ISSN 2349-7475

Indian Buildings Congress

Volume Twenty Three
Number One
2016

Seminar on

Towards Building Smart & Sustainable Infrastructure In Urban Development

October 06-07, 2016
New Delhi

PRELIMINARY PUBLICATION

Indian Buildings Congress

Vol. Twenty Three Number Two 2016

21st Annual Convention
and
National Seminar on

Towards Building Smart & Sustainable Infrastructure in Urban Development

October 6-7, 2016
New Delhi

आधुनिक तकनीक सुरक्षित निर्माण
INDIAN BUILDINGS CONGRESS

Preliminary Publication

ISSN No. – 2349 - 7475

Published By :-

Pradeep Mittal
Honorary Secretary,
Indian Buildings Congress
Sector-VI, R.K. Puram,
New Delhi – 110022
Phone No: 011- 26169531, 26170197
Fax No: 011-26196391
E-mail: info@ibc.org.in, indianbldgscongress@gmail.com
Website: www.ibc.org.in

Printed at
Viba Press Pvt. Ltd.,
C-66/3, Okhla Phase- II,
New Delhi -11 0020.
Phone: 011- 41611300, 41611301

FOREWORD

India along with rest of world is going through a rapid urban and demographic transition. By 2050, about 70 per cent of world's population will be living in cities, and India is no exception. Providing smart and sustainable infrastructure is of great importance for appropriate growth, poverty reduction and environmental sustainability for the nation.

It is the physical infrastructure like water supply, drainage, sewerage, solid waste disposal, power supply, etc. which makes it possible for human beings to live and pursue their avocation comfortably in life. One of a city's most important pieces of critical infrastructure is its water system. With populations in cities growing, it is inevitable that water consumption will grow as well. The term "smart water" points to water and wastewater infrastructure that ensures this precious resource and the energy used to transport it is managed effectively.Water loss management is becoming increasingly important as supplies are stressed by population growth or water scarcity. Many regions are experiencing record droughts, and others are depleting aquifers faster than they are being replenished. Incorporating smart water technologies allows water providers to minimize wastage by finding leaks quickly.Smart meters which are available now can provide real-time information enabling customers to understand and monitor their water usage and assist the water utility in managing its network and provide better customer service. Smart meters also provide a more detailed understanding of where water is being used, and in what quantities, enhancing the ability to pinpoint and tackle leakages.

Waste management is another area of concern in Indian cities that needs smart interventions. Urban areas in India generate more than 1,00,000 MT of waste per day. A large metropolis like Mumbai generates about 8000 MT waste per day. Collection, processing, transporting and disposing this municipal solid waste remains a major challenge. Inappropriate and inadequate waste management is a cause of poor public health and environment. Waste collection and treatment is still low in India and holds potential for being upscaled through smart initiative. Smart containers with sensors detecting overflow situation can be used to make ULBs respond to the situation. This, coupled with efficient collection, segregation and treatment can make cities healthier and clean.A smart solid waste management system is being put in place using Swiss technology at GIFT City where garbage will be disposed offwith minimum human interference using vacuum suction.

Construction and Demolition Waste is also an important issue. I'm always shocked at the amount of waste I see when visiting a typical project under construction. We all tend to accept that construction is a messy process. Fortunately, there are many opportunities for us to reduce these staggering numbers. Most of us are familiar by now with the "reduce, reuse, recycle" mantra, the basic tenets of which apply here as we seek to minimize construction and demolition waste.

There is lot of potential for increasing energy efficiency and thereby decreasing the carbon footprint by use of smart metering. Smart meters provide the smart interface between you and your energy provider. Installed in place of your old, mechanical meter, these meters operate digitally,

and allow for automated and complex transfers of information between your home and your energy provider. For instance, smart meters will deliver signals from your energy provider that can help you cut your energy costs. Smart meters also provide utilities with greater information about how much electricity is being used throughout their service areas.

Devoting the Annual Session to a discussion of this vital theme is of great relevance and will be surely welcomed by all the professionals connected with built environment. Indian Buildings Congress has already to its credit, a series of seminars that pertained to themes of great contemporary importance. This Session is yet another that furthers the highly commendable and endearing tradition that the Congress has come to establish.

(Shobhit Uppal)
President, IBC &
Dy. Managing Director
Ahluwalia Contracts (I) Ltd

PREFACE

Urbanization has fuelled unprecedent growth in our cities which has resulted in huge strain on their physical infrastructure. If the country is to improve its urban life, we shall have to remedy the situation in the existing cities by re-engineering the old ones and build new sustainable infrastructure elsewhere. It is estimated that in the next decade, 140 million people will move to cities by 2020 and 700 million by 2050. Indian cities have narrow financial resource base leading to monetary constraints. Consequently the cities are unable to commit requisite financial resources for development.

Resource constraints are not only financial but also capability driven. Planning capabilities often do not match up to requirements. Capacity to execute has also been traditionally poor due to shortage of skilled personnel, apart from lack of financial resources. It is evident that the sheer magnitude of the challenge requires solutions that are more efficient, cheaper and holistic. Technology has proven to be the key, and arguably the only enabler of sustainable outcome. Going forward, the challenge is to scale up such solutions and make our overall urbanization process smart and intelligent. In order to make intelligent urbanization a nation wise phenomenon in India, there is an urgent need to strength our urban basis i.e. governance and financing, while enhancing capabilities and embedding technology.

Smart water network along with augmentation of water supply are needed along with treatment, supply and management of water from the source. It is a fully integrated set of products, solutions and systems that enable water utilities to remotely and continuously monitor and diagnose problems, pre-emptively prioritize and manage maintenance issues and remotely control and optimize all aspects of water quality, conservation and distribution network. Further, lack of sewerage and sanitation facilities lies at the root of several diseases in the Indian cities. Therefore poor sanitation is not only an infrastructure issue but also a marker of unhygienic living conditions. To redeem the situation, about 250 million more people need to be provided access to sanitation facilities in cities in the next ten years.

India meets its electricity demands presently with 67 percent from thermal resources, i.e. coal and gas, 19 per cent of that demand is met with hydropower, 12 per cent from renewable and 2 per cent from nuclear power, while many analysts point to developing solar and nuclear capabilities as essential. India will need greater capacity and efficiency in all sectors to meet India's energy needs. Over 200 GW of power is required to be added over a period of ten years. The focus should be on design integration of different technologies to provide cost effective solutions. Preparation of development plan for a smart city itself requires a lot of research and study of the past experiences to arrive at a workable solution, apart from need for timely implementation of such schemes. Different examples from across the world have proved that technology is a key enabler to help achieve these goals at the lowest cost in an efficient manner.

All these aspects and related issues shall be deliberated during the proposed National Seminar on "Towards Building Smart & Sustainable Infrastructure in Urban Development", to be held at New Delhi during first half of October, 2016. The topic has evoked a keen response from the authors. We have received 33 papers out of which 21 papers have been selected in this publication.

The contribution of the esteemed authors is gratefully acknowledged. I would like to thank all the members of the Technical Committee for rendering their help in screening and selection of papers.

(Deepak Narayan)
Convener, Technical Committee &
Former E-in-C, Delhi PWD

TECHNICAL COMMITTEE

CONVENER

Deepak Narayan
Former E-in-C, Delhi PWD

ADVISORS

Abhai Sinha
Director General, CPWD
New Delhi

Divakar Garg
Former DG, CPWD
New Delhi

C.S.Prasad
Chief Advisor, EPIL, &
Fmr. DG,CPWD
New Delhi

Desh Ratan Gupta
Executive Director (E&HM)
Railways Board
New Delhi

Brig. Girish Joshi
Dy. Dir. General Works (D)
E-in-C's Branch, IHQ
New Delhi

K.P. Singh
Engineer-in-Chief
North DMC, Delhi

Anant Kumar
Chief Engineer, NDMC
New Delhi

I. S. Sidhu
Chief Operating Officer, FEDO
New Delhi

Deependra Prashad
Consulting Architect
New Delhi

J.K. Choudhury
Former Chief Engineer (E) CPWD,
New Delhi

Praveen Bhargava
Chief Engineer, (Plann.)
Delhi Jal Board

V.K. Jain
Chief Engineer (I&FC)
Delhi

P.S. Chadha
Consultant, IBC

M.S.Toor
Chief Instructor, IBC

CONTENTS

TECHNICAL SESSION I : PLANNING

TECHNICAL SESSION II : WATER MANAGEMENT

TECHNICAL SESSION III : WASTE MANAGEMENT INCLUDING C & D WASTE

TECHNICAL SESSION IV : ENERGY MANAGEMENT

TECHNICAL SESSION - I

PLANNING

TOWARDS BUILDING SMART AND SUSTAINABLE INFRASTRUCTURE IN URBAN DEVELOPMENT

Dr. Ms. Ponni Concessao* and Dr. Oscar Concessao

Abstract

The need to make cities sustainable will drive the adoption of a range of smart solutions. With mass urbanization emerging as an unstoppable trend across the world, cities need to become sustainable on many levels. The solution is to design smart solutions at all levels to help meet multiple challenges and lead to the development of Smart Cities. Increasing urbanization and awareness of sustainability issues are setting off a wave of investments in revitalization of existing cities and development of new ones. However, given the scale of the challenge, simply throwing more money at the problem is not a solution.

The world needs a new operating paradigm that provides for the needs of urban residents in an economically viable, socially inclusive, and environmentally sustainable way. Businesses and governments are starting to recognize the role of technology in meeting these objectives. City investments that include a large ICT (information and communications technology) component can enable the designing of smarter cities that offer a better quality of life for their residents while being more sustainable and cost efficient. It is not only the residents that stand to benefit from this trend; governments can meet their objectives faster and more cheaply, while ICT players find themselves at the cusp of a whole new market. If these stakeholders hope to play and win in this unchartered territory, they will need to adopt a new operating paradigm.

INTRODUCTION

According to a recent UN report, 54% of the world's population were living in urban areas in 2014, a proportion that is expected to increase to 66% by 2050, when another 2,5 billion people are added to urban areas. Furthermore, there were 28 mega-cities with 10 million inhabitants or more worldwide in 2014. By 2030, the world is projected to have 41 mega-cities. Many, if not most, services in cities and buildings are directly or indirectly dependent on electricity and electronics, and increasingly on IT systems. When Hurricane Sandy struck the North-eastern United States in 2012, it brought home to millions how central electricity is to their lives. When electrical power from a central source is down, water supply is cut off, sewage overflows, fires rage out of control and all modes of communication and transportation are disrupted.

NEED TO ACHIEVE SUSTAINABILITY

To prosper and avoid major issues, cities must achieve economic, social, and environmental sustainability and become "smart cities" in the future. This can only be realized by integrating their infrastructures and services to improve urban efficiencies. Technical solutions for improving overall efficiencies that are directly relevant for smart cities already exist in many domains, such as buildings, transportation, industry and services. They include energy management (generation and distribution), lighting, heating and cooling, appliances, communication networks and mobility solutions. The Internet of Things (IoT), the network of interconnected objects or devices embedded with sensors and mobile devices which are able to generate data and to communicate and share that data with one another, is set to play a central role in smart cities

**Consulting Architects, Chennai*

SMART ENERGY

Smart energy requires the optimization of electricity supply systems. This includes the integration of generation from new renewable energy sources, transmission and distribution networks and connected user installations.

