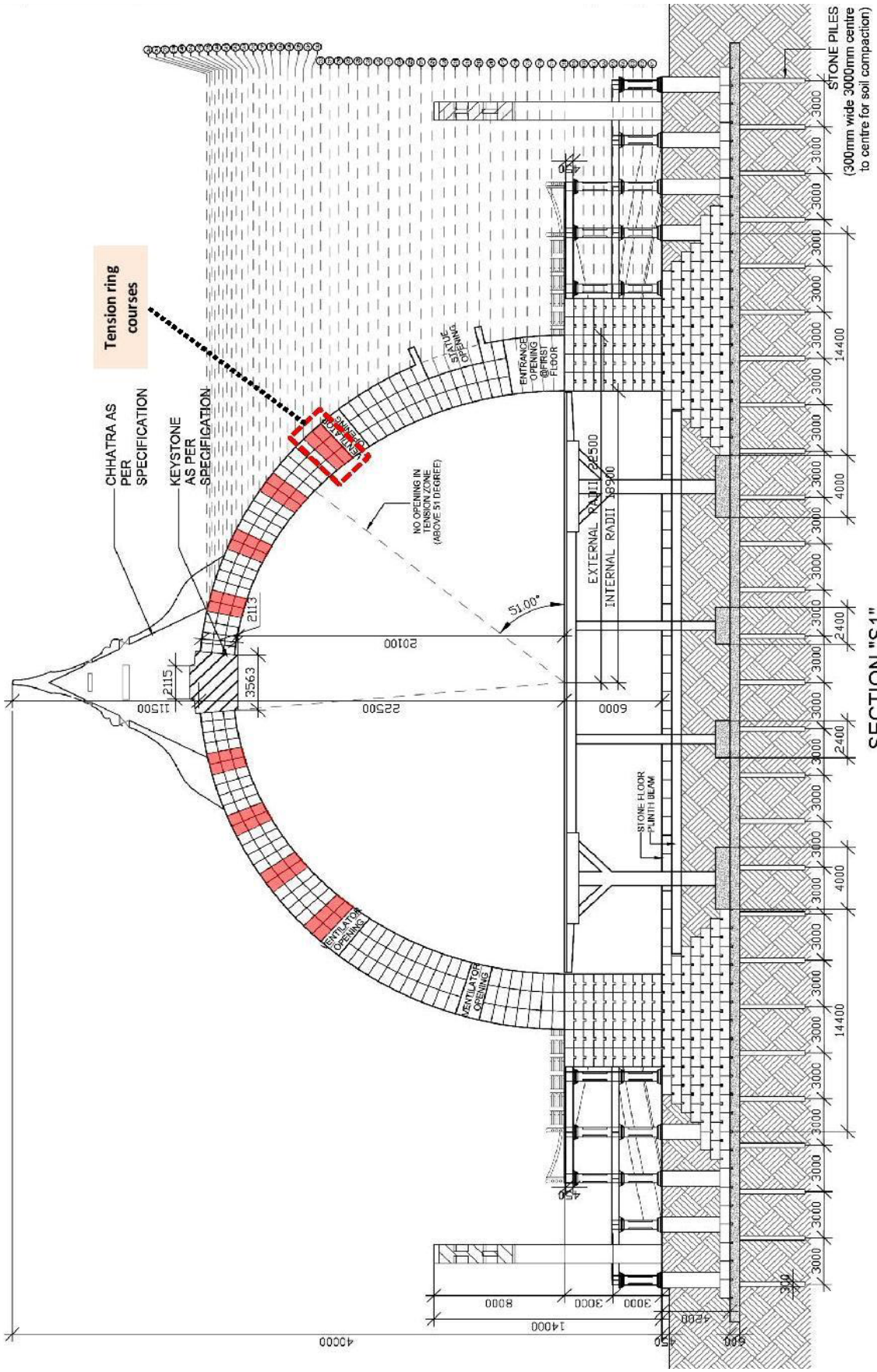
FOUNDATION COURSE DETAIL

No.of stones in Foundation Course
= L1+L2+L3+L4+ ... + L12
= 192+192+192+ ... +192
= 2304 Stones

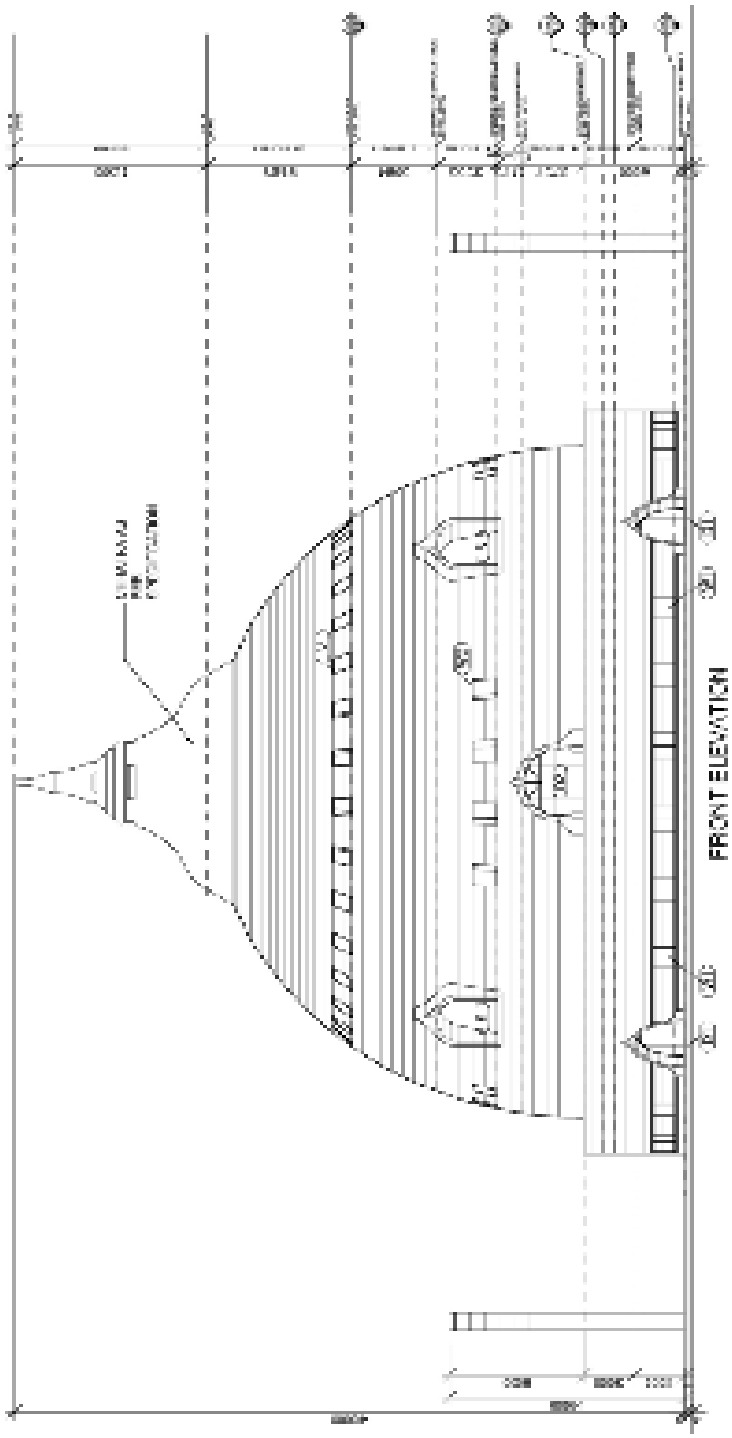


Items				
S.No.	SOR No	Description	Unit	Rate
1	7.1	Random rubble masonry /infill with white sand stone of required size in foundation upto plinth level with		
	7.1.1	cement mortar 1: 6 (1cement:6 coarse sand)	cum	2643.20
9	4.1	Providing and laying in position cement concrete of specified grade		
	4.1.1	1:1½:3 (1 Cement: 1½ coarse sand: 3 graded stone aggregate 20 mm nominal size)	cum	5924.65
10	5.9	Centering and shuttering including strutting, propping etc. and removal of form for :		
a	5.9.1	Foundations, footings, bases of columns, etc. for mass concrete	sqm	193.95
b	5.9.6	Columns, Pillars, Piers, Abutments, Posts and Struts	sqm	467.85
11	5.22	Steel reinforcement for R.C.C. work including straightening, cutting,bending, placing in position and binding all complete upto plinth level		
		Thermo-Mechanically Treated bars	kg	56.6
12	5.22A	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete above plinth level.		
		Thermo-Mechanically Treated bars	kg	56.6
13	5.33	Providing and laying in position machine batched and machine mixed design mix M-25 grade cement concrete for reinforced cement concrete work		
a	5.33.1	All works upto plinth level	cum	6446.45
b	5.33.2	All works above plinth level upto floor V level	cum	7250.05

Foundation Details



Sectional Details of Stupa Wall and Foundation



Front Elevation of Stupa

- **Indoor Environmental Quality**
  The use of non-toxic materials, combined with natural ventilation and effective air filtration will help improve indoor air quality in the museum building specifically. The controlled indoor moisture levels will protect users from mold, chemicals, combustion by-products and other indoor pollutants.

DESIGN OF STONE MASONARY STUPA

Initially, the project is conceptualized to make it unique by constructing it in stone masonry to preserve Lord Budha's holy relics. A detailed discussion with the masonry expert of IIT Roorkee, IIT Delhi and IIT Patna were done to understand the best practice. A study of structural design of few existing monumental masonry dome type structure like "Goal Ghar" of Patna," Vipassana Pagoda"of Mumbai have been done before preparing the detail design of stupa. Features like foundation system and structural design has been prepared as per requirement and will be looked into at the time of execution.