SMARTER BUILDINGS

Buildings make up 40% of global energy demand – and will soon account for 60% of it. Smart cities need smarter, more energy-efficient buildings. Buildings use electricity for equipment and systems such as escalators, lifts, access control, heating, ventilation and air conditioning (HVAC) or appliances. Automation can make buildings smarter. It is more advanced in commercial than residential buildings as the former are usually refurbished and modernized more frequently. Automation in buildings includes the installation of programmable thermostats, timers and sensors that switch heating off or on, ventilation, lights, escalators and other equipment such as security systems, as required.

SMART LIGHTING

Smart lighting can be fitted in buildings. It can also be installed in public and external spaces such as streets, plazas and parking lots. Street lighting installations, which may account for as much as 40% of local authority electricity bills, are seen as opening possibilities for providing long-term savings and good returns on investment. LED-based lighting solutions, replacing high-intensity discharge lamps, introduce tailor-made and smart solutions, in particular when combined with control nodes and various sensors which allow for remote on/off switching and some level of dimming control. LED-based lamps are also extremely energy efficient.

WATER AND WASTE MANAGEMENT

As more and more people move to urban areas, the demands on water supply as well as on waste water and solid waste management are bound to increase significantly. Fresh water supply is heavily dependent on electrical systems, from the pumps needed to extract water and send it to mains water networks to purifying installations required to ensure that water is safe to consume. Increasingly, water supply systems are connected to IT networks and can be operated from remote sites. Likewise, waste water treatment is becoming highly automated and relies on electrical equipment such as pumps, rotating motors for clarifiers and aeration tanks.

IMPLICATIONS OF URBANIZATION

Urban populations are growing at a faster rate than their cities can support. Cities are stretched to the limit, struggling to provide basic urban services at unprecedented scales. The drought of 2006 in London, the worst in a century, will be remembered for the dirty little secret it exposed. Hundreds of thousands of liters of water enough to fill 10 million bathtubs was leaking every day from the city's old and rotting pipes, some of which dated back to the Victorian era. All over the world, major cities Cairo, Los Angeles, Beijing, Paris, Moscow, Mumbai, Tokyo, Washington, São Paulo have stories to tell of electricity, transportation, or water systems in crisis. Traffic congestion and pollution continue to increase as overcrowding has become endemic. Urban poverty, associated with unemployment and inadequate housing and services, is a serious socioeconomic challenge. Although the exact circumstances vary from one city to the next, all urban areas have one thing in common critical infrastructure is technologically outdated, woefully inadequate, increasingly fragile, and incapable of meeting even the current needs of all its residents.

Estimates differ, but it is clear that significant investments are required to meet urbanization demands. Global spending on city development and building infrastructure is expected to flow into trillions of dollars over the next 30 years, largely concentrated in developing nations (Fig.1).

These investments have multiplier effects as they trigger opportunities to grow secondary sectors and services while injecting liquidity into the market, ultimately serving to create a more sustainable socioeconomic environment.

Take India, for example. Indian cities need to prepare for an influx of tens of millions of people in the coming decades. The 170-million-plus slum dwellers in India surpass the total populations of all but five countries in the world. Mumbai, which originally planned to accommodate 7 million residents, is now home to 18 million. The resulting urban sprawl and

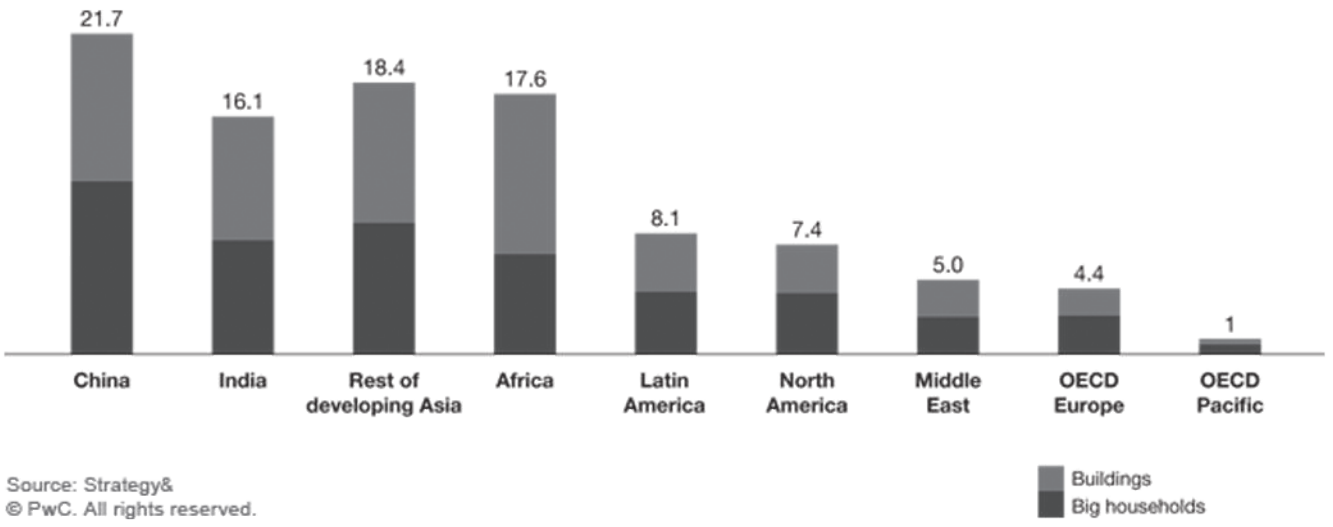


Fig. 1 Cumulative Building Construction Spend (2005–2035, in US$ trillions)

lack of affordable housing have brought to Mumbai the dubious distinction of fostering the single largest urban slum settlement in Asia: Dharavi.

By 2025, there are expected to be 13 urban agglomerations in India with more than 10 million inhabitants. Providing for these numbers of people is no mean feat. Given the pace and magnitude of urbanization, the solution does not lie in simply throwing more money into the usual tactics for addressing the problem. Building more roads can serve only as a temporary reprieve from congestion and can do little to reduce pollution in a rapidly urbanizing environment. Generating more electricity or developing new sources for water cannot purge the system of such embedded inefficiencies as distribution losses, leakage, and pilferage.

SEVEN URBAN DEVELOPMENT TRENDS TO WATCH IN 2016

As the urban development trend continues to grow, a new way of city living is being created in the nation's metropolitan areas. Urban development is being driven by demographic changes to a younger set, thus creating the need for mixed-use and mixed-income models of urban design. The result of this growth, with proper development, includes higher density in downtown areas, more diversity among its residents, more dynamic, social, and interconnected people, and more environmentally conscious architecture and renovations. It is when city planners and city-building professionals come together with an understanding of the following trends, that the nation's metropolitan areas can enjoy the momentum and new opportunities of urban development.

- **Sustainable Building and Development:** As awareness of green building practices becomes more common, builders and developers must adapt to include such methods. Utilizing sustainable materials, incorporating water conservation, and utilizing appropriate landscaping for the region are a good start.
- **Addressing to Mixed-Income Residences:** The increasing cost of urban housing in many cities, including Denver, has pushed lower and middle-income workers out of the city. Yet studies show that having a diversity of people residing in our cities not only makes them more vibrant, but also adds to the overall economy of metropolitan areas. As such, a well-functioning city needs to incorporate a mix of housing types. Affordable housing needs to be incorporated into new development via cross-subsidization with a developer voluntarily or mandatorily including a percentage of such units.
- **Preparing for Shifts in Demographic Trends:** There are two significant demographic changes on the horizon, and it's important for developers to take note now. First, over the next 30 years, the population of Americans over age 65 will double, and the number of those

over 85 will triple. In 2015, housing demands for seniors was 18,000 units per year, and is expected to grow to 82,000 units per year by 2030. The second shift will come from the rapid growth of minority populations, who are already approaching 50 percent of the home buying market. With this growth comes the need for affordability, and amenities that address such factors as larger family sizes, multigenerational families, and specific cultural preferences.

- **Density, Density, Density:** With greater demand for city living, comes the need for development to provide greater density. Modern design can minimize the feel of large, overbearing structures by incorporating altering building heights, varying elevations and exteriors, and reducing unsightly parking structures. The result of quality density projects is positive urban dynamics, including cost-effective public services, and vibrant neighborhoods.
- **Walk ability and Mass Transit:** Residences that are within walking distance of stores, parks, amenities and employment tend to have a higher value than those that don't. Developers and city planners can create a compatible pattern of mixed-use projects to create smaller villages within the city. These villages create a sense of identity and loyalty to the neighborhood and its businesses. Adding mass transit to these areas makes getting around the city that much easier, while also reducing traffic congestion and auto pollution. For example, a light-rail system that carries 120 passengers along a city arterial removes 60 cars from each of the city's streets.
- **Public Spaces and Amenities:** Getting out and about are some of the best parts of living in a city. Developers, planners, and builders who make the most of public space will contribute to the overall happiness and well being of residents. Such amenities could include wider sidewalks, plenty of lighting at night, planters, water features, public art, seating areas, jogging paths, pet parks, and open green space; all of which are desirable features that help make the urban lifestyle more humane, interactive, and vital.
- **Modernizing Urban Infrastructure:** In order for all of this growth to be truly sustainable, it is necessary for municipal and metropolitan leaders to make extensive investments in their city's basic infrastructure. Most U.S. cities have waterlines that are more than 100 years old and pose health and safety risks. Dated rail stations, aged airports, and crumbling bridges, tunnels and underpasses all contribute to the public's lack of confidence in urban governance. Cities must focus on three levels of infrastructure to create the conditions to draw future private investment to urban areas. These include the existing infrastructure in need of repair, such as bridges and tunnels; the modernization of existing infrastructure with new technologies, such as interactive power grids linked to smart appliances; and the installation of new forms of infrastructure for the future, such as high-speed telecommunications lines.

Many of these trends have been on the radar for years. As developers, planners and builders create new urban climates, it is important to keep in mind demographic shifts, technological advancements, and sustainability concerns in order to create urban living to address our needs now and well into the future.

AN ALTERNATIVE VISION FOR CITIES OF THE FUTURE

Urbanization is an inevitable progression. It can go well, it can happen badly, but progress it will. To make urbanization a positive and productive transformation that will deliver long-term gains to citizens, three goals need to be achieved social equitability, economic viability, and environmental sustainability. Social equitability is based on the principle of inclusion; there is no discrimination in access to benefits across population segments. Economically viable solutions are those that are financially self-sustaining. Environmental sustainability ensures the preservation of the environment for future generations.

Businesses and governments are starting to recognize the role of technology in meeting the goals of urban infrastructure provisioning both today and in the long term. Previous centuries saw industrial infrastructure such as railways, roads, and telephone lines preparing the way for new cities and new connections. This century's urbanization is based on

the integrated management of the economic, social, and infrastructure aspects of urbanization via the use of networked information. An intelligent solution ensures more equitable access to services an aspect in which several one-off urban development projects today are found wanting.