Conceptual view of Stone Masonry Stupa

DETAIL DESIGN AND CONNECTION DETAILS OF STONE MASONARY UNIT ARE AS FOLLOWS

A detail study has been done to design the interlocking system of stone masonry unit to check the safe transmission of all types of forces including seismic force from superstructure to the substructure. Interlocking arrangement of some existing structure like Vipasana-Pagoda and Akshardham temple, Ayodhya temple has also studied to understand the nature of forces on structure. A sequential analysis for stability (including seismic forces) during construction of stone Masonry wall has also been done to assure the safe construction of Dome structure. Finally a small scale of wall model has been prepared and tested on shake table in IIT Patna upon which final details were worked out for construction which are as follows:

COMPARISON WITH RCC DOME STRUCTURE

Detail analysis was done for structure design of stupa for both construction methodologies to understand the behavior of structure. Detail STAAD modeling had been prepared for the same Stupa using RCC as a construction material and later detailed analysis and design was also carried out on that STAAD model. The detailed quantity calculation and cost estimation of Masonry Stupa and RCC Stupa has been done to understand the variation in both construction methodologies. Summary of cost analysis of both are as follows:-

Item	Stone Masonary Stupa	RCC Stupa
Cost inclusive finishing all complete	131.00 Cr.	102.00 Cr.
Assessed life of structure	More than 1000years	About 100years

Cost Comparison

Cost of Stone masonry stupa is about 28.40% above than RCC structure, but considering the longevity, historical and monumental importance construction of Stone Masonry Stupa is quite justified.

CONCLUSION

- The low-rise buildings and scattered development of site allows for simpler materials and passive climatic solutions, which are a key to economic sustainable design.
- The use of natural ventilation through correlated movement of hot and cool air will save electricity and maintenance charges for the main

stupa. The integration of built environment with landscape and water bodies will help in saving energy costs and increase sustainability of buildings.

- The concept of integrating nature with architecture to achieve green sustainable design is preliminary focused on minimum ground coverage by buildings to give maximum area for green development.
- It is one of the largest Stone Masonry Stupa to be built and first time in history of modern India having its expected life span of more than 1000 years.
- The use of sustainable building material such as sandstone is used, so that exterior of stupa building merges well with the historic environment and surroundings.
- Being a monumental historical building, very precise Geotechnical investigation including MASW test for Liquefaction has been performed, proper mitigation has been done to take care of any type of settlement due to liquefaction during future seismic action at PGA-0.44g.
- Sufficient numbers of Dhaulpur sand stone from quarry site has been brought to IIT Delhi for tests. Geotechnical test of sand stone and different types of test on Sand stone masonry wall along with mortar (Lime mortar) has been done before design stage to ascertain all aspects of material.
- SAP Model has been prepared by using actual material property of sandstone masonry unit and stone Masonry. The same model was used to perform Non Linear dynamic analysis of dome structure.
- A sequential analysis for stability (including seismic forces) during construction of stone Masonry wall has also been done to assure the safe construction of Dome structure.
- Using Vibro Compaction Stone pile not only liquefaction of soil has been mitigated upto the depth of 30 meter but also SBC of soil has been enhanced by more than 3 times of the original SBC determined earlier.
- Due to increment of SBC of soil the cost of foundation is considerably reduced. It was found that the Cost of mitigation and ground improvement was not more than 5% of the saving in foundation cost.
- Cost of Stone masonry stupa is about 28.40% above than RCC structure, but considering the longevity, historical and monumental importance construction of Stone Masonry Stupa is quite justified.

REFERENCES

1 IS 1893-Part 1 (2016). Criteria for Earthquake resistant design of structures.

2 IS 4326-2013 Earthquake Resistant Design for Masonary Building.

3 IS 456-2000 PLAIN AND REINFORCED CONCRETE

4 Andrews, D.C.A. and Martin G.R. (2000) "Criteria for Liquefaction of Silty Soils", Proc. 12th WCEE, Auckland, New Zealand.

5 Luehring , R., Dewey , B., Meji a, L., Steve ns , M. a ndBae z , J., 1998, "Liquefaction Mitigation of Silty Dam Foundation Using Vibro -Stone Columns and Drainage Wicks.

6 NEHRP recommended provisions for seismic regulations for new buildings and other structures (FEMA 450), 2003 Edition, Prepared by the Building Seismic Safety Council for the Federal Emergency Management Agency, Washington, D.C.

7 Seismic Guidelines for stone Masonary components and Structures by S.E Chidiac, S.Fooand MS Cheung.

8 Two approach for Analysis of Masonary Structure: Micro and Macro modeling; Paulo B.Lourenco, University of Minho.

9 SEISMIC SAFETY IN ANCIENT STONE DOMES REINFORCED BY AN ORIGINAL METHOD Moshe DANIELI (DANIELASVILI), Arcady ARONCHIK, Jacob BLOCH

10 Domes from Antiquity to the Present. Proc. of the IASS-MSU Int. Symposium. Istanbul, Turkey, May 30-June 3, 1988. Publisher: Mimar Sinan Universities, Istanbul, 1988.

11 BS EN 1052 – 3:2002 Methods of test for masonry

12 Equilibrium Analysis of Masonary Domes by Wanda W Lau Michigan state university

SUSTAINABLE CONSTRUCTION USING RECYCLED CONCRETE AGGREGATES

V. SRINIVASAN*

Abstract

Urban areas have become one of the most intensive sectors in the use of raw materials and energy. Construction sector today has become one of the largest consumer of natural resources and energy in various forms which has become serious concern for sustainable development. The demolition of building structures produces enormous amounts of materials that results in a significant waste stream. The environmental aspects of waste from the building sector have been of great interest in recent years in India as well as in other countries. Utilization of alternative aggregates in the construction sector is increasing these days due to extensive exploitation of natural resources. Recognising the widening gap between demand and supply of traditional materials the promotion of energy efficient, environment friendly building technologies, that could produce building by recycling and reuse of waste materials is the need of the day. Due to large consumption of aggregates, even small reductions of greenhouse gas emissions per ton of manufactured concrete can make a significant global impact on environment. Different approaches for the removal of adhered mortar of RCA (Recycled Concrete Aggregate) are outlined in this paper. Significant amount of research has been carried out on recycled aggregate in concrete and their effectiveness is well documented. The waste generated during the dismantling process has potential to be recycled as raw materials to reproduce building materials or other products. This research article is an attempt to identify issues and possible suggestions to reduce the harmful effect of use of recycled aggregate in concrete.

INTRODUCTION

Urban areas have become one of the most intensive sectors in the use of energy and raw materials. Explosion of population, rapid urbanization and fast growth in civil infrastructure many of old structures being demolished are increasing day by day. Buildings are being demolished due to various reasons like obsolescence due to deterioration, functional performance, natural disasters, reconstruction for better economic gains, etc. The demolition of building structures produces enormous amounts of materials that results in a significant waste stream. The environmental aspects of waste from the building sector have been of great interest in recent years in India as well as in other countries. Indian Construction Industry is an important activity in the economy and it creates impact on the environment due to the quantity of waste generated and the consumption of natural resources. Rapid growth in construction activities in recent years has led to increased generation of construction and demolition (C&D) waste. The major contribution to waste generation is from the demolition of buildings and structures. The wastes are generally disposed as landfills or illegally dumped carelessly on roads, back lanes or drains. Recycled aggregates obtained from construction and demolition waste mainly differ from natural aggregates in that they are composed of natural aggregate with cement mortar attached. Due to adherence of the cement mortar, the recycled aggregates have a lower density and absorb more water than natural aggregates.

The United Nations Environment Programme (UNEP) identified five infrastructure areas for achieving resource efficient urban areas i) Building energy efficiency, ii) Waste Management, iii) Sustainable urban transport, iv) Water / waste water, v) Urban ecosystem management. The generation of construction and demolition waste and municipal solid waste is mostly related to the life cycle of buildings. Recycling of building waste can reduce the need for energy and natural resources, reduce the need

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for land area for extracting resources and reduce the need for land area for land fill. The benefits of recycling depend on the materials and the form of recycling. The construction industry is one of largest exploiters of natural resources both renewable and non-renewable that is adversely altering the environment of the earth. Indian construction will rely heavily on raw materials such as sand (for concrete and mortar), soil (for clay bricks), stone (for aggregates) and limestone (for cement); the extraction and production of which have significant ecological impacts. Some of these materials, especially sand, are already facing supply constraints (environmental bans and restrictions), thus affecting the sector. Current estimated annual consumption of these five categories of materials is shown in Table 1. Table 2 shows the Construction and Demolition waste generation in selected Indian Cities.

Table 1: Estimated Annual Consumption of Construction Materials in India

Sl. No	Material	Quantity
1	Sand	750 million tonnes
2	Soil	350 million m^3
3	Stone (aggregate)	2 billion tonnes
4	Limestone	242 million tonnes
5	Cement	297 million tonnes

Source : Ministry of Housing and Urban Affairs, 2018

Table 2: Construction and Demolition waste generation in Indian Cities

City	Population in Million (Census 2011)	Daily CDW generation (Tonnes / day)	Annual CDW generation* (Million tonnes / annum)
Mumbai	12.44	2,500	0.75
Delhi	16.79	4,600	1.38
Bengaluru	8.44	875	0.26
Chennai	6.50	2,500	0.75
Kolkata	4.50	1,600	0.48
Jaipur	3.47	200	0.06
Patna	2.52	250	0.08
Ahmedabad	6.06	700	0.21
Bhopal	1.92	50	0.02
Coimbatore	2.62	92	0.03

Source : Ministry of Housing and Urban Affairs, 2018
** Daily generation has been multiplied by 300 to calculate annual generation*

In India, C& D waste generated is an environmental, social and economic challenge. The objective is the recovery through recycling of C & D waste in the production of construction materials in order to minimise the environmental impact in urban area. Nowadays, attention has been paid to recycling with in the building sector in several ways. Guidelines and standards have been introduced that will indirectly, promote increased recycling. Natural graded granular materials are conventionally used as a fill material for various civil engineering applications.

In India C&D waste has two components

i) Major components
- Cement concrete
- Bricks
- Cement plaster
- Steel (RCC, door/window frames, roofing support, railings of staircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (demolition of old buildings)

ii) Minor components
- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)
- Electrical fixture(aluminum / copper wiring, wooden baton, switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

Fig. 1 and Table 3 shows the percentage distribution and tonnage of various constituents of C&D waste in India as assessed by the different organisations in different years.

Typical composition of C & D Waste in India

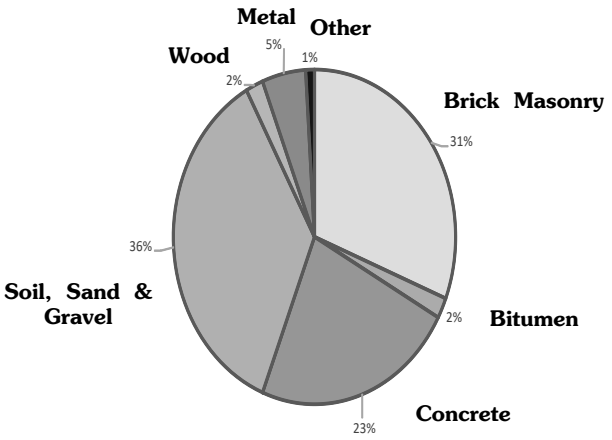


Fig. 1: Typical composition of C&D waste

The use of recycled aggregates in structural concrete is still sparse because their use in concrete posed problems related to workability, strength and durability. The composition of the wastes produced depends on the type of construction, example when a concrete bridge superstructure or flyover is demolished, the wastes will be almost concrete and its steel reinforcement. On the other hand, demolition of old residential blocks may result in the wastes like soil, masonry, brickwork, tiles, wood, metal, plastics, concrete etc. Estimates for the composition of typical demolition wastes in India have been conducted by various agencies as shown in Table 3. Based on TIFAC study, quantum of waste generated during construction is around 35 kg/m^2 of construction activity, while during demolition waste generated is about 350 kg/m^2 of demolition. The Central Pollution Control Board (CPCB) has estimated quantum of solid waste generation in India to be nearly 48 million tonnes per annum for the year 2000, out of which waste from construction industry accounted for about 12 to 14.7 million tonnes. The Fig. 1 indicates the proportion of concrete wastes to vary from 23 to 35 percent and proportion of soil between 32 to 43 percent. With development in data collection, more precise estimates of the composition of C & D wastes will also be available.

Table 3: Estimates of C & D wastes generation in India

Organisation	Quantity (Million tonnes per year)	Year
TIFAC	12 to 14.7	2001
MoEF	10-12	2010
CSE	626	2013
GIZ	700	2015
CSE	530	2016
Jain et al	150	2019

Source: TIFAC- Technology Information, Forecasting and Assessment Council (under DST)

MoEF - Ministry of Environment and Forest, CSE-Centre for Science and Environment

GIZ- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

A glimpse of Construction & Demolition Waste generation in different developed and developing countries is presented in Table 4. During last few decades, considerable research work has been carried out in different countries like Germany, United Kingdom, Japan, USA, China, Hong Kong, Denmark, Netherland etc. and they found in several engineering applications the recycled materials performed well.

Table 4: Construction and Demolition Waste generated annually in various countries

Country	Quantum per year(Million Tonnes)	Year
Australia	19	2009
Belgium	11.02	2011
China	100	2006
France	85.65	2011
Germany	72.40	2011
India	14.7	2005
Ireland	2.54	2011
Japan	85	2000
Norway	1.5	2003
South Korea	61.7	2013
U.K.	99.10	2011
U.S.A	140	2012

Source:

i) Guidelines on Recycling, use and management of C & D Wastes, ICI Bulletin 01

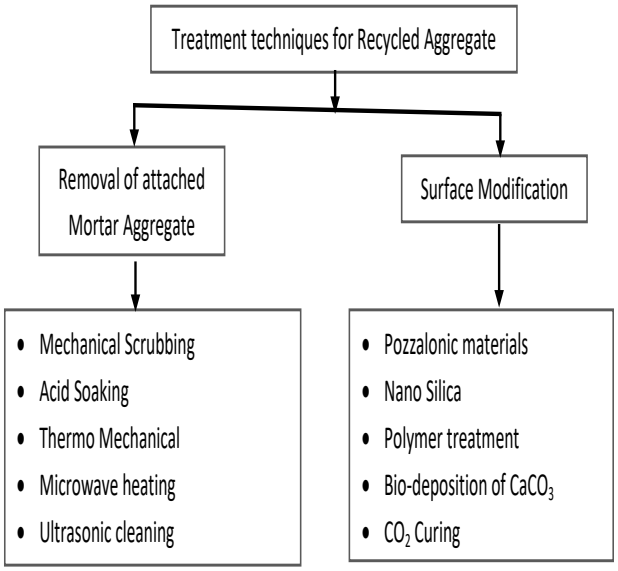
ii) Handbook of recycled concrete and demolition waste 2013

Approximately 2.7 billion metric tonnes of aggregates currently used in USA, 60-70% aggregates are used in structural concrete, 10-15% for pavements, other road construction and maintenance work consumes another 20-30%. Recycled aggregates in the US produced by natural aggregate producers, debris recycling centers and contractors, which have a share of 50%, 36% and 14%, respectively. Target of 90% recycling ratio, actual results improved from a mere 48% in 1990 to almost 96% in 2000, mostly as sub base material in road construction in Japan. In Hong Kong as of the end October 2003, more than 10 projects involving reinforced pile caps, ground slabs, beams and parameter walls, external building and retaining walls, and mass concrete have consumed over 22,700m^{3}of concrete using RA.

TREATMENT METHODS

In order to improve the quality of RA, (Recycled Aggregates) several techniques have been de-

veloped in published literature (Chart 1). The waste generated during the dismantling process have potential to be recycled as raw materials to reproduce building materials or other prod-



Flow Chart 1: Processing method for Recycled Aggregate

ucts. However, these methods can be broadly categorized into two categories. The first category removes the loose mortar particle on the surface and the second category modifies the aggregate surface.

i) Chemical Treatment

Acid corrosion beneficiation technique uses this capability of strong acids to reduce the mortar present in the RCA. The recycled concrete aggregates were pre-soaked in acidic environment at room temperature for 24 hrs. The coarse aggregates were picked and washed with running water to remove acidic solvents. Acidic solvents are adopted, like hydrochloric acid (HCL) and sulphuric acid (H_2SO_4) with a concentration of 0.1 mole. The treated aggregates were dried in sun light and some loose part of adhered mortar generated by the action was removed by milling the aggregates. It has been reported that among the various strong acids tested for the removal of mortar from RCA, the highest mortar removal rates were achieved using sulphuric (H_2SO_4) and hydrochloric (HCL) acids. The efficiency of the chemical treatment method depends on various parameters, including the porosities of mortar and NA (Natural Aggregate), type of acid, acid concentration, acid volume, RCA volume, temperature, container type (static vs. dynamic), soaking duration, etc. However, acid soaking is not suitable for limestone aggregates.

ii) Heating and Scrubbing Method

In heating and rubbing methods, a combination of thermal stresses generated through conventional heating at specified temperature and the mechanical stresses generated through rubbing of RCA are used to remove the mortar. Recycled concrete aggregates were heated in an oven maintained at 300°C- 500°C for 24 hrs to dehydrate the mortar which makes the cement paste brittle and weak. The heated concrete is subsequently sent to the rubbing equipment for removal of the mortar from the surface of coarse aggregates to be removed. However, due to the use of highly energy intensive heating and rubbing treatments, this method is not being environmental friendly. In the mechanical treatment, adhered mortar can be removed by crushing the waste concrete chunks repeatedly adopting two/three stage crushing (Jaw, followed by Impact crushing etc.). The recovered RCA could be further treated by employing mechanical rubbing & scrubbing on its surface.

iii) Coating with Cement Slurry

Coating recycled concrete aggregate with cement slurry improves the bond between the aggregates and cement paste in concrete by modifying the surface. Cement

slurry with water cement ration 0.42 to 0.5 is prepared and mixed with recycled concrete aggregates. Excess cement slurry is then drained. The coated aggregates after drying are cured in water for 7 days.

iv) Coating with cement slurry and Micro Materials

The Micro materials like silica-fume, flyash and ultrafine slag are finer than cement. They are expected to fill the pores as mortar is more effective than the cement alone. 15% comprised of silica fume / flyash ultra fine slag and the remaining was cement. The water to cement ratio of 0.42 to 0.50 was maintained and the recycled concrete aggregates were coated and cured for 7 da

v) Microwave Heating

Natural aggregate and mortar are both dielectric materials and are heated up due to dielectric losses when exposed to microwaves. The extent and pattern of microwave heating of dielectric materials depend on microwave frequency, microwave power and most importantly the electromagnetic (EM) properties of the material. Attenuation factor is an important EM property commonly used to estimate the microwave heating rate. Generally, mortar has a higher attenuation factor and thus is expected to heat up faster than NA when exposed to microwaves.

Mortar removal, is a vital technique, which could produce RCA with similar morphology & properties to conventional aggregates and also, the same mix design approach (use of RCA in dry condition) could be used, not causing any trouble to the site engineers. All the RCA beneficiation techniques described in this paper require a variety of additional mechanical and thermal processes including heating, rubbing, sieving and conveying, which result in an increase in the overall cost, energy use and carbon footprint of recycling. The various approaches for the removal of adhered mortar of RCA are outlined in the table 5.

Table 5: Various Approaches for the removal of Adhered Mortar of RCA

Treatment method	Large scale production	AM (Adhered Mortar) Removal	Ease of operation	Duration	Remarks
Mechanical rubbing	Yes	Medium	Convenient	Short	• More energy consumption • Multiple stage process
Acid soaking	Not suitable	Low	Operator sensitive	Long	• More water footprint • Long residing time • Issue of handling acid • Contamination of aggregates due to sulphates and chlorides
Microwave Heating	Not suitable	Medium	Inconvenient	Very short	• Arching and fire ball formation in presence of organic impurities • Involves specialized equipment
Conventional Heating and scrubbing	Yes	High	Convenient	Medium	• More energy consumption

PROPERTIES OF RECYCLED AGGREGATES

The recycled concrete aggregates are extracted by crushing the hardened concrete, their properties are not same as those of the natural aggregates. This is due to the quality and quantity of the cement mortar adhering to the recycled concrete aggregate particle. It was reported that RCA can be produced with acceptable gradation suitable for concrete construction. However, the recycled concrete aggregates exhibit a lower bulk density, up to 17%, than that of natural aggregate. The water absorption of recycled concrete aggregates was reported to be twice as that of natural aggregates. Recycled concrete aggregates are generally lighter with a specific gravity of up to 6% lower than the natural aggregates. Sulphates and chloride contents of recycled aggregate was similar to that of natural aggregate. As soon as the demolition of a structure occurs, the waste gathered from the demolished site is gathered and put through a rigorous recycling process in order to reuse as aggregates. Before commencing the primary process of crushing it is imperative that the impurities are removed from the construction and demolition waste. Application of specialized equipment is vital in recycling process. Today there are several manufactures producing a variety of equipment such as jaw crushers, magnetic separators, two cone crushers, sieves/ screens, washing equipment, etc.

The recycled concrete aggregates exhibit inferior mechanical properties than the natural aggregates, due to the construction from which the recycled aggregates are extracted. Recycled concrete aggregates extracted from high strength concrete exhibit 42% higher Los Angeles abrasion value, and the corresponding value for the aggregates extracted from low strength concrete was 52%.