Governments of many countries are taking the lead in developing the next generation of cities driven by technological solutions. For example, South Korea is building a new city with state-of-the-art schools, hospitals, apartments, office buildings, and high-end cultural amenities.

THE UNDERLYING TECHNOLOGY

The vision of a modern smart city is that of an urban center that is safe, green, and efficient because all structures whether used for power, water, waste management, or transportation are designed, constructed, and maintained with the use of advanced, integrated materials, sensors, electronics, and integrated networks. This vision is made possible by a host of underlying technology components (Fig.2).

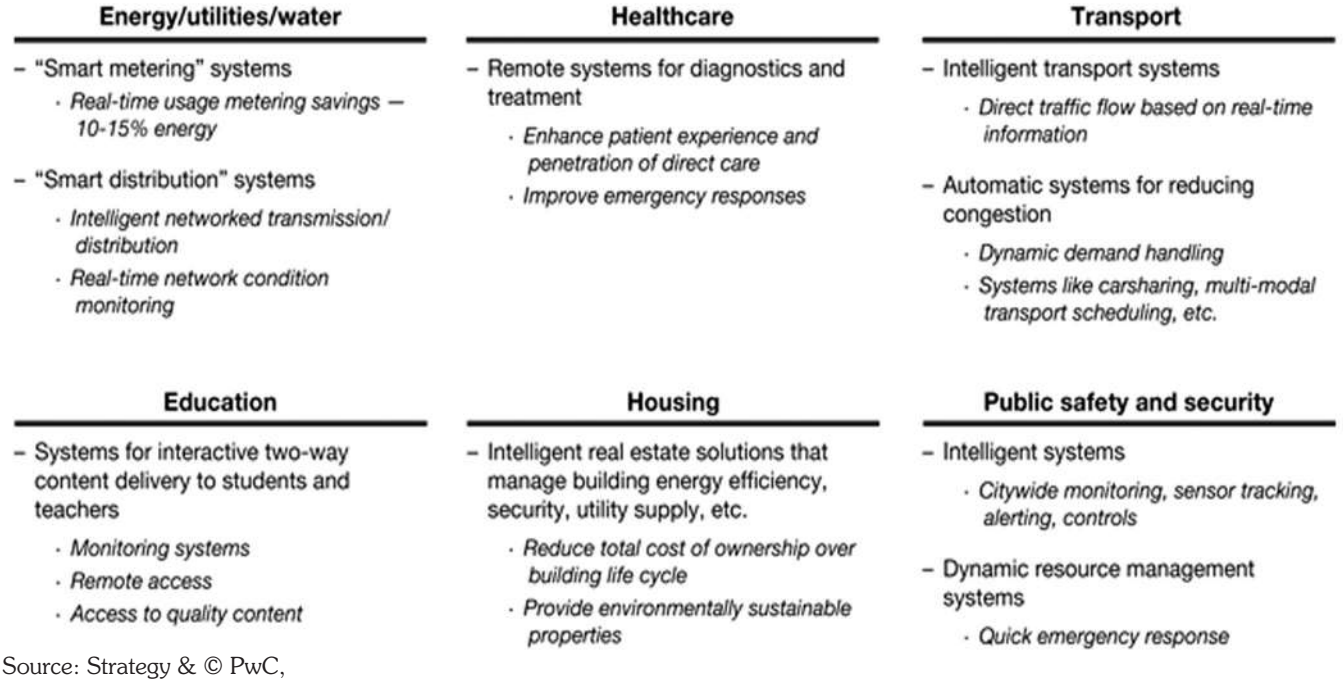
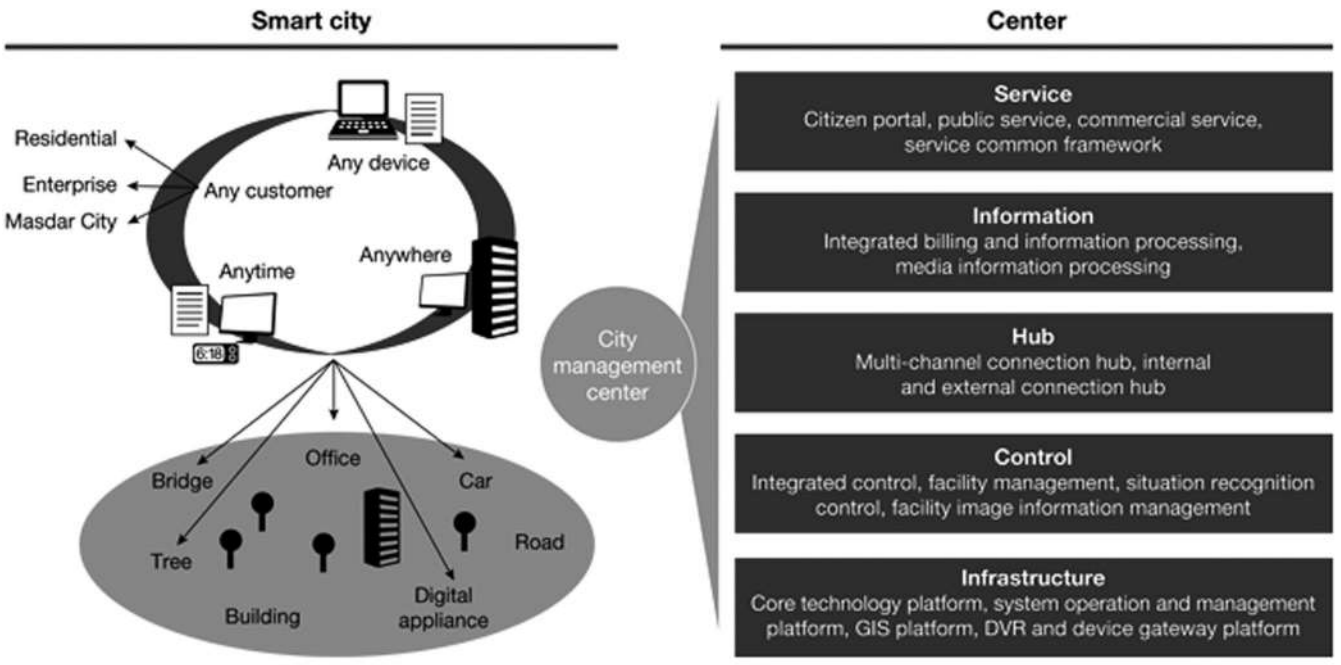


Fig. 2: Examples of ICT-Based City Solutions

The use of smart grids/meters for water and power transmission provides a technology-enabled solution to reduce leakage and waste and increase transparency and reliability. Smart grids deliver electricity from suppliers to consumers using two way digital technologies and can integrate alternative sources of electricity such as solar and wind energy.

TECHNOLOGY SOLUTIONS

These technology solutions not only make urban service delivery economically viable, but also ensure environmental sustainability and social inclusiveness. Modern cities integrate these various technology components to deliver a higher quality of life to their residents. ICT strategies of leading "smart cities" are typically based on three key tenets. First, the ICT infrastructure should enable interaction and interconnectivity between and across homes, office buildings, transportation systems, and smart utilities to ease the chore of urban living for the citizenry. Second, services should be universally accessible to all city residents. Third, services should be centered on the individual consumer and focused on a superior consumer experience. In order to deliver against these tenets, a host of public and private services focused on citizens need to be powered by a common underlying network that provides connectivity across the city (Fig.3).



Source: Strategy & © PwC, All right reserved

Fig. 3: Concept of a Smart City

BENEFITS OF SMART CITIES

Smart cities offer the promise of a better, more sustainable lifestyle to their constituents in the following ways:

- **Efficient Usage:** Technology solutions across the fields of energy, transport, and waste lead to direct economic and environmental benefits. Examples include customized energy consumption through smart metering, micro-grids, and dynamic pricing.
- **Connected and Transparent Public Services:** Efficiency in public and citizen services was driven by siloed e-governance initiatives in the early days. Over time, the focus has shifted to connected delivery of government services, which allows for a better citizen experience. An example is one-stop updating of location records that feed seamlessly to post offices, police records, banks, schools, and taxation databases. Integrated record management also allows for holistic health services across locations. Ready access to services and those services' performance standards for all individuals serves the cause of transparency and equity in city governance.
- **Increased Safety and Security:** Smart cities tend to deploy integrated public safety and security solutions (remote monitoring, smart cameras, pattern recognition, and red flagging through heuristic platforms), resulting in safe and secure settings for their citizens.
- **A Better Lifestyle**: These next-generation cities combine and broaden their objectives to create stronger links between government, education, and industry by leveraging ICT. In order to attract and retain talent, these cities also provide world class amenities in terms of schools, housing, landscaping, and retail and entertainment outlets.

CONCLUSION

The world is urbanizing rapidly, and significant investments will be required to fulfill basic demands. The unprecedented urban growth that is expected, especially in countries such as India and China, demands a radical and proactive response. This will require a wide range of policies and practices to be conceptualized around new socially inclusive and environmentally friendly paradigms. Technology has a role to play, and the global community is waking up to it. The current situation holds tremendous potential for governments to build cities of the future that can serve as engines of growth by attracting talent and

investment in the global competitive landscape. Property developers and ICT players that embrace these trends have an opportunity to cash in on the benefits.

Bibliography

1. Urban Real Estate Investment: A New Era of Opportunity, By Rob Benson February 2016.
2. IEC *e-tech* article by Morand Fachot, first published in September 2015
3. Sustainable urbanization: The role of ICT in city development by Sandeep Dave, Gregor Harter, Ashish Sharma, Jai Sinha , August 5, 2010
4. Fourth Five-Year Plan, Planning Commission, Government of India.
5. "Reinventing the City: Three Prerequisites for Greening Urban Infrastructures," WWF and Strategy&, 2010.
6. "A Renewable Oasis," Melissa Master Cavanaugh, strategy + business, spring 2010.
7. "Grid Wise: The Benefits of a Transformed Energy System," Pacific Northwest National Laboratory under contract with the United States Department of Energy. December 2008.

DEVELOPMENT OF SMART AND SUSTAINABLE URBAN INFRASTRUCTURES – CHALLENGES

TAPAN DAS*

Abstract

India is marching to become a developed nation with sustainable economic growth. Urban development is the engine of the economic development of the nation.

As per the study by Booz & Co. urbanization is rampant in India, where an average of 30 people move from rural areas to the city every minute. India is set to build 500 new cities over next 20 years to house 700 million more city dwellers by 2050.Growing urbanization brings with it challenges of providing adequate land, water, food, better infrastructure, employment opportunities and of course, better living standard. Thus, urban development needs to be improved by adopting the smart route and at the same time focusing on the sustainability in order to provide better living conditions. Smart sustainable urban areas will be the foundation for a better future – a future where cities care for people, the earth, air, water and the environment. In the process India faces many challenges such as water and waste management, efficient energy management, mobility, the built environment, education, health care and safety. To address the increasing aspirations of the urban dwellers India must rejuvenate its urban development, failing which the challenges may become insurmountable.

The core objective of this paper is to highlight the prevailing challenges for urban development in India and is intended to stimulate actions on the possible avenues for merging the concept of sustainability with the smart infrastructure for efficient urban development.

INTRODUCTION

World is experiencing an unprecedented transition from rural to urban living, because the urban areas or cities are the hubs of economic growth of any nation. With their unique characteristics and cultural identities urban areas present various options for business, employment, leisure, entertainment, healthcare and education. These attributes attract people from rural regions to urban regions seeking opportunities for employment, education and better lifestyle. The global urban population has risen to 54% of total population and is set to rise to over 66% by 2050. India is no exception. Its urban population increased from 222 million in 1990 to 410 million in 2014. The forecast is to increase to 814 million by 2050 as per the study of World Economic Forum in April 2015.

The rapid increase in India's urban population has put significant pressure on its existing urban infrastructure and services. Urbanisation is one of the biggest challenges that India faces today.The increase in urban infrastructure and service capabilities did not grow commensurating with the urban population growth. This created gaps between demand and supply in India, resulting to significant pressure on its existing urban infrastructure and services. In developing country like India, cities and urban regions must bridge the demand and supply gap for core physical and social infrastructure and provide a safe environment for urban dwellers for developing a thriving economy.

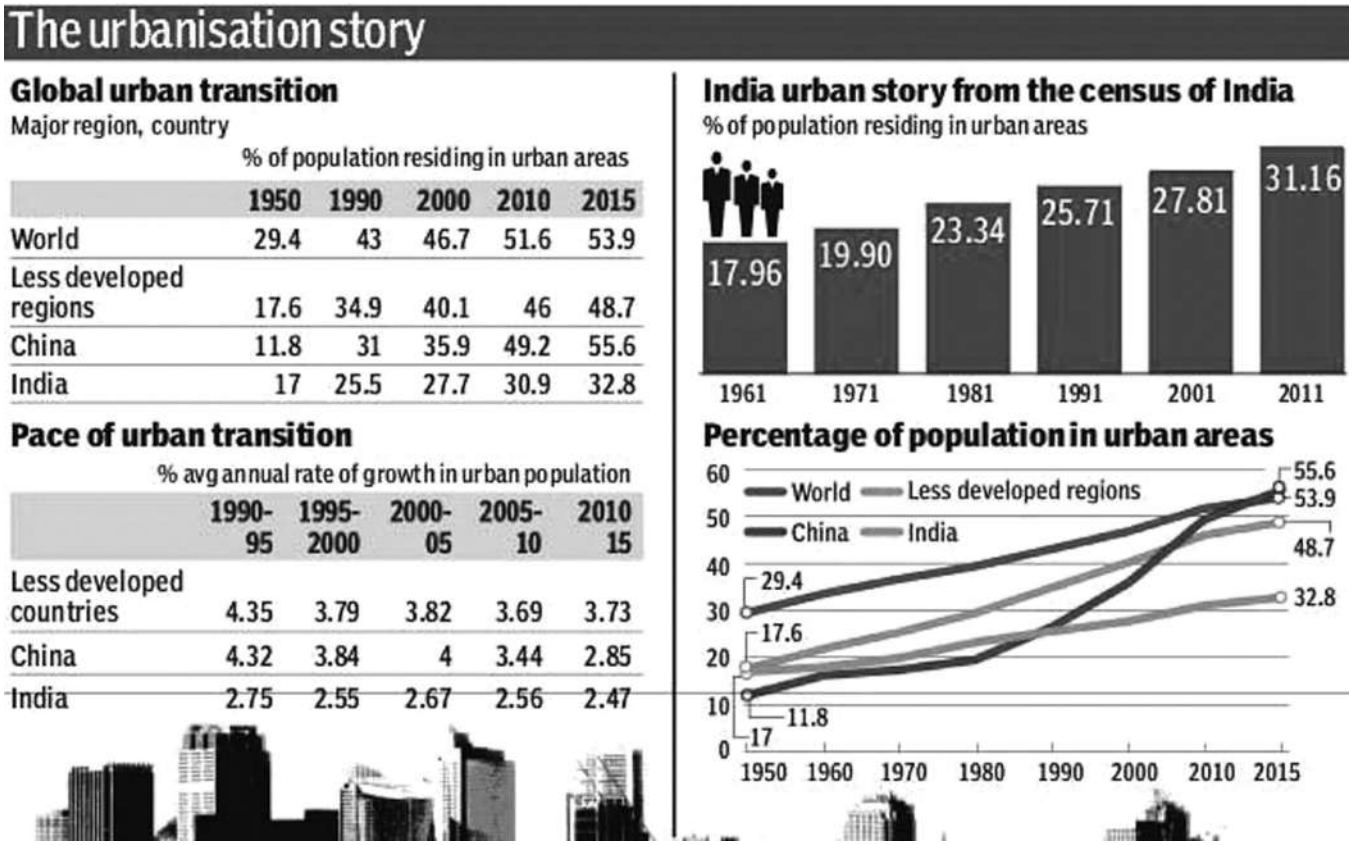
As per the findings of "World Economic Forum survey", cities and urban areas in India face challenges to meet demand and supply gaps such as water management, waste management, energy

* *Managing Director, Das Consulting Group & Senior Consultant, M/s ICT Pvt. Ltd, New Delhi*

production and its efficient management,mobility, built environment and safety. These challenges may derail India's growth if timely and adequate actions are not taken. Situation is all the more alarming as both the access to basic urban services and their quality are constrained.

EMERGING URBAN LANDSCAPE IN INDIA

As per the "World Development Indicators Database, 2014 of World Bank", urban landscape of India has witnessed dramatic change in a short period of time. Between 2004 and 2014, population increased by approximately 14%, out of which urban population grew by almost 27%, whereas, rural population grew by only about 8%. There are mainly two reasons for rapid growth of urbanisation : the rural population is migrating to cities in search of opportunities, and /or existing semi-urban areas are developing into urban areas with improved services for its inhabitants (Fig.1)



Source: Census 2011

Fig. 1: The Urbanisation Story

Though cities or urban areas are considered as offering unlimited opportunities but it is actually illusory, because of limitations of resources such as land and utilities. As a result, development of urban areas in India has in most cases been characterised by the rampant consumption of these resources with little checks on the manner of consumption or the availability of such resources. Due to lack of planning and regulations such growth generally result to development of clusters of infrastructures with improper utilities and services. The myth of comfortable and efficient livings in urban areas, thus, explodes.

Most cities do have development plans and strategies but its imlementations become difficult due to unregulated construction of dwelling units, lack of utility resources and lack of regulatory framework etc. This creates a complex situation prohibiting planned and systematic growth. Depending upon its background of development every city faces unique challenge related to land use, water availability, power, infrastructure and environment. Therefore, every urban development needs innovative solutions

to its problems to grow in a sustainable manner.

WHY SMART AND SUSTAINABLE URBAN DEVELOPMENT

In order to provide better living conditions for existing and future generations, infrastructures in urban areas are required to be improved by adopting the smart route ensuring sustainability. Presently, urban infrastructures are mostly developed without giving much consideration to sustainability. Urban development ensuring the concept of sustainability paves way for the smart cities.

Over the years there have been many definitions of smart city. Each of these definitions had varied linkages with sustainability. However, recent concept of smart city (Fig.2), incluing Government of India's smart city guidelines, do give priority to principles of sustainability.

All the definitions share the common vision of smart sustainable urban development, which is based on robust ICT-enabled infrastructure and service delivery system. Thus, an urban development needs to be both sustainable and smart. Master plan of ITU-T FG-SSC specifies that there can be no single aproach for making an urban region both smart and more sustainable. Each urban region is unique in economic, environental and social context. Therefore, its development has to be determined through unique path to become smart and sustainable.

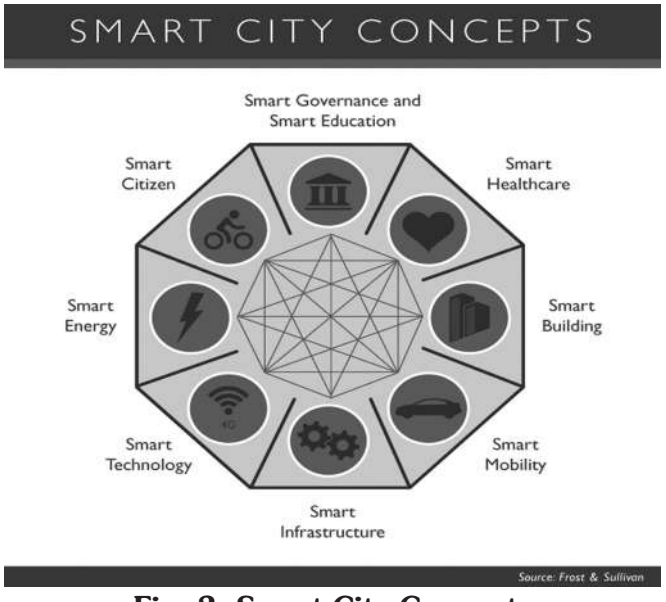


Fig. 2: Smart City Concepts

COMPONENTS OF SMART AND SUSTAINABLE URBAN DEVELOPMENT

Sustainability of smart development of urban areas calls for economic and inclusive stakeholder engagement, robust governance, accountability, continuous monitoring and transparent reporting. These are the tenets of sustainability which are required to be embedded into smart urban area development plans. This also requires articulation of the role of ICT in achieving vision, urban development bench marks to meet the requirements of the citizens. Various components of smart and sustainable tenets are detailed below:

SMART COMPONENT	SUSTAINABLE COMPONENT
Institutional infrastruture	**Economic progress**
E-governance & citizen	- Competitive economy, services
	- Employment growth & opportunity
	- Affordable housing
	- Governance
Physical infrastructure	Environmental stewardship
- Smart energy management	- Climate change mitigation & adaption
- Smart water management	- water, waste and energy management
- Smart waste management	- Green buildings
- Urban mobility	- Sustainable transport
- Smart communications	- Water quality and air quality
- Smart environment	Natural resource - management
- Smart spaces	- Biodiversity and green cover
- Smart surveillance	
Social infrastructures	**Social development**
- Smart health care	- Social inclusion, stakeholder engagement and participation
- Smart education	- Human rights
- Recreation: Art, sports, entertainment Economic infrastructure	- Sanitation, public health and safety
- Incubators,skill development centres Specialised business parks, business hubs etc.	

(Source: Knowledge paper of PwC, 2015)

SMART SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The SDGs are set of development targets. There are 17 goals with 169 indicators to define smart and sustainable development agenda spearheaded by United Nations. These are shown in Fig. 3.