Particle Size Distribution

It is observed that recycled coarse aggregate are reduced to various sizes during the process of crushing and sieving (by a sieve of 4.75mm), which gives best particle size distribution. The amount of fine particles (<4.75mm) after recycling of demolished concrete were in the order of 5-20% depending upon the original grade of demolished concrete. The good quality natural aggregate can be obtained by primary, secondary & tertiary crushing whereas the same can be obtained after primary & secondary crushing incase of recycled aggregate. The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock.

Specific gravity and water absorption

The specific gravity (saturated surface dry condition) of recycled concrete aggregate is found from 2.35 to 2.58 which are lower as compared to natural aggregates. Since the RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption in RA ranges from 3 to 12 % with the actual value depending upon the type of concrete used for producing the aggregate. This value is higher than that of the natural aggregates whose absorption is about 0.5 – 1 %. The Table 6 gives the water absorption of concrete with differently processed RCA.

Table 6: Properties of Concrete with differently processed RCA

Processing Method	Water Absorption (%)
Ordinary Crushing	5.61
Improved Jaw and Impact	3.14
Screw abrading crusher	1.85
Acid cleaning (HCL)	0.92
Acid Cleaning (H_2SO_4)	0.81
Heating and rubbing	0.78
Heating (Microwave)	2.80

Bulk Density

The rodded & loose bulk density of recycled aggregate is lower than that of natural aggregate. Recycled aggregate had passed through the sieve of 4.75mm due to which voids increased in rodded condition. The lower value of loose bulk density of recycled aggregate may be attributed to its higher porosity than that of natural aggregate.

Crushing and Impact Values

The recycled aggregate is relatively weaker than the natural aggregate against mechanical actions. As per IS 2386, the crushing and impact values for concrete wearing surfaces should not exceed 45% & 50% respectively. The crushing & impact values of recycled aggregate satisfy the BIS specifications. Table 7 shows the comparison of recycled aggregates and natural aggregates. The Properties of Recycled and Natural Aggregates are presented in Table 7.

Table 7: Comparison of Recycled Aggregates & Natural Aggregates

Properties	RCA1	RCA2	Natural Aggregates
Specific gravity	2.38	2.42	2.65
Water Absorption %	6.58	7.16	1.90
Fineness modulus(<20mm)	6.98	6.96	6.94
Bulk Density (Rodded)	1486	1475	1524
Bulk Density (Loose)	1372	1328	1420
Crushing Value %	32.2	35.3	25.5
Impact value %	48.3	54.5	18.53
Slump (W/C 0.5)	15	10	30

EXPERIMENTAL STUDY ON RECYCLED AGGREGATE

Materials Used

Ordinary Portland Cement OPC 43 grade conforming to IS 8112-1989 was used in the investigation. Locally available river sand passing through 4.75 mm sieve as per IS 383 provisions confirming to zone II were used as fine aggregate. Machine crushed locally available hard granite, well graded 20 mm and down size was used as coarse aggregate. The concrete debris were collected from different sources and broken into the pieces of approximately 80 mm size with the help of hammer & drilling machine. The two different mix proportions of characteristics strength of 20 N/mm^2 and 25 N/mm^2 commonly used in construction of low rise buildings are obtained as per IS 10262 for both recycled aggregate concrete and natural aggregate concrete. Due to the higher water absorption capacity of RCA as compared to natural aggregate, both the aggregates are maintained at saturated surface dry (SSD) conditions before mixing operations with water cement ratio 0.48 and 0.45 respectively for M20 & M25 grade concrete.

Compressive Strength

The average compressive strengths cubes cast are determined as per IS 516 using natural aggregate and RCA at the age 7,14 & 28 days and reported in Table 8 and Chart 2 & Chart 3. As expected, the compressive strength of RAC is lower than

Table 8: Trial mix for (OPC with Natural Aggregate and Recycled Aggregate)

		OPC with RCA & NA (M20)		OPC with RCA & NA (M25)	
		Recycled Aggregate	Natural Aggregate	Recycled Aggregate	Natural Aggregate
w/c ratio		0.48	0.48	0.45	0.45
Superplasticizer		0.45%	0.5%	0.5%	0.5%
Slump		11 mm	27mm	23 mm	34 mm
Compressive Strength (MPa)	7 days	24.1	30.95	24.86	31.26
	14 days	32.45	37.46	33.82	38.54
	28 days	36.86	44.87	38.94	48.26

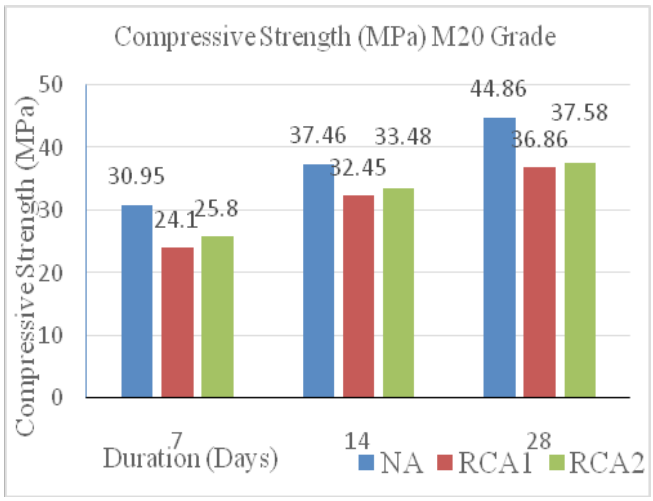


Chart 2: Compressive Strength for M20 Concrete

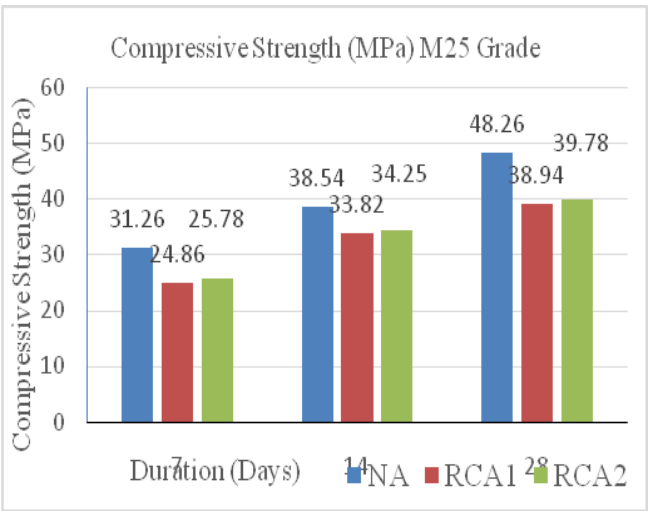


Chart 3: Compressive Strength for M25 Concrete

the conventional concrete made from similar mix proportions. The amount of reduction in strength depends on parameters such as grade of demolished concrete, replacement ratio, w/c ratio, processing of recycled aggregate etc.

CONCLUSION

Indian construction industry consumes the larger amounts of natural resources on earth. The need for the use of recycled concrete aggregates in concrete construction is being realized worldwide from the environmental and sustainable development point of view. Recycling and reuse of building wastes have been found to be an appropriate solution to the problems of dumping of thousands tonnes of debris accompanied with shortage of natural aggregates. The use of recycled aggregates in concrete prove to be a valuable building materials in technical, environment & economical respect. Recycled aggregate possess relatively lower bulk density, crushing & impact values and higher water absorption as compared to natural aggregate. The variation also depends on the original concrete from which the aggregates have been obtained. There are several reliable applications for using recycled coarse aggregate in construction. The alternative options available depend on the local conditions and requirements and vary from one region to another. For instance, in countries with limited natural resources like Singapore, concrete recycling plays a strategic role in providing alternative sources of aggregates for the concrete industry. The most common approach for quantifying the environmental impact of a process is to estimate the energy use and the carbon emissions. With proper understanding of behaviour of recycled aggregate and adoption of necessary precautions, recycled aggregate can find a considerable usage in civil and structural applications. The scientific advancement in recycling and reuse of building waste will lead to a sustainable use of natural resources.

REFERENCES

1. Abbas, A., Fathifazl, G., Fournier, B., Isgor, O.B., Zavadil, R., Razaqpur, A.G., Foo, S., (2009), Quantification of the residual mortar content in recycled concrete aggregates by image analysis, Mater. Charact., 60 (7), 716-728.
2. Building Materials & Technology Promotion Council (2018), Utilisation of Recycled Produce of Construction & Demolition Waste, New Delhi
3. Buchner, S. and Scholten, L.J. (1992), Demolition and Construction Debris Recycling in Europe, European Demolition Association (EDA).
4. Central Pollution Control Board (CPCB), Report on management of municipal solid wastes, New Delhi, 2000
5. Chakradhararao, M., Bhatta charya S.K., Barai, S.V (2011) "Behaviour of recycled aggregate concrete under drop weight impact load", Construction Building. Materials, 25(1), 69-80.
6. Chini, A., and Bruening, S. (2005), Deconstruction and Materials Reuse in the United States, International Council for Research and Innovation in Building Construction (CIB)
7. Deyu Kong, Ting Lei, Jianjun Zheng, Cheng-