(Source: Knowledge paper of PWC, 2015)

Fig. 3: Pillars of Smart City & Sustainable City

CHALLENGES OF URBAN DEVELOPMENT IN INDIA

Early Responses to Urbanization

Municipal institutions in India existed for more than 300 years but the constitution did not recognize these institutions as decentralized autonomous entities for a long period after India's independence. Therefore, urban planning did not get due attention and support for programme implementation for a considerable period. Only during the Second Five Year Plan town and country planning laws were created. Thereafter, master plans for few cities were developed. During Third Five Year plan only two state capitals and few industrial towns were developed. However, Fourth Five Year Plan emphasized the need to limit urban population growth and Fifth Five Year Plan promoted small towns. The Rent Control Act and Urban Land Ceiling and Regulation Act affected adversely the urban ownership rights and land redevelopment. Consequent to the focus on rural India over a considerable period of time, the Indian cities face challenges across physical, social, economic and governance dimensions. Consequently, severe supply and demand gaps got generated in the city facilities and services. This situation drove cities towards a planned approach for urbanization. Though piecemeal efforts have been made but such approaches lacked the thrust to address mega issues.

SPECIFIC CHALLENGES

Almost all sectors of planned development face challenges, some requiring immediate attention and others require long-term actions. The Challenges of supply and demand gap range across sectors like water, waste, sanitation,mobility and quality and affordability of health and education.

Challenges in Built Environment Sector

- **Lack of development plan:** Most of the cities in India do not have ultimate development plans including neighbourhood planning. Even where development plans were drawn these are not up-dated with varied requirements consequent to passage of time. Even in some cases such plans are not implemented. Cities' development plans are not integrated with the expected socio-economic changes. These result in creation of urban sprawl.
- **Neglected inner core and business districts of cities:** In the last six decades there has been practically no investment for the development of the inner cores and old business centres of the cities. Therefore, infrastructure in these areas did not grow in tandem with the population growth, resulting to choking of the facilities. These areas became vulnerable to natural and man-made disasters.
- **Lack of affordable housing:** In the last few decades real estate prices in India have increased manyfold. Simultaneously, there has not been any planning or efforts to develop affordable houses. This created lack of housing for the weaker segments of the society, resulting in emergence of slums.
- **Informal dwellings:** Non-availability of affordable housing compelled the urban poor and migrants to go for slum dwellings. Most Indian cities are plagued with large swaths of land within the settlements. Such settlements lack the basic urban infrastructures such as water, sanitation, waste management and electricity, resulting in poor quality of life and health hazards.

Challenges in Water Sector

- **Inadequecy of water:** Rapid urbanisation in India in past few years has led to a drastic reduction in the availability of water per person. Water reserve has dwindled from 4,000 cubic meters per person per year in 1951 to 1,000 cubic meters per person per year in 2011. 97 million citizens do not have access to safe drinking water. This down ward trend is continuing. Country is now considered water stressed. Existing sources of water are being stretched to their maximum capacity.
- **Leakages in distribution:** Non-revenue water in urban India accounts for 50% of water production, compared to only 5% in Singapore. This situation is primarily caused due to leaking pipes, pilferage of water, tampered meter or no metering at all.
- **Dependency on rain:** The average rainfall is in the range of 300 mm to 3,400 mm across the length and breadth of India. But India lacks robust mechanism of rainwater harnessing and recycling of used water to augument water

availability. Most rainwater gets wasted off or seeps underground, making it non-consumable. Water Management Authorities in urban India recover only 30-35% of operation and maintenance costs.

Challenges in Waste and Sanitation Sector

- **Low waste collection efficiency:** Waste collection efficiency ranges from 70-90% in urban cities and less than 50% in smaller cities. Less than 30% of waste is segregated.
- **Inadequate recovery of costs:** The current system of waste collection is heavily dependent on manual operation. It costs 25-50% of the Municipality budget.The recoveries of operation and maintenance expences are less than 50%, resulting to financial strain on the Municipality budget.
- **Open defecation and manual scavenging:** Even today more than 50 million people defecate in the open, creating alarming situation in the sanitation sector. The practice of manual scavanging is still prevelant in some parts of Indian cities.
- **Low treatment of sewerage:** Even in large cities, 50% of households are not connected to sewerage system. Only 20% of waste water is treated.
- **Indequate citizen participation:** Normally communities do not participate in waste management. There is indifferent attitude of the citizens in segregation of waste.

Challenges in Power and Energy Sector

- **Shortage of electricity:** In urban India, availability of electricity is 93.90% only. Even the areas with easy access to electricity, very few urban areas have 24/7 access to electricity. This situation has resulted to increased reliance on non-commerial sources of energy and hydrocarbon-based generators.
- **Excessive reliance on hydrocarbons:** India is the fourth largest consumer of electricity. But it does not have abundant hydrocarbon resources to meet its energy demands. On an average 61% power is generated from coal and 9% from petroleum products, leading to excessive imports of petroleum products and detrimental environmental impact.
- **Leakges in distribution:** In India the aggregated and commercial (AT&C) losses for electricity distribution are over 25% for most cities. In some states the AT&C losses range from 15% to 75%. This impacts the capacity of the network and the cost of electricity to the consumers.

Challenges in Mobility Sector

- **Congestion:** With the increase in urban population and increased availability of funds, private vehicles have increased without commensurate increase in road infrastructure. This has resulted to congestion in the city roads.
- **Inadequacy of public transport:** In India available public transport is approximately 22% of the total requirement. Out of 85 cities having population more than 0.5 million, only 20 cities have adequate city bus service. The absence of public transport infrastructure results in overcrowding and poor quality of service.
- **Reliance on private transport:** Between 1951 to 2004, India witnessed 100 fold increase in private vehicles, with the share of buses decreasing from 11% in 1951 to 1.1% in 2004.

Challenges in Education Sector

- **Lagging literacy rate:** According to 2011 census, overall literacy was 74%, an increase of 8% over the previous statistics. However, India lags far behind when compared to Asian peers. Moreover, India's mean in years of schooling is 5.12, compared to 8.17 of China and 7.54 of Brazil.
- **Indequate quality of education:** Though in the last two decades the enrolment in schools in urban India has improved but curricullum of the learnings across scholastic and non-scholastic remaind poor.
- **Skill Gap:** A gap exists between the skill level of undergraduates and the level required by the private sectors, main recruiting source of these graduates. This increases the cost of training to bridge the skill gaps.
- **Lack of research funding:** The main

reason of talent exodus from India is the lack of infrastructure and funding for research and development(R&D). Most of the institutions lack research infrastructure. R&D is a critical aspect of smart cities as innovation will continue to be a key driver.

Challenges in Healthcare Sector

- **Unaffordable healthcare:** The percentage of medical insurance cover is fairly small. As per the survey of 2010, this results to approximately 61% of the total healthcare expenditure as out-of-pocket expenses. This puts added burden on the incomes.
- **Low availability of healthcare:** Against an expected level of 85 doctors per 1,00,000 people, India has only 45 doctors. Situation is the same with nurses and midwives. The problems are likely to worsen due to an increasing population and life expectancy in urban India.
- **Lack of wellness programme:** The focus in India has been on curative medicine rather than on preventive care. For common outbreakes of malaria and dengue generally preventive measures are taken. This is ineffective in eradicating the recurrences. The rise in diabetes and cardiovascular diseases in urban India calls for increased focus on preventive health and wellness.

Challenges due to Ineffective Governance

- Many challenges emerge due to ineffective governance structures, lack of autonomy of urban local bodies and lack of financial independence.
- State and city governments are least prepared to handle the type of urban transformation outlined in the Urban Development programme of Government of India in 2015. The lack of preparedness is due to leadership with limited powers, indequate revenue base, poor collaborration among planning and administrative bodies within cities, archaic processes and insufficient capacity.

THE WAY FORWARD

Ministry of Urban Development of India has launched city rejuvenation programme for 100 cities in India. This programme aims to improve physical, social, economic and governance infrastructure. The development of the identified cities will take place through the adoption of a pan-city initiative to improve the quality of life of all citizens and through one of the three "area based development" strategies of retrofitting, redevelopment and green field.

- **Retrofitting:** A city's existing area (Fig.4) will be developed by adopting smart solutions without making major modifications to the built environment.
- **Redevelopment:** A city's existing derelict area will be redeveloped from the built environment with the aim to improve its infrastuctures and service delivery.
- **Greenfield:** A city's vacant area will be developed using innovative planning, financing and implementation.

Fig. 4: Unplanned Development

Fig. 5: Smart and Sustainable Development

Essential elements for the development of smart and sustainable infrastructures (Fig. 5) will be as under:-

- Assured electricity supply with at least 10% of the energy requirements met through renewable energy.
- Adequate water supply with the recycling of waste water, harvesting and reuse of storm water.
- Adequate urban transport with an emphasis on non-motorised transport, pedestrian- friendly pathways, intelligent traffic management and smart parking facilities.
- Enhanced citizen experiences with engaging usage of open spaces and a safe environment for women, children and elderly.
- Robust IT connectivity and the smart metering of services.

CONCLUSION

Smart and sustainable infrastructures are the foundations for sustained economic development. Quality of urban infrastructure and services ensure economic growth, social equity and environmental sustainability. Challenges are many. Therefore, India must improve its regulatory environment and urban governance in order to facilitate technology to provide benefits. A clear long-term vision and pragmatic leadership are essential to guide through the reforms needed.

Reforms are required at various tiers of government to overcome the present challenges and to accelerate the implementation of urban development schemes. Dedicated efforts will be required by all stakeholders to create an environment where balance is achieved between the private sector's goal to maximise the returns and the public sector's goal to achieve social welfare at minimum cost. It is hoped that cities in India will accelerate the reform process for development of smart and sustainable infrasructures.

REFERENCES

1. World Economic Forum. The Future of Urban Development & Services: Recommendations for the G.O.I, April 2015 .
2. Gobal Survey on Urban Services conducted by World Economic Forum, October & December 2015.
3. World Development Indicators, 2014 database of Wotld Bank.
4. Ministry of Urban Development, G.O.I. Smart Cities: Mission Statement& Gudelines, June 20 15.
5. Report on Indian Urban Infrastructure & Services, March 20116. Knowledge paper of PWC, 2015.

SMART HABITAT – A NEW CONCEPT

Dr. K M Soni*

Abstract

Government of India has already started action on developing one hundred smart cities in India and thus smart habitats will be essential part of the smart cities. Smart habitat will have all essential smart devices and equipment requiring 24x7 electric power and continuous wi-fi connectivity. The smart habitat will lead to comforts and joyful life to the inhabitants.

The main objective of smart habitat is comfort but it should not only be comfort in terms of devices and their operation through information communication technology (ICT) and safety but also a traditional habitat in terms of heating, lighting, ventilation as well as cultural harmony. Smart cities shall endeavour to have smart physical, social, institutional and economic infrastructure and shall generate options for all residents to pursue their livelihood and interest gainfully.

Smart homes will also be energy, water and material efficient, thus to be designed accordingly for sustainable development. Important features of smart homes are presented in the paper including advantages and disadvantages of the same.

INTRODUCTION

Smart or sometimes referred as intelligent habitat is one that is able to offer a self adaptive system to ensure the comfort of the occupants. Self adaptive system is important for survival of the occupant. Thus a smart or intelligent home should be able to enhance not only the comfort but also the quality of life of the occupants. With internet of things (IoT) in advanced stage, smart habitat (Fig.1) is defined as a habitat in which the tools, equipment, devices and appliances are connected through internet for operations as these have become the part of comfort and it is presumed that such comfortable conditions will make the life easy and enjoyable and meaningful.

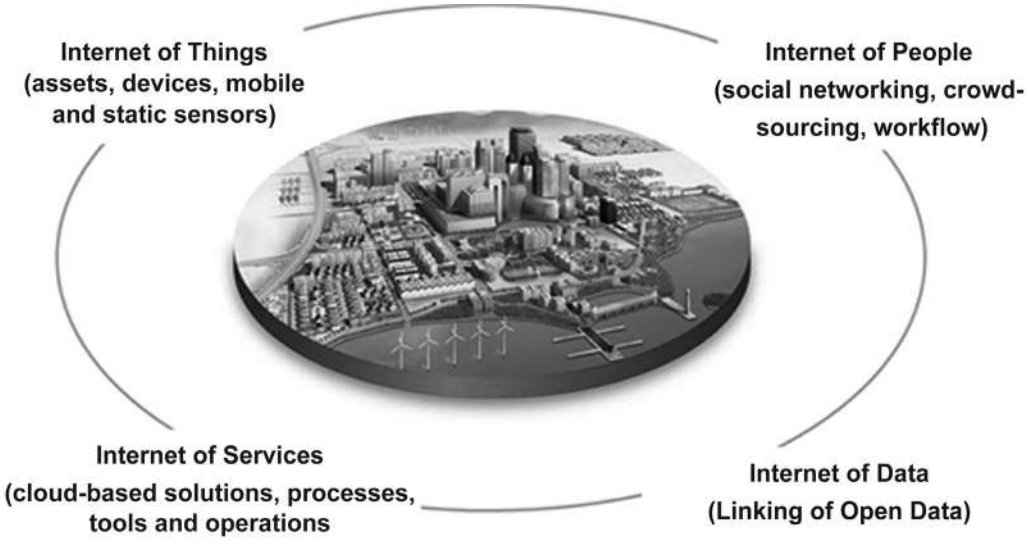


Fig. 1: Smart Habitat

* *Chief Engineer, CPWD, Mumbai*

There may be two types of broad categories in the smart habitat one; connecting all the utilities and the other; connecting devices used for entertainment. Thus smart utility appliances help life to make it comfortable and smooth while smart devices make life happier, full of fun. Both smart appliances and entertainment devices make the home lively, comfortable and interactive thus making it smart. Concept of smart home then can be connected to smart services and smart grids and thus whole city operating on such concept is termed as smart city. Thus smart habitat is a small unit of a smart city. Therefore, concept of smart city is based on 24x7 internet connectivity and thus internet will become important part of human life. The importance of internet can be understood from the fact that in 2008, the number of things connected to internet was more than the number of people on earth and by 2020 it may cross 50 billion. And thus internet of things (IoT) is going to surpass all the expectations. Smart homes will be only a part of such applications.

REQUIREMENTS OF SMART HABITAT

A smart home will require smart appliances, smart devices, smart services and ultimately smart governance. Since everything will be internet based, impact of internet will be in business, entertainment, education, communication, medical, health and also on day to day activities including maintenance of home and appliances. Thus, IoT will be platform for devices to communicate electronically to the world around them be; social, educational, environmental or users and service providers. Smart habitat will also require such smart environment to work based on IoT. Such smart environment will be a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements embedded seamlessly in the everyday objects of people's lives and connected through a continuous network. This would require 24x7 continuous power supply and internet connectivity. Thus smart environment in itself may look like a small world where different kinds of smart devices are continuously working in a smart house to make life comfortable. This would require compatibility of the devices and utility equipment with IoT and thus automated smart equipment and devices will replace manual and wired electric or electronic devices and equipment and thus making life more comfortable requiring almost no physical and even hazardous work. Smart environment for every location will be different for the systems, services and human and even for a hybrid of these and will have virtual environment enabling smart devices to access pertinent services anytime and anywhere based on the requirements. For this, physical environment will have to be embedded with smart devices of different types. However, humans may themselves be accompanied by smart devices such as mobile phones, laptops, tablets, remote controls and surface mounted devices. Such environment may have the features as remote control of devices, device communication, information acquisition/dissemination from sensor networks, enhanced services by intelligent devices and predictive and decision making capabilities. Thus the features of smart homes will be automation, controls and energy.

OBJECTIVES OF SMART HOMES

The main objectives of smart homes are said to be;

- Optimization of inhabitant productivity
- Minimizing operating costs
- Simplifying use of technologies
- Ensuring security
- Enhancing accessibility and
- Improving comforts

The new concept of smart homes is based on ICT and personal autonomy. Personal autonomy should have two basic concepts; one - being able to communicate to others and to control its medium of life. In fact communication in smart habitat also plays a very important role in three aspects i.e. communication between person to system, between system to system and then system to person through controls at different levels. In first communication is a primary controller while in second, it is joint control and in the third control is by the system.

Smart homes will have comfortable home temperature, comfortable audio level of audio-video equipment, light flux level etc as all the equipment can be controlled remotely. Thus one will have comfortable environment as per his or her choice. But then a family may have different comfort requirements living in same habitat and such human interface may not necessarily be implementable. One

may have choice for seeing a movie at a particular time and can program a television and thus it would automatically switch over to that particular programme. The human interface cannot be avoided in selection of programmes though similar conditions may exist in homes which are not smart. It also needs to be understood that with the wireless equipment in place, every activity of the home can be monitored from a distance and thus privacy and safety issues may also crop up.

Smart houses at a future date, may have robotic servants and when programmed, they could start working accordingly. Suppose, a robot has to clean the house at 6 am, it would start cleaning it right at 6 am. If one programmes lights to be switched off at 10pm, they would automatically get switched off at that particular time. This is for the comfort of the inhabitants living in smart homes but by chance if the habits of the habitats are not matching, there may be disputes though cause of the disputes may not be smart devices but inhabitants themselves.

Then there may be different types of services and equipment, and they need to be appropriately interconnected and programmed. Once, the conditions change, one may need reprogramming the utilities and complete system making it very expensive.

SMART EQUIPMENT FOR UTILITY SERVICES

Smart homes will have smart meters for electricity, gas, or water consumption. The devices used for measurements will be able to communicate the information back to the consumers almost even on real time basis if required otherwise as per the time communicated to the devices. Such devices would force to the consumers to plan the activities as per the economics of consumption as peak hour pricing will always be higher. Such meters can be connected to smart grid which would have wi-fi enabled meters that are able to communicate between appliances at home. These smart grids can even be connected to global smart network which would supply say electric power to the required grid.

SMART DEVICES

In a smart house, theoretically all the equipment and devices should be smart for compatibility. Thus old wired equipment and devices will become obsolete. In the beginning there may be some equipment and devices which can be run through sensors but ultimately smart equipment and devices would be required for compatibility. Thus smart homes indirectly will force to procure all the equipment and devices as per the compatibility requirement. In future, ICT companies may have to tie up with other companies manufacturing such equipment and devices, or they may themselves start manufacturing them. It is also possible that AMC of the smart system will be in the hands of ICT companies, the cost of which will be decided by them.

SMART HOMES AND SMART CITIES

Smart homes are part of smart cities and hence all the services whether entertainment, energy, water, waste management, traffic, transport, communications etc. needs to be smart to give an overall concept of smart city. Smart city thus would be based on ICT for all the services and will have 24x7 internet connectivity. Such homes would be energy, water and material efficient providing better comfortable indoor living conditions. Thus smart homes will include smart solutions including the following:

- Savings of natural resources due to energy, water and material efficiency,
- Functional efficiency in terms of proper orientation, and indoor air quality.
- Comfortable and cultural bindings.
- Sustainable, IT governed with respect to capital, operation and maintenance costs compared to normal buildings.
- Having smart connectivity to smart services including water supply, sewerage, drainage, electricity, education, health, safety, security, insurance, telephone, Wi-Fi, business, funeral facilities etc.
- Smart meters, equipment and devices.

Smart home is a unit of a city which is developed by the engineers/architects/planners. Traditionally a city is developed as per the growing requirements. The services in such a developed city are provided and co-ordinated by the government and private authorities and developed according to the city

requirements. For the planned development, master plans and development plans have to be prepared for such cities. Such a city progresses to an electronic city in which e-services are planned and people switch over to e-governance in place of manual services. ICT systems play an important role in such a city. The city switches over to become a mobile city in which this becomes the major source of communication. Smart city is next step to the next step forward.

SMART GOVERNANCE

Smart habitat is a unit of smart cities. Thus it is not only smart houses but city services also need to be smart. To make services and city smart, smart governance will be a basic requirement. Smart governance is about the decision making and management of the public services with efficiency, community leadership, continuous improvement, innovation, and efficient technological services. Thus smart governance will include smart leadership that is bold, initiative bearing, willing and able to take hard decisions like raising and recovering cost of services, implement reforms in governance, prevent unauthorized constructions besides removing encroachments and take on unlawful mafia. And then, smart people living in smart habitat and smart cities should be willing and able to pay the cost of such services. In the conference on "National conclave of states/UTs on smart cities", smart people were defined as those; able to question, pay the cost of services, prevent fellow citizens from violating rules and demand their due and are alert.

REPLACEMENT OF DEVICES

The problem with smart home is that one requires all the smart devices, equipment and utilities and thus one needs to replace existing equipment and devices as those are to be made wireless and interconnected online. Some companies may sell sensors to turn or connect existing devices to make them partially smart. Similarly door openers, fire alarms, dryers, television networks can also be made partially smart by connecting hubs. Then such hubs can be connected to smart phones also to operate them. Sensor can send the signals as well.

RISKS OF SMART HOMES

Possible risks of smart homes can be clubbed broadly in four categories as follows:

- Privacy
- Security
- Health hazard
- Costly

Privacy of a person depends upon the eye watching it. Smart homes will have direct and indirect ways of having eyes on the people living in smart homes. From the data available with the companies, one can analyse your sleeping time, rising time, absence, presence, devices being used by you with their timings, your standard of living, your interests, and so on. Thus your privacy may be in someone else's hands and if these data are used or misused, individual privacy will be at stake.

Smart homes will be having all smart devices and equipment and thus bugging with electronic chips will be very easy. Also hackers can misuse the appliances and meters thus threatening the security and bills.

Smart homes will have items emitting radiation and this is going to be of serious concern as exposure to radiation throughout the stay in the smart houses will pose health problems.

Smart homes are not going to be cheaper both during construction and operation and maintenance hence there may be no space for poor in such places.

CONCLUSION

One hundred smart cities are to be developed through Public Private Partnership (PPP) model, and thus smart habitats would become a reality soon. Smart homes will provide amenities, comforts and enjoyment to the inhabitants and thus will help in curbing health problems. These homes will be designed for requisite energy, water and efficient materials leading to saving of natural resources. Smart devices and smart equipment will require 24x7 electric power and internet connectivity and thus radiation level may pose a threat to health which needs to be taken care of.