chang ma, Jun jiang and Jing jiang, (2010). Effect and mechanism of surface coating pozzalanics materials around aggregate on properties and ITZ micro structure of recycled aggregate concrete, Constr. Build. Mater, 24(5), 701-708.
8. Fang Yuan., Li-yin Shen., Qi-ming Li. (2011), Emergy analysis of the recycling options for construction and demolition waste, Waste. Manage., 31(12), 2503-2511.
9. Handbook of recycled concrete and demolition waste, Woodhead publishing, 2013
10. Indian Concrete Institute (2015), Guideline for recycling, use and management of C & D wastes, ICI report of Technical Committee.
11. Indian Concrete Institute (2019), Seminar on Use of Alternative aggregates for Sustainable Concrete Construction, 26 Nov 2019, ICI Chennai Centre.
12. Indian Roads Congress: 121 (2017), Guidelines for use of construction and demolition waste in road sector
13. Kiyoshi Eguchi, Kohji Teranishi, Akira Nakagome, Hitoshi Kishimoto, Kimihiko Shinozaki,Masafumi Narikawa, (2007)., Application of recycled coarse aggregate by mixture to concrete construction, Constr. Build. Mater., 21(7), 1542–1551.
14. Kou. Shi Cong, Poon. Chi Sun and Chan. Dixon, (2008), Influence of fly ash as a cement addition on the hardened properties of recycled aggregate concrete, Materials and Structures (2008), 41, pp 1191–1201.
15. Limbachiya M.C., Koulouris A., Roberts J.J. and Fried A.N.(2004), Performance of Recycled Aggregate Concrete, RILEM International symposium on Environment Conscious Material and systems for sustainable development, pp 127-136.
16. Meyer, C. (2009), The greening of the concrete industry, Cement. Concrete. Comp., 31(8), 601–605.
17. Nisbet. Michael, Venta. George, Foo. Simon,Demolition and Deconstruction: Review of the Current Status of Reuse and Recycling of Building Materials, Air and Waste Management Association.
18. Rahal, K. (2007), Mechnical Properties of Concrete with Recycled Coarse Aggregate, Building & Environment,Vol. 42, pp 407-415.
19. Salomon M.Levy, Paulo Helene, (2004), Durability of recycled aggregates concrete a safe way to sustainable development", Cement Concrete. Res. 34(11), 1975–1980.
20. Srinivasan,V., and Singh, S.K.,Properties of Recycled Concrete Aggregate and its Application in Buildings, National seminar on Towards building smart & sustainable infrastructure in urban development, Indian Buildings Congress, October 6-7, 2016, pp 114-121.
21. Shayan. Ahmed and Xu. Aimin, (2003), Performance and Properties of Structural Concrete Made with Recycled Concrete Aggregate, American Concrete Institute Materials Journal, pp 371-380.
22. Tam W.V.Y, Gao X.F, and Tam C.M, (2005),Micro structure analysis of recycled aggregate concrete produced from two stage mixing, Cement and concrete composites , Elsevier, 35, pp 1500- 1507.
23. Tavakoli, M. and Soroushian, P. (1996), Strength of Recycled Aggregate Concrete made using Field Demolished Concrete as Aggregate, ACI Materials Journal, Vol. 93, No.2, pp.182-190.
24. TIFAC Home page, http://www.tifac.org.in/images/pdf/annual%20report/AR2016.pdf , August 2017.

SOLUTIONS FOR PURE WATER IN SUSTAINABLE DEVELOPMENT OF GREEN BUILDINGS

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Abstract

All water from lakes, reservoirs, rivers, and underground aquifers require some form of treatment to render it suitable for drinking. Surface water supplies typically need a higher level of treatment than do groundwater suppliers. The primary standards are intended to protect public health by establishing maximum contaminant levels (MCLs) for harmful substances (pathogens, toxic organics, and heavy metals) in drinking water. Secondary standards are guidelines related to the esthetic aspects of drinking water (taste, colour, odor). Primary standards are enforceable by law; secondary standards are not.

Surface water treatment includes clarification and disinfection. Some suspended solids can be removed in a process called sedimentation, in which the particles settle to the bottom of a large tank called a clarifier.

INTRODUCTION

Water withdrawn directly from rivers, lakes, or reservoirs is rarely clean enough for human consumption if it is not treated to purify it. Even water pumped from underground aquifers often requires some degree of treatment to render it potable that is suitable for drinking.

The nature and extent of treatment required to prepare potable water from surface or subsurface sources depend on the quality of the raw (untreated) water. Better-quality water needs less treatment. Generally, a source of raw water with a coliform count of up to 5000/100 mL and a turbidity of up to 10 units is considered good. Water with coliform counts that frequently exceed 20,000/100 mL and turbidities that exceed 250 units is considered a very poor source and requires expensive treatment to render it potable. The primary objective of water purification is to remove harmful microorganisms or chemicals, thereby preventing the spread of disease and protecting public health. In addition to being safe to drink, the water must also be esthetically pleasing. It should be crystal clear, and it should not have any objectionable colour, taste, or odor.

Generally, groundwater may require some degree of treatment. It is usually free of bacteria and suspended or colloidal particles because of the natural filtration that occurs as the water percolates through the solid. But because it is in direct contact with soil or rock, groundwater often contains dissolved minerals, such as calcium or iron.

The most common type of treatment for surface water includes clarification and disinfection. Clarification is usually accomplished by a combination of coagulation-flocculation, sedimentation, and filtration; the most common method for disinfection in the advanced country is chlorination. A typical flow diagram that shows the sequence of the individual treatment steps, or unit processes, is shown in Fig. 1.

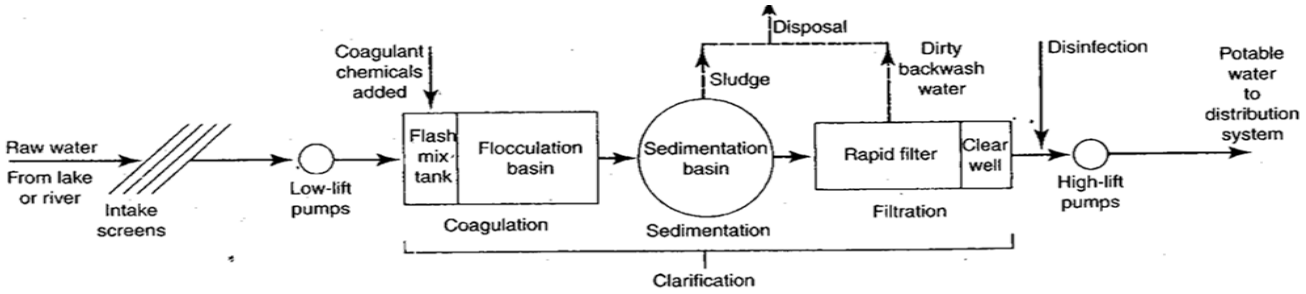

Fig. 1: A Flow diagram of a typical surface Water Treatment Plant

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DRINKING WATER STANDARDS

Based on the results of public health research and scientific judgment two types of drinking water standards are established i.e. primary and secondary. Primary standards are designed to protect public health by setting maximum permissible levels of potentially harmful substances in the water. Secondary standards are guidelines that apply to the esthetic aspects of drinking water, which do not pose a health risk (for example, colour and odor). Primary standards are enforceable by laws; secondary standards are not.

Most primary standards are specified as maximum contaminant level, or MCLs; these are the enforceable limits. Primary standards may also be specified as treatment technique (TT) requirements, which are set for those contaminants that are difficult or costly to measure; specific treatment processes (for example, filtration or corrosion control) may be required in lieu of an MCL to remove those contaminants.

Primary MCLs

MCLs for potentially toxic or harmful substances reflect levels that can be safely consumed in water, taking into account exposure to substances from other sources. They are based on consumption of 2 L (roughly 2 quarts) of water based fluids every day for a lifetime (which would result in a one-in-a-million chance of having the described health effect). The states can establish MCLs that are more stringent than those set by the central government. Categories of primary contaminants include organic chemicals, inorganic chemicals, microorganisms, turbidity and radionuclides. Except for some microorganisms and nitrate, water that exceeds the listed MCLs pose no immediate threat to public health. However, all these substances must be controlled because drinking water that exceeds the standards over long periods of time may be harmful.

Organic chemicals, many synthetic organic chemicals (SOGs) are included in the primary regulations. Some of them (like benzene and carbon tetrachloride) readily become airborne and are known as volatile organic compounds (VOGs). Table 1 shows a partial list of maximum allowable levels for several selected organic contaminates.

It is seen from Table 1 that extremely small concentrations can have public health significance. Levels are expressed in terms of mg/L; 1 mg/L is equivalent to one part per million. The MCL for the insecticide lindane, for example, is 0.0002 mg/L; this value can also be expressed in 0.2 μg/L (micrograms per liter) and is equivalent to 0.2 parts per billion.

Table 1: Selected Primary Standard MCLs and MCLGs for Organic Chemicals

CONTAMINANT	HEALTH EFFECT	M C L (mg/L)	TYPICAL SOURCE	MCLG
Aldicarb	Nervous system effects	0.003	Insecticide	0.001
Benzene	Possible cancer	0.005	Industrial chemicals, pesticides, paints, plastics	0
Carbon tetrachloride	Possible cancer	0.005	Cleaning agents, industrial wastes	0
Chlordane	Possible cancer	0.002	Insecticide	0
Endrin	Nervous system, liver, kidney effects	0.002	Insecticide	0.002
Heptachlor	Possible cancer	0.0004	Insecticide	0
Lindane	Nervous system, liver, kidney effects	0.0002	Insecticide	0.0002
Pentachlorophenol	Possible cancer, liver, kidney effects	0.0001	Wood preservative	0
Styrene	Liver, nervous system effects	0.1	Plastics, rubber, drug industry	0.1

Toluene	Kidney, nervous system, liver, circulatory effects	1	Industrial solvent, gasoline additive, chemical manufacturing	1
Total trihalomethane (TTHM)	Possible cancer risk	0.1	Chloroform, drinking water chlorination by product	0
Trichloroethylene (TCE)	Possible cancer	0.005	Waste from disposal of dry cleaning materials and manufacture of pesticides, paints, waxes; metal degreaser	0
Vinyl chloride	Possible cancer	0.002	May leach from PVC pipe	0
Xylene	Liver, kidney, nervous system effects	10	Gasoline refining by-product, paint, ink, detergent	10

Inorganic Chemicals

Several inorganic substances (that is, containing no carbon) particularly heavy metals are of public health importance. Some of these inorganics are listed in Table 2. Treated water is sampled and tested for inorganics at least once per year in public supplies. For most inorganics, MCLs are the same as the MCLGs, but the MCLG for lead is zero; the use of lead pipe and lead solder of flux for installation of repair of public water systems is no longer allowed in the advanced countries.

Arsenic, a well-known poison, can contaminate drinking water supplies naturally if the raw water has been in contact with certain rocks and minerals. Arsenic can also enter water sources from industrial and mining activities. It is found at higher levels in groundwater than in surface waters, such as lakes and rivers. Nitrate levels above 10 mg/L pose an immediate threat to children younger than 1 year. Excessive levels of nitrate can react with hemoglobin in blood to produce an anemic condition known as blue baby. Nitrates can enter water supplies naturally from soil and mineral deposits as well as from fertilizers and sewage pollution. The sources and health effects of other inorganic drinking water contaminates are summarized in Table 2.

Table 2 Selected Primary Standard MCLs for Inorganic Chemicals

CONTAMINANT	HEALTH EFFECT	MCL (mg/L)	TYPICAL SOURCE
Arsenic	Nervous system effects	0.005	Geological, pesticide residues, industrial waste, smelter operations
Asbestos	Possible cancer	7 MFL[a]	Natural mineral deposits, air conditioning pipe
Barium	Circulatory system effects	2	Natural mineral deposits, paint
Cadmium	Kidney effects	0.005	Natural mineral deposits, metal finishing
Chromium	Liver, kidney, digestive system effects	0.1	Natural mineral deposits, metal finishing, textile and leather industries

Copper	Digestive system effects	TT[b]	Corrosion of household plumbing, natural deposits, wood preservations
Cyanide	Nervous system effects	0.2	Electroplating, steel, plastics, fertilizer
Fluoride	Dental fluorosis, skeletal effects	4	Geological deposits, drinking water additive, aluminum industries
Lead	Nervous system and kidney effects, toxic to infants	TT	Corrosion of lead service lines and fixtures
Mercury	Kidney, nervous system effects	0.002	Industrial manufacturing, fungicide, natural mineral deposits
Nickel	Heart, liver effects	0.1	Electroplating, batteries, metal alloys
Nitrate	Blue-baby effect	10	Fertilizers, sewage, soil and mineral deposits
Selenium	Liver effects	0.05	Natural deposits, mining, smelting

Lead and Copper Rule

Treatment techniques have been set for lead and copper because the occurrence of these chemicals in drinking water usually results from corrosion of plumbing materials. All systems that do not meet the action level at the tap are required to improve corrosion control treatment to reduce the levels. The action level for lead is 0.015 mg/L and for copper is 1.3 mg/L.

Microorganisms

This group of contaminants includes bacteria, viruses and protozoa. The total coliform group of bacteria is used to indicate the possible presence of pathogenic organisms. In testing for total coliforms, the number of monthly samples required is based on the population served and size of the distribution system. Standards now require that coliforms not be found in more than 5% of the samples examined during a 1 month period. This is now known as the presence/absence concept; it replaces previous MCLs based on the number of coliforms detected in the sample. All coliform-positive samples have to be further tested for feat coliforms (or Escherichia coli), the presence of which is strong evidence of recent sewage contamination and indicates an urgent public health risk.

Turbidity

The presence of suspended particles in the water is measured in nephelometric turbidity units (NTUs); NTUs measure the amount of light scattered or reflected from the water. Turbidity testing is not required for groundwater sources. Turbidity affects more than just the appearance of water; it can be health hazard in drinking water and is therefore controlled as a primary contaminant. Turbidity interferes with disinfection by shielding microorganisms.

Radionuclides

Water can be contaminated with radioactive substances from natural sources in the environment, as well as from human sources (e.g., radioactive wastes). Exposure to ionizing radiation (alpha and beta particles, and gamma radiation) emitted by radionuclides in drinking water can result in an increased risk of cancer and other adverse health effects. Most naturally occurring radionuclides found in water are alpha particle emitters. They come from weathered rocks that contain trace amounts of radioactive isotopes of uranium and other elements. Another natural radionuclide is tritium, which is a beta particle emitter. The radioactive gas radon occurs in certain types of rock and can get into groundwater. Radionuclides from human sources primarily beta particle emitters, are the result of improper low-level radioactive waste storage, transport, or disposal practices.

Secondary MCLs

Under the Secondary Drinking Water Stand-

ards, a range of concentrations is established for substances that affect only the esthetic qualities of drinking water (for example, taste, odor, and colour), but have no direct effect on public health. Secondary standards are presented in Table 3.

Table 3: Secondary Drinking Water Standards

CONTAMINANT OR ADVERSE EFFECT	SUGGESTED LEVEL	CONTAMINANT EFFECT
Aluminum	0.05 – 0.2 mg/L	Discoloration of water
chloride	250 mg/L	Salty taste; corrosion of pipes
Color	15 color units	Visible tint
Copper	1.0 mg/L	Metallic taste; blue-green staining of porcelain
Corrosivity	Non corrosive	Metallic taste; fixture staining, corrected pipes (corrosive water can leach pipe materials, such as lead, into drinking water)
Fluoride	2.0 mg/L	Dental fluorosis (a brownish discoloration of the teeth)
Foaming agents	0.5 mg/L	Esthetic; frothy, cloud, bitter taste, odor
Iron	0.3 mg/L	Bitter metallic taste; staining of laundry, rusty color, sentiment
Manganese	0.05 mg/L	Taste; staining of laundry, black-to-brown color, black staining
Odor	3, threshold odor number	Rotten-egg, musty, or chemical smell
pH	6.5-8.5	Low pH: bitter metallic taste, corrosion High pH: slippery feel, soda taste, deposits
Silver	0.1 mg/L	Argyria (discoloration of skin), graying of eyes
Sulfate	250 mg/L	Salty taste; laxation effects
Total dissolved solids	500 mg/L	Taste and possible relation between low hardness and cardiovascular disease; also an indicator of corrosivity (related to lead levels in water); can damage plumbing and limit effectiveness of soaps and detergents
Zinc	5 mg/L	Metallic taste

SEDIMENTATION

The impurities in water may be either dissolved or suspended. The easiest way to remove the suspended material is to let the force of gravity do the work. Under quiescent conditions, when flow velocities and turbulence are minimal, particles that are denser than water will be able to settle to the bottom of a tank. This process is called sedimentation, and the layer of accumulated solids at the bottom of the tank is called sludge. The tank may be called a sedimentation tank, a settling tank, or a clarifier.

Coagulation and Flocculation

Suspended particles cannot be completely removed from water by plain settling, even when they are given very long detention times and low overflow rates. Some of the very small turbidity-causing particles, called colloids will not settle out of suspension by gravity without some help. If certain chemicals, called coagulants, are rapidly mixed in the water and then the mixture is slowly stirred before allowing sedimentation to occur, the particles will settle.

One of the properties of colloidal particles that keeps them in suspension is small electrostatic charge that they each carry. Because of the presence of like charges, colloidal particles plus each other apart and avoid collisions. The coagulant chemical, however, neutralizes the effect of the colloidal charges. Once neutralized, the coagulant particles can collide and agglomerate (stick together), forming larger and heavier particles, called flocs. The coagulant also reacts with the natural alkalinity in the water, forming a sticky solid precipitate that comes out of solution and helps in the formation of the flocs by capturing particles.

After that initial flash-mix of the coagulant with the water, a gentle agitation caused by slow stirring further enhances the growth of the flocs by increasing the number of particle collisions. The slow mixing or stirring process is called flocculation. The combined rapid mix-slow mix process is usually referred to as coagulation. Most of the flocs formed during coagulation are settleable and can be removed from the water in a sedimentation tank. Coagulation generally precedes the sedimentation process in a typical water treatment plant.

Ballasted Coagulation

A relatively new development in coagulation technology adds fine sand particles of the mix of alum and polymers. The sand particles adhere to the clumps of coagulated material and the added weight speeds up the settling process. A machine called a hydrocyclone separates the sand from the sludge, allowing the sand to be washed and recycled. Ballasted coagulation allows the same amount of water to be treated in a smaller tank than would otherwise be needed.

FILTRATION

Even with the help of chemical coagulation, sedimentation by gravity is not sufficient to remove all suspended impurities from water. About 5 % of the suspended solids may still remain as non settleable floc particles. These remaining flocs can cause noticeable turbidity and may shield microorganism from the sub-sequent disinfection process. To produce a crystal clear potable water that satisfies the requirement of 0.5 NTU (the MCL for turbidity), an additional treatment step following coagulation and sedimentation is typically needed.

This next step is physical process called filtration. Filtration involves the removal of suspended particles from the water by passing it through a layer or bed of a porous granular material, such as sand. As the water flows through the filter bed, the suspended particles become trapped within the pore spaces of the filter material, or filter media, as it is called. This is shown schematically in Figure 2. Filtration is an important treatment process in a surface water purification plant. In fact, many of these facilities are called filtration plants, even though filtration is only one step in the overall treatment sequence.

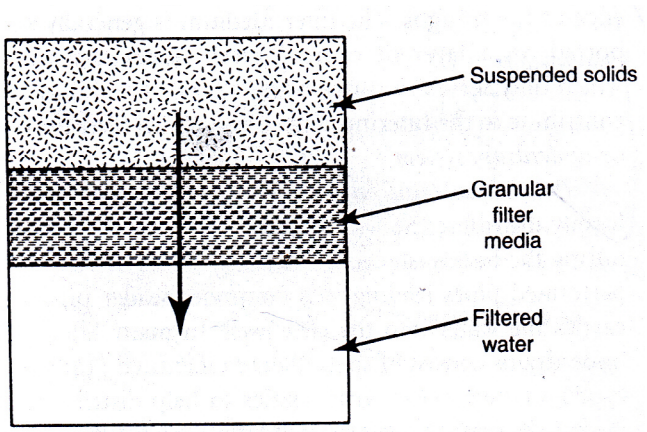

Fig. 2: Schematic diagram of the Filtration Process

DISINFECTION

The unit process described above coagulation, sedimentation and filtration together compose a type of treatment called clarification. Clarification removes many microorganisms from the water along with the suspended solids. But clarification by itself is not sufficient to ensure the complete removal of pathogenic bacteria or viruses. A potable water must be more than crystal clear-it must be completely free of disease-causing microorganisms. To accomplish this, the final treatment process in water treatment plants is disinfection, which destroys or inactivates the pathogens.

Chlorination

Chlorine is the most commonly used substance for disinfection in the advanced countries. The addition of chlorine or chlorine compounds to water is called chlorination. Chlorination is considered to be the single most important process for preventing the spread of waterborne disease.

Molecular chlorine, Cl_2, is a greenish-yellow gas at ordinary room temperature and pressure. In gaseous form it is very toxic, and even in low concentrations it is a severe irritant. But when the chlorine is dissolved in low concentrations in clean water, it is not harmful, and if it is properly applied, objectionable tastes and odors due to the chlorine and its by-products are not noticeable to the average person.

Other Methods of Disinfection

Chlorination is the most widely used method for disinfection of water supplies in the United States of America because of its economy and its ability to maintain a protective residual. Other methods of disinfection have been receiving more attention in recent years, primarily because of the problem of THM (Trihalomethanes) formation and the potential effect on public health.

OZONE

Ozone (O_3) is highly reactive gas at ordinary temperature and pressures, and acts as a potent disinfectant when mixed with water. It has been used for more than 90 years in European countries as an alternative to chlorine, which sometimes leaves a noticeable taste and odor in drinking water.