Planning a smart city requires in depth feasibility study based on business, industrial, commercial, social, infrastructural and citizen's needs as well as

environmental considerations. A master plan has to be developed for each smart city, dovetailing the existing infrastructure with the new infrastructure.

The concept of smart habitat is gaining importance where advanced features would be developed. Huge investments and development will be needed to solve problems of traffic, parking, waste generation and pollution. The factors for creating smart development like physical infrastructure, social infrastructure, economic infrastructure and institutional infrastructure have to be suitably incorporated in master plan for development. Thus the cost of living and services would go up. The people living in smart cities would need to have enough financial resources to meet cost of such services. Thus smart homes would be affordable only by high income group people which could be termed as 'Smart People". Smart city would also need developing service and manufacturing industry to generate economic and financial resources of earning, both for citizens and the government.

REFERENCES

1. Singh K V and Soni, K M (2015), "Smart Metering for Utility Services". Preliminary Journal of Indian Buildings Congress.
2. http://www.noisygeek.com/smart-homes/
3. http://ahmedabadcity.gov.in/portal/jsp/Static_pages/pi_smartcitysolution.jsp
4. www.moud.gov.in

PLANNING EXCELLENCE FOR BUILDING SUSTAINABLE INFRASTRUCTURE IN SMART HABITATS

LT. COL. L. SHRIHARSHA*

Abstract

Urbanization, as a global phenomenon, is unstoppable, but uncontrolled urbanization results to chaos and disorder, disrupting normal lives, and which all major Indian cities are facing today. Urban growth needs to be ruthlessly controlled by detailed planning and immaculate execution for meeting the expectations of all stakeholders. With extensive focus on environment, balancing sustainability without resource misuse is the need of the hour. For habitats to survive and continue growing, supporting infrastructure of essential services is a pre requisite. Predictability of population growth is a critical factor which will influence the success or failure of the infrastructure support system, and hence as part of any urban planning process, the regulation of population growth in these areas becomes an essential mandate.

Urban development calls for a two pronged approach – one for the urban development, and the second, parallel growth of the neighbouring areas to arrest migration and overloading of essential services network. A combination of regulations, meticulous perspective planning, and flawless execution, followed by a strictly controlled deviation will be the hallmark of a successful urban settlement, worthy of being a model for emulating in future.

INTRODUCTION

The concept of smart cities as envisaged by the current planners in the country is a habitat which offers an equal opportunity to citizens of different economic and intellectual strata in terms of employment, investment opportunities, and a decent living option to its residents. This belief that living and working in the company of likeminded professionals enhances the professional performance and also the quality of life is an age old philosophy. Nearly 2000 years ago, Kautilya had advocated a similar concept of establishing the basic structure of the country on the lines of economic activities and employment, with similar logic in the ancient city of Pataliputra also. Such instances of civilizations organizing themselves on the lines of social and economic activities have also been reported from the areas stretching from Egypt to Indus valley some 4000 to 2000 years before our era .Prosperity of a civilization has therefore always been and continues to be associated with systematic and controlled urbanization of settlements around centres of economic activities.

THE INDIAN EXPERIMENT – PAST AND PRESENT

Post-independence, India has experimented with this concept of urbanization in different forms. The first recorded evidence of this experiment dates back to 1962 – 67, when Prof MS Thacker, Member, Planning Commission highlighted the necessity of developing satellite towns and growth centres to evolve a spatial structure of human settlements which can integrate the urban and rural settlements on the one hand and was also conducive to the development of local, regional and national economy on the other. This was followed by another attempt in the early 80s, when the Govt of India set up the National Commission of Urbanization (NCU) to address the necessity of a planned and integrated policy formulation for urban development in and around the existing urban areas. Accordingly, the National Commission under the stewardship of Mr Charles Correa recommended the development of 329 new growth centres and strengthening of the existing metropolitan cities. Unfortunately, the policy makers

**Project Management Consultant, Banglore*

could not implement this well thought of approach to develop the landscape of the nation and gave up the efforts without documenting any shortcomings in this regard. Finally in the early 2000's the concept of Smart Cities has taken shape. Table 1 compares salient parameters of infrastructure facilities to be provided in Satellite towns/Growth Centres and the Smart Cities.

Table 1: Salient Parameters

Parameters	Smart cities	Satellite towns/Growth centres
Transport	Maximum travel time of 30 minutes in small and medium size cities, and 45 minutes in metropolitan areas	Adjacent to metropolitan cities.
Spatial Planning	175 persons per Ha along transit corridors	Not defined
Water Supply	24 x 7 @135 lit/ person/day	24 x 7 @135 lit/ person/day
Electricity	24 x 7 and 100% recovery of cost	Not defined
Health facilities	Telemedicine facilities to 100% citizens	All civic amenities to be provided
Other facilities	All civic amenities to be provide, Use of renewable energy in all sectors	All civic amenities to be provided

The philosophy of urban development during this journey of evolution from "Urban and Rural Development" to "Satellite Towns and Growth Centres" to "Metropolitan Cities" had been to develop virgin terrain adjoining the existing developed centres to expand the existing habitats. Though the planning norms and facilities envisaged for smart cities is the same as any other urban settlement, the major difference is the deployment of Information and Communication Technology (ICT) to leverage its potential to improve governance and management of resources.

As a nation we have failed in planning and providing even basic infrastructure services like roads, water supply, electric power supply, and sewage disposal mechanisms to support the growth of townships. The recent floods in Gurgaon, NOIDA, Chennai and Bangalore are but some of the examples which highlight our poor performance in this aspect of town planning. In this backdrop one major question that needs to be addressed by the planners is – how differently are we handling this project this time to ensure its successful implementation and sustenance over the years?

POTENTIAL DISRUPTERS OF INFRASTRUCTURE CREATION

The fundamental challenge in creating successful smart cities lies in a clear understanding of the concept and the outcome. While IT and IT Enabled Services (ITES) are only enablers, the "Brick and Mortar" component remains the predominant game changer. Unfortunately the way things are being planned even at the highest levels indicates an excessive focus on IT and ITES, and IT companies taking a proactive role in the entire process and trying to get into the driver's seat. There is a more than required "misplaced" reliance on ICT in this entire scheme of Smart Cities. It should be appreciated that the role of ICT will be restricted only as an "enabler"for effective and efficient governance of these smart cities.

Irrespective of which discipline drives these smart city projects, some fundamental aspects, which has the potential to give sleepless nights to policy makers and administrators, and should be addressed right at the start are discussed in the succeeding paragraphs. These also will impact the creation of supporting services infrastructure essential for the sustenance of these smart cities.

Demographic Expectations

Urbanization as a weaver of dreams has always lured people from various economic strata and all walks of life. With the right to reside and settle in any part of the country protected by the provisions of Article 19 (e) of the Constitution, there is no way that one can restrict the inflow of population into these zones. This surge of human population into urban developments has thrown the best of plans haywire. The expectations of a good life, much better than the one in rural areas and semi urban areas, will drive people in hordes to flock and create settlements around these designated Smart City centres. Also, compounding these demographic challenges is the increasing population of urban poor, due to skills becoming redundant on account of advancing technologies.

As a guideline, it is defined that in greenfield development atleast 15% affordable housing should be provided. The first question is what is the definition of "affordable"? Without a clear definition of this term, and with the cost of land sky rocketing, affordability becomes a very abstract term. Second question that arises is whether the 15%is adequate to house the manpower needed for doing menial jobs ranging from housekeeping, drivers, office staff, and many such roles. The third question is why has affordable housing been envisaged in only nine of the twenty cities in the Area Based Development plan of Smart Cities? With organised "slum creators mafia" rampant in all parts of the country, there is a need to insulate the areas adjoining smart cities from these mafias.

Physical Space and its Management

The strategy defined by the Government for these Smart Cities does not seem to address these aspects of additional land for infrastructure creation in a holistic and practical manner . With planning parameters of 500 acres for retrofitting, 50 acres for redevelopment and 250 acres for new development, services infrastructure apparently appears to be compromised. As of May 2016, it was estimated that Delhi alone needs an additional 1,500 acres for disposing its solid waste. Couple this with the current levels of generation of 18 lakh tonnes of E waste generated in the country currently, which with the ICT compliment of Smart cities is bound to increase and the dismal performance of only 1.5% recycling attained . While this is just the tip of the magnitude of the problem that planners face, this also highlights the necessity for elaborate planning, especially for the supporting infrastructure and services for these smart cities.

The other major menace plaguing all major cities across India is the blatant violation of land use and encroachments. This misuse of land usage norms has been subjected to severe criticism by courts across the nation, including the Apex Court. The recent fiasco in Bangalore, where encroachment, both in collusion with the officials at the helm of affairs and also due to their ignorance which has been a source of heart burns is nothing new in the country.

Keeping in mind the planning norms for various facilities that have to be provided and the space required for creating various essential services facilities, the space stipulated for various approaches indicates a lack of foresight into the magnitude of the problem that is facing the planners and administrators.

Distributed Ownership and Multiple Decision Makers

The lack of a coordinated approach to infrastructure creation in the existing framework of governance of cities is another major hurdle which needs to be addressed. Though it is desirable that ownership of infrastructure creation should be vested with one single agency, where multiple activities get coordinated and executed without disturbing one another's efforts, in reality this seldom happens. Right from the decision to decide ownership of land, which is ambiguously distributed between the Revenue Department, the local governance bodies and the Survey department, the authority to undertake development works is exercised by various departments at their whims and fancies regardless of the negative impact on others assets.While Smart City Advisory Forums are mandated under the guidelines, the independence that the Technical Experts will exercise in the presence of the heavily loaded political fraternity in this forum and their constructive contribution in improving the efficiency of planning is debatable.

To compound this ownership problem is the JV model which is being adopted to build and maintain these cities. The multiple dimensions of ICT and Infrastructure creation and maintenance which is an integral part of the process of building smart and sustainable Infrastructure brings in multiple players with their own vested interests and agendas. In a very well-articulated article, the challenge of these multiple agencies vying for the share of the pie has been aptly described.

PLANNING FOR SUCCESS

In today's boundary less world, acquiring knowledge and technology to create world class services facilities is not a task worth losing sleep about. The challenge is not in designing and creating these infrastructures, but in building human centred urban centres, and ensuring its sustenance over an extended period with minimal operational costs. With the track record of poor past performance in building

sustainable cities, the current plans as envisaged for Smart Cities in India needs to be revisited to deliver world class supporting infrastructure.Some recommendations for enhancing the success rate of this initiative are:-

Inclusive Governance Mechanisms

The key to sustaining infrastructure support to any habitat centre is in scrupulously ensuring that the control of the dependency on these services is within the control of the planners and the administrators. Therefore it becomes imperative that a framework for governing and controlling the population in these smart cities, addressing the concerns of all stakeholders, should be well defined, documented and communicated even before commencing the design. This will ensure that the capacity projections over the years for planning infrastructure are realistic and prevent collapsing of systems due to overloading. This will also give an opportunity to accommodate the requirements of security agencies, civic services and ICT and integrate them seamlessly into the construction plans. Operations and maintenance without disturbing the daily lives of the occupants gets build into the system with an integrated approach. As a strategy, the development of neighbouring towns and rural areas should be explored to arrest large scale migrations to these urban developments.