Ozone is more effective than chlorine as a disinfectant when used to prevent outbreaks of cryptosporidiosis. Water treatment facilities in Milwaukee, Wisconsin, were recently upgraded for just this purpose. A flow diagram of the ozone water purification process is shown in Fig.3.

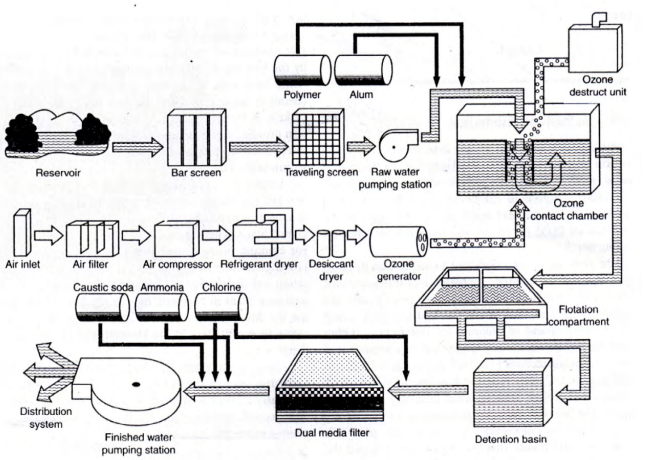

Fig. 3: A Flow diagram of the Ozone Water Purification Process

CONCLUSION

Depending on the quality of the raw water supply, other treatment processes may be required in addition to clarification and disinfection. For example, water supplies containing dissolved salts of calcium and magnesium, called hard water, must often be treated to reduce levels of those compounds. Hardness in water interferes with lathering of soap, and cause deposits of scale in water heaters and pipes. This is more of an economic and esthetic problem than a health problem. Reduction of calcium and magnesium levels is called water softening. It can be accomplished either by a lime-soda method, or by the ion-exchange method. It is not desirable to eliminate hardness completely because very soft water can be corrosive and cause damage to metal pipes and plumbing fixtures.

Desalination: Desalting is a process that separates freshwater from brackish water or seawater. Two types of desalination methods are available - thermal processes and membrane processes. Thermal processes use heat transfer and a phase change of vapor to freshwater, and membrane processes use thin sheets of special materials that allow freshwater to pass through.

REFERENCES

1. "CIA- The world fact book". Central Intelligence Agency. Retrieved 2008-12-20. Engstrand L. (2008) Helicobacter in water and waterborne routes of transmission. Journal of Applied Microbiology, 90:80S-845.
2. D.M. Lewis (in 2010) Application of photo disinfectants in water purification vol. 5 (6) pp. 628-635.
3. Fenwick A (2006) Waterborne Infectious Disease-could they be consigned to Rthtory. Science, 313: 1077-1081.
4. Ganoza CA, Matthias Collins-Richards D, Brouwer KC, Cunningham CB, Segura ER Gilman RH, Gotuzza E, Vinetz JM (2006). Determining risk for severe leptospirosis by molecular analysis of environmental surface waters for pathogenic Lepotspira PLOS Med., 3:1329-1340.
5. Goodman KJ et al. (1996) Helicobacterpylori infection in the Colombian Andes: a population-based study of transmission pathways. Arnerice Journal of Epidemiology, 144: 290-299.
6. Gregory BM, Frick EA (1995). Faecal coliform bacterial concentration in Stream of the Chattahochee river national recreation Area, Metropolitan Atlanta, Georgia, May – October 1994 and 1995. US geological Survey Report, 00-4139.
7. Gleick, P.H., ed (1993). Water in Crisis: A Guide to the World's Freshwater Resources. Oxford University Press.p. 13, Table 2.1 "Water reserves on the earth".

PRINCIPLES OF VASTU SHASTRA FOR GREEN AND ENERGY EFFICIENT BUILDING AND ITS PRACTICE THROUGH BYELAWS

VIBHOR GOEL* AND KUSHAAN KAPUR**

Abstract

This paper establishes an elaborate relationship between Vaastu (the ancient building science) and how it can (VAASTU) help in the construction of green energy efficient buildings if it is included in various state bye-laws.

Vaastu is ancient but effective study of weaving the natural movement of sun and wind with the designing and orientation of the structure, which makes it more sustainable. Amalgamation of vaastu and our modern technology gives a holistic building guide. After analyzing the regional bye-laws of Mumbai region, as Mumbai being the biggest metropolitan in our country, it has been concluded that state bye-laws have the scope of including certain important concepts of Vaastu, which can be presented as standards and guidelines for the construction of sustainable buildings.

INTRODUCTION

Vaastu is derived from the word VASATI which means GRUHA or PLACE OF DWELLING , it is basically the science of structures. Land is considered to be the VASTU and the construction on this land of any worth is considered to be VASTU e.g. temples,cities,buildings etc. Land is considered to be MUKHYA (principal) vastu, there are 2 types of vastu shown in figure below.

All the beings on this earth including buildings are made up of 5 elements or the panchbutas as shown in Table 1, without them the physical being is impossible. These elements have certain characteristics which have an effect on our lives and all the physical being.

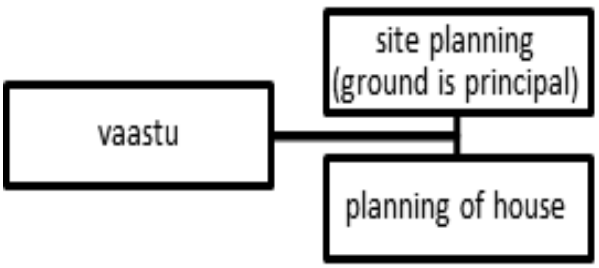

Table 1: Panchbutas

Aakasha (space)	Sound (shabda)
Vaayu (air)	Sound (Shabda) & touch (sparsha)
Agni (fire)	Sound (shabda), touch (sparsha) & Rroop (form)
Jala (water)	Sound (shabd),touch (sparsha), form (roop)
Bhumi (earth)	Sound (shabd), form (roop), touch (sparsh), rasa & guna (quality)

The universe constitues of various energies, the magnetic field of the cellestial bodies, movement of sun and moon, wind movement etc. Similalrly a built structure also comprises of certain energies and the harmonious uninterrupted flow of energy makes a building sustainable and green in nature. These energies have a resultant effect on human health. If the harmonious flow of energy is interrupted, it amounts to the creation of negative spaces in the buildings which are sunlight or wind deficient ,this effects human psychology.

Vaastu empasizes on placing lighter structures towards NE and heavier structure towards SW. SE corners are hottest and NE coolest,due to the sun path which tilts to the south. Placement of roof

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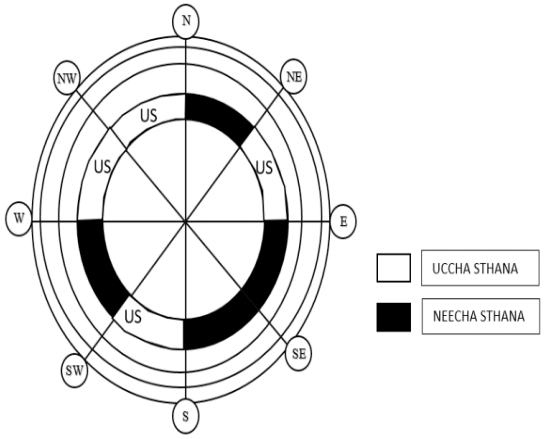
slopes would be from west to east or from south to north. Windows & doors should be placed in the NW,N,NE,&SE directions considering the prevailing wind directions which helps in keeping the building hot in winters and cool in summers. Placement of water bodies like water tanks in N & NE directions due to the presence of the sun energy which has purification abilities. Uccha sthana is the benefic position and Neecha sthana is the malefic position. The building structures and openings e.g.- doors, windows, lighter objects , underground tanks, borewell etc. should be facing the benefic position so that the sun energys is captured at it's best to make the structure more sustatiniable. On the contraray Neecha sathana the malefic position of the structure should be designed for thicker walls and heavier objects can be placed there.

Sun rises from the east passes through the south and sets in the west. However due to the 23.5° inclination of the earth forms its vertical axis, the east is not the first direction that receives the sunray. It is northeast, the same application can be applied to the cardinal west. Light makes it possible for us to see, but sun-light lends drama to what we see. Sun light is probably the most powerful design element in architecture. One should never use large glass areas on the east or west unless protected by scientifically designed sun control devices, otherwise a hot box will be the result. The north is the ideal



exposures, there the sun is above and can easily be shaded by a roof over hang, awning type projection, or horizontally fixed or moveable louvers to stop the sun and allow the lower rays of the winter sun to come in and help heat the interior[1].The methods/techniques explained above can be used to utilise ground coverage of any resultant plot. Plot selection depends on various factors. These factors can be used to decide the most favourable land-use for a plot. These include effect of orientation, roads along the plots, soil considerations, extension of the plot, level of land inside and outside the plot, surroundings and the connection to the plot. Shape of the plot plays as essential role as the micro layout of the structure can be designed efficiently for the best possible and permisible ground coverage.

Traditional architecture is always accompanied with a set of rules and principles that are to some extent based on environmental criteria as well as the dominant belief system of the specific culture. These two variables seem to be inter related and in some situations dominating one another. It is an ancient belief system, similar to other traditional architectural sciences such as Feng shui, which also deals with the principles designed to make the most use of the environment and more specifically climate as one of the sun rays, the earth's magnetic poles and the geopathicn zones. Many rules have been legislated in ancient Indian architecture dealings with environmental criteria that are now considered superstitious; however applying them may be useful in designing, building in complete harmony with surrounding nature[1]

By using these thechniques we will try perfecting the by laws for every land use to make the document a complete and a holistic building guide.

ANALYSIS OF DEVELOPMENT CONTROL AND PROMOTION REGULATIONS FOR REGIONAL PLANS IN MAHARASHTRA

The development control and Promotion regulations for regional plans in Maharashtra is divided into 12 parts. Part 1 talks about the applicability of regulations, Procedure to provide development permission and commencement certificate and the power of administrations to implement these regulations. In Part 2, 3 and 4 it is clearly focused on the land use classification, permissible uses, ground coverage, open spaces, height regulations, services and utilities areas, FSI/FAR and special requirements in various categories of buildings, settlements and specified zones. Additional FSI/FAR provisions in certain categories like educational/ medical/ hotels/ institutional buildings and religious building etc are provided in the 5th

Part. Further, in part 6-fire protection requirement is regulated through construction materials, material for interior decoration and defining the standards for fire lifts, service ducts, electrical services, gas supply, transformer, fire alarm and so on. Part 7 elaborate all the standards and regulations to have a good quality structural design, construction methods, building services, drainage and sanitary, signage and outdoor display structures. Part 8 focus on the regulation for provisions regarding facilities for physically handicapped persons, installation of solar assisted water heating system and rain water harvesting, which is a concept of energy saving and sustainability. To define the proper utilization of spaces below flyover, commercial use of lands owned by Zillaparishads or MSRTC and for the regulation of special activities like mining, erection of mobile tower, part 9 and 10 can be referred. In Part 11 and 12 special schemes are introduced for special townships, tourism development and various other supplementary provisions for clarification and appeals (Government of Maharashtra, Urban development department, 2018).

After analysing the development control regulation of Maharashtra regional plans we can clearly see that there is very minimum description regarding green buildings concepts which can be seen through the energy saving and water sustainability in part 8 only. There is no regulation or description regarding resource efficient green building or technologies for net zero energy building. There is a lack of basic design parameter, no understanding about the use of natural energy, waste reduction, smart growth and sustainable development.

Building climatology which is the scientific study of climate in context with the built environment and can provide natural ventilation and keep the building structure favorable for climates, is also not described in the DCRs. If all Buildings in urban areas were made to adopt green Building concepts, India could save more than 8400 MW of power, which is enough to light 5.5 lakh homes a year according to estimates by TERI[3].

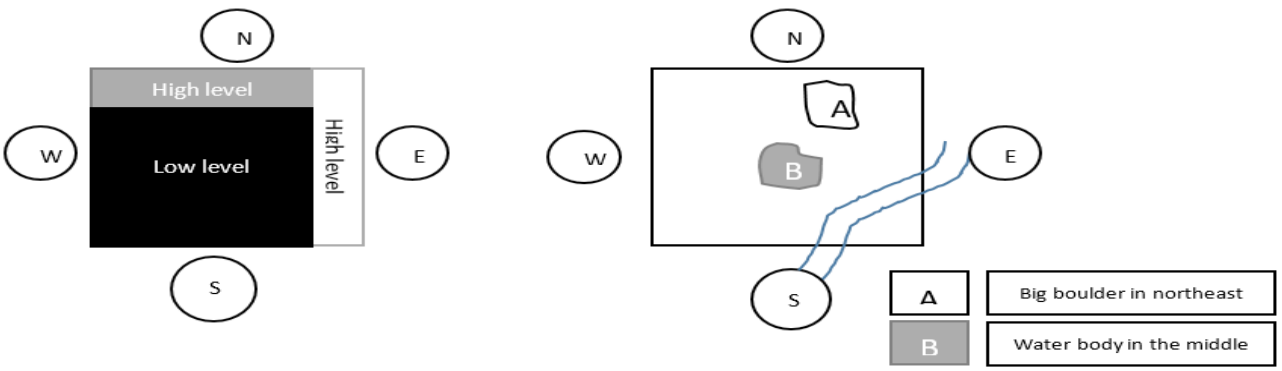
Identification of deficiencies and gap analysis

Part 2- General Planning and Building Requirements

Point 11.3 in the by laws states "The construction within blue and red flood line along the river side may be permitted at a height of 0.50 m. above the red flood line." This statement just gives a standard; it can be completed by addition of the concept of ground level for plots with water bodies[7] states "as far as possible such plots should be avoided. In unavoidable circumstances, the pits, ponds, nallah should be filled and consolidated; rocks and boulders blasted, cut and removed and the plot levelled keeping southern and western sides of the plot higher".

Point 12.2 states "Every person who erects a building shall not at any time erect or cause or permit to erect or re-erect any building which in any way encroaches upon or diminishes the area set apart as means of access". If any approach roads diminish the area they can be either fenced or shut off completely by compound, walls or they can be sold to the adjacent plot owner to retain the regular shape of the plot.

In addition to 13.3 which talks about open spaces or recreational spaces - As per Vastu guidelines, open spaces towards the northeastern side of the plot are considered one of the best locations[6] The



North Eastern side is considered to be auspicious as it is a Uccha Sthana and receives the morning sun. In addition to point 15.4.1 (c) which talks about the balconies – terrace, portico, porch, balconies should be located in North, East & North-East sides of the building[7] to receive more sun.

In addition to 15.4.1 (h) which talks about staircase mid landing – the staircase can be built in any direction except North East[7]. The mid landing can be placed in the west direction, while climbing the stairs ones face should face South or West to avoid contact with direct sunlight, which will in turn keep the staircase cool. In addition to point 15.5 which talks about the building height- keeping south, south west and west higher as compared to the other parts of the building controversially North, North East and East should be lower in heights[7]. This will in turn allow the morning sunlight to be received by neighboring structures and it will allow sunlight to enter to the majority part of the building.

Point 17.3 explains about kitchen- provision for gas cylinder to be kept under the cooking platform. Empty or unwanted cylinders to be placed in the North West corner[7]. To avoid direct sunlight on the cylinder, Sink and wet areas to be designed towards North East as for the sunlight to keep the area dry.

Point 17.4 which elaborates upon the standards of Bathrooms – The attached bathrooms should not be facing North East and the pipe network should be designed in a way that the wastewater is drained in the North or North East direction because the sunlight works as a natural disinfectant, this helps in keeping the structure dry.

In addition to point 17.6 and 17.8 which talks about cupboards and the store room respectively – cupboards and other heavy objects should be placed in the Neecha Sthana of the structure which constitutes of thick walls as the sunlight and wind energy should not be interrupted by heavier structures and objects.

Point 17.14 talks about wells – The wells should be dug in Northeast or Eastern sides preferably in between mid-North and Northeast[7]. As wells are open and the stagnant water is more susceptible to impurities, hence direct sunlight from Northeast or Eastern direction will help to keep the water disinfected.

Point 17.15 explains standards for soak pit - .W.C should be constructed above the septic tank due to paucity of space. They should never be placed in the centre. North East corners are strictly prohibited[7]

Part 3 (a) General Guidelines for Residential Land-Use

The entire area of colonies of big group housing projects should be planned meticulously as per Vastushastra.

1) All roads should be laid east to west or south to north parallel so that earmarked plots be rectangle or square in shape.
2) The slopes of area, inducing roads if possible, should be towards east: north keeping north-east, the lowest.
3) Bore wells, ground reservoirs, fountains, parks etc. should be in north-east of the colony Area.
4) Overhead water tanks can be in south-west or southern zone.
5) Community centres, temples, Prayer-halls etc. should be again in north.
6) Rain water should flow preferably towards east, north-east or north.
7) Swimming pools should be constructed in north-east zone.
8) Sufficient space should be allotted and arrangements made for common facility centres like shops, hospital, schools, banks, post office, parks, primary health centres, library etc. within reasonable distance
9) Bigger colonies should have facilities for cinema house, hotels, playground, primary health centres, auditorium, marriage halls, firefighting service, police station etc[7] within reasonable distance.

Part 3(b) General Guidelines for Commercial Complexes

1) A Strategic or vantage location to be selected for this in the main centre of the city or growth centre of the city with good approach.
2) Care should be taken to provide for sufficient Parking space for cars, scooters and cycles which may be in cellars in north, north east and east or outside the building in front.
3) Generator, if it is to be provided should be placed in southeast.
4) Office rooms, cabins etc. should be placed

in second floor on wards. A corridor should run in between, and rooms or halls placed on both the sides of corridor

5) Basement, ground and first floors are normally used exclusively for shops, restaurants, Banks etc.
6) Toilets are to be provided only in north-west or south-west portion strictly avoiding north-east.
7) Adequate lawns and greeneries with big trees can be developed in south and west and only with tender flowering plants in eastern and northern sides including fountains[7]

Part 4 – Guidelines for Construction of Spiritual Places

1) Spiritual institute must be constructed facing towards East or North.
2) Spiritual institute must have regular shape building such as rectangle or square but it should never be oval, circular or having more than four sides.
3) More space should be left open towards East and North-east and possibly establish a meditative hall or temple.
4) Toilets in spiritual institute should be constructed in West or North-west but never on East or North-east.
5) Pantry should be made in South-east only.
6) Staff or administration must sit in South-west portion facing north.
7) Electrical equipments should be placed in South-east direction or portion of building.
8) Entrance gate of institute should also be constructed in East only and gate must be stronger and huge than other doors of institute.
9) Windows in the rooms should be maximum on Eastern side and minimum on Southern side[5]

CONCLUSION

Provision of development as per Vastu in Regional by laws gives us a sense of righteous and judicious direction and orientation, which not only helps in the designing of the structure but also assists in the systematic development of the neighboring structures. Designing as per vaastu allows all the structures to receive equal and abundant amount of natural energy, which in turn makes the community more sustainable. Biology of the building is generally ignored during construction. With Vaastu we realize that the buildings are to be treated as living organism and each part of the building requires natural energy to the most. Vaastu emphasize upon natural energy because structures and their designs have a lasting effect on human minds and psychology. If we see something beautiful it causes us to feel pleasure. The feeling of pleasure is a result of oxytocin, endorphins and DHEA being released inside our brain[4] To conclude we would like to say that a successful amalgamation of old and new techniques is the recipe to a sustainable future as human beings are a product of constant evolution and it effects the way we design our structures, communities and cities.

REFERENCES

1. Barodia, P. (n.d.). VASTU SHASTRA: A HOLLISTIC APPROACH. JALANDHAR: LOVELY PROFESSIONAL UNIVERSITY.
2. Government of Maharashtra, Urban development department. (2018). Standardised Development Control and Promotion Regulations for Regional Plans in Maharastra.
3. Gupta, D. Y. (2010, JANUARY). Retrieved from NBMCW: https://www.nbmcw.com/tech-articles/tall-construction/15837-need-for-developing-green-building-concept-in-the-country.html
4. Ricci, N. (2018). The Psychological Impact of Architectural Design. Scholarship @ Claremont.
5. Shastra, V. (n.d.). Vastu for Religious/Spiritual Educational Institutions. Retrieved from Vastu Shastra : https://www.vaastu-shastra.com/spiritual-religious-institutions-vastu.html
6. Team, C. E. (2014, March 14). Vastu tips for open spaces around buildings. Retrieved from coomonfloor.com: https://www.commonfloor.com/guide/vastu-tips-for-open-spaces-around-buildings-39498.html
7. V.V.Raman, p. (1996). Principles & Practice Of Vastu Shastra. Jaipur: N.K. Arun ,Vidya Bhawan Publishers & Booksellers.

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