Distributed ICT Ownership

The ICT layer for governance, which is a critical feature of Smart Cities, should be standardised and replicable, irrespective of the size of the city or the functions, and not subjected to individual company uniqueness. This will ensure that there is no dependency on any vendor, facilitate ease of maintenance and remove all constraints to change vendors if performance is not acceptable. This can be achieved by independently designing solution with a team which will not be involved in the operations and maintenance. Contracting the implementation and maintenance to different vendors will expedite the identification of glitches and also stabilization of solutions. This will also relieve the implementation team of the major responsibility of getting entangled in the technical maze of requirements, clarity, and ambiguity. One can attain synergy by complementing professional competencies and at the same time eliminate competition and rivalry. Also linking the ICT fees to the revenue generated will ensure that the downtime and shortfall of skilled manpower, two critical areas where service providers cut corners, is totally eliminated.

Government Controlled Assets

The JV should be structured in a manner that the control and decision on utilisation of the physical assets is vested with the Government. This will ensure that the "affordable" housing is in reality affordable, made available to the deserving, and not cornered by cash rich firms. A mechanism to identify the deserving based on their functional engagement within the smart cities has to be put in place in consultation with all stakeholders. This will also ensure that there is no over exploitation of natural resources ,threat of encroachments eliminated and balance revenue generation by making Peter pay for Paul.

Technological and Functional Compatibility

Most of the plant and machinery of the various infrastructure services are integrated with a lot of electronics and IT solutions for their operations and maintenance. This will involve the engagement of technically qualified manpower for the routine operations, which has a cost implication, and imposes an additional burden on the occupants of these smart cities. The life cycle cost of maintenance of infrastructure of public utilities must be considered with the initial capital cost before deciding on the selection. The ease and compatibility of functional requirement must drive the selection process rather than the technological trend of the day. The availability of trained manpower at a viable cost to operate and maintain these facilities is another factor which should influence the selection process. The selection and deployment of ICT for other services should also be weighed against the authorized scaling of manpower and their related costs over the life time of the facilities.

CONCLUSION

Urbanization has always enticed people from all walks of life in search of economic prosperity and a better quality of life. Nevertheless, in recent time, the unfettered growth of these urban centres has disrupted the planned growth, leading to chaos and confusion. The core infrastructure elements listed out as inclusion in the smart city is no different from that

required in any other urban development, except for the layer of ICT which is intended to be superimposed over all these services for effective management of resources. With foresight, meticulous planning, and uncompromising governance framework, this is an achievable goal.Integrating the learning from past experiences of urbanization to avoid the pitfalls is very critical for successfully building smart cities, which are actually smart, human function centric and sustainable.

REFERENCES

1 Draft Concept Note on Smart City Scheme, page 3, Ministry of Urban Development, Govt of India, india.smartcitiescouncil.com/…/Concept-Note-on-Smart-City-Scheme_0.pdf?accessed 04 Jul 2015

2 Kautilya, The Arthashastra, L N Rangarajan, Penguin Books, 1992, page 178.

3 Vanished Civilizations, Reader's Digest association Limited, London, page 177.

4 A History of Technology and Invention – Progress Through the Ages, Edited by Maurice Daumas, The Tulsi Shah Enterprises, Bombay, 1969, page 70.

5 The Role of National Policy on Urbanization of India, Puja Mondal, http://www.yourarticlelibrary.com/india-2/the-role-of-national-policy-on-urbanization-in-india/4702/, accessed 04 Jul 2015

6 Draft Report of the Steering Committee on Urban Development: Eleventh Five Year Plan (2007-2012), Govt of India, Planning Commission, New Delhi, page 13. http://planningcommission.nic.in/aboutus/committee/strgrp11/str11_hud1.pd, accessed 04 Jul 2015

7 Draft Concept Note on Smart City Scheme, Annexure 3, page 34 - 36, Ministry of Urban Development, Govt of India, india.smartcitiescouncil.com/…/Concept-Note-on-Smart-City-Scheme_0.pdf?., accessed 04 Jul 2016

8 "Tell us what exactly a Smart City is, Chief Secretary asks Centre", The Hindu, 18 Apr 2015, Bangalore Edition, Page 4.

9 Smart City Mission, Ministry of Urban Development, Govt of India, http://smartcities.gov.in/writereaddata/Challenges.pdf, accessed 10 Aug 2016.

10 Smart City Mission, Ministry of Urban Development, Govt of India, http://smartcities.gov.in/writereaddata/smartcityguidelines.pdf, page 9, accessed 10 Aug 2016

11 Smart City Mission, Ministry of Urban Development, Govt of India, http://smartcities.gov.in/writereaddata/ABD_Components.pdf

12 Smart City Mission, Ministry of Urban Development, Govt of India, http://smartcities.gov.in/writereaddata/Strategy.pdf accessed 10 Aug 2016

13 At half the height of QutubMinar, Meet Delhi's garbage high rises, https://in.news.yahoo.com/half-height-qutub-minar-meet-034500326.html accessed 10 Aug 2016.

14 India's e waste growing at 30% per annum: ASSOCHAM – cKinetics Study, 06 Aug 2016, http://www.assocham.org/newsdetail.php?id=5725 accessed 14 Aug 2016

15 Encroachments: High Court asks BBMP to name 'erring' officials. The Hindu, Bangalore Edition, 10 Aug 2016, page 1.

16 "We don't need IT here": The inside story of India's Smart City gold rush, Rahul Bhatia, The Guardian, 22 Jan 2016, https://www.theguardian.com/cities/2016/jan/22/inside-story-india-smart-city-gold-rush-it accessed 14 Aug 2016

17 How unchecked pumping is sucking aquifers dry in India, Ian James, The Desert Sun, 10 Dec 2015, http://www.desertsun.com/story/news/environment/2015/12/10/how-unchecked-pumping-sucking-aquifers-dry-india/74634336/

18 Smart City Mission, Ministry of Urban Development, Govt of India,http://smartcities.gov.in/writereaddata/smartcityguidelines.pdf , page 5 & 6, accessed 14 Aug 2016

OPTIONS FOR PROMOTING SMART INFRASTRUCTURE FOR SUSTAINABLE URBAN DEVELOPMENT

Jit Kumar Gupta*

Abstract

Infrastructure has been considered as the prime mover of urban economy, efficiency, productivity and bedrock on which the entire urban superstructure is made to stand. Accordingly, provision of adequate infrastructure, becomes critical if the quality of life is to be ensured and urban areas are be made engines of economic growth. Poor quality of life prevailing in majority of urban centers can be largely attributed to the availability of inadequate infrastructures. Since infrastructures play critical role in leveraging and accelerating the pace of the socio-economic development, accordingly putting in place innovative options and effective policy framework to provide basic infrastructure on equitable basis, even to the poorest of poor of citizens, in urban centers assumes importance.

Creating self-sustaining infrastructures and providing efficient delivery mechanism in urban centers would call for promoting planned /sustainable urban development through preparing and implementing better master plans, making cities compact, defining realistic infrastructure norms and standards, adopting cost- effective and state of art technologies, involving communities, promoting people-public-private partnership, making higher budgetary allocations, contracting out services, leveraging urban development for smart infrastructure development.

INTRODUCTION

Infrastructure is the foundation, sustainer, backbone and bedrock of any settlement structure. Quality of life has also been found to have high degree of positive co-relationship with the available quality of physical and social infrastructures. Accordingly, adequate infrastructure facilities have been considered critical not only for leveraging productivity, improving operational efficiency, promoting rational growth and planned development of urban centers but also for accelerating the economic development of the country and minimizing poverty. Infrastructure is also closely related to human beings, enabling them to perform their basic functions of living, working, mobility and care of body and intellectual pursuits, effectively and efficiently.

In the post- independence era, governments have traditionally been providers of basic services because of their monopolistic nature usually involving high up-front costs and long payback periods besides requiring huge amount of resources and investments to keep them operational. These services are characterized by existence of large number of externalities making it difficult for agencies to recoup investment costs and operational expenses through levy of normal user charges. Cities are finding it increasingly difficult to provide appropriate level of infrastructures and efficiently to maintain and operate them.

The fact that infrastructure services do not pay for themselves and the government does not have resources and financial capacity to subsidize the beneficiaries, it has resulted in low availability of infrastructure. Ever increasing demand and requirement has led to the increased deficiency in volumes as well as quality of services delivery. Genesis of infrastructure problems in India has roots in large population base and rapid march to urban areas besides unplanned/haphazard development and low capacity of urban local bodies to plan/ provide/ maintain adequate infrastructure. Rapid growth of urban population has obvious implications in terms of provision and delivery of infrastructures and services.

* *Ex-Director, College of Architecture, IET Bhaddal, Chandigarh*

URBANIZATION

Urbanization in India is known for its massiveness of population and spread. According to Census 2001, with urbanization standing at 27.7%, 278 million Indians lived in 5161 urban agglomerations. This number increased to 377 million in 2011 with agglomerations increasing to 7935 and urbanization going to 31.1%. Based on massive differential between urban and rural growth rate (2.1% against 0.7%), out of projected population of 1.4 billion, over 600 million people may be living in urban areas by 2030,. Next four decades are likely to witness enormous growth in terms of numbers of urban centers, their size and population. Urban centers are likely to emerge as major settlements, housing large proportion of Indian population besides making sizeable contribution to the national economy. With highly positive correlation between urbanization and GDP, urban centers will be major drivers of Indian economy and story-writers of its growth and development. This calls for critically and objectively looking at the urban centers in terms of their pattern of growth and development, provision of adequate infrastructures and evolving strategies to make them more productive, smart, efficient, healthy and sustainable.

INFRASTRUCTURE ISSUES

As per the status paper prepared by the National Institute of Urban Affairs on the Norms and Standards of Municipal Basic Services in India (April, 2007);

"At the aggregate level although nearly 91 percent of the urban population is reported to have access to safe drinking water supply, there are severe deficiencies with regard to quantity of water available to urban residents (CSO, 2004). A recent survey conducted by the NIPFP show that in a sizeable number of urban centers, the availability of water is even less than 100 liters per capita per day, as only 2.7 per cent of sample municipalities are reported to supply over 100 liters of water per capita per day (NIPFP 2000). Approximately 28 per cent of the municipalities provided less than 50 liters per capita per day, which is less than half of the norms recommended by the Zakaria Committee for towns less than 20,000 persons. Even supply between locations is also known to be highly skewed, being very little per head in slums and concentration of poor (Mathur, 2001). In case of sanitation, although nearly 50 percent of the urban population is covered with sanitation services, only 28 percent of the urban households are connected to the public sewerage system. Further, whereas approximately 300 urban centers have a sewerage system, only 70 of them have sewage treatment facilities. The position with respect to the collection and disposal of garbage is worse. The coverage is low as nearly 30-40 percent of garbage is left on the city streets uncollected daily (IIR 2001). There is, thus, a major deficiency in the provision of urban infrastructure and services despite major efforts in the past. The problems are not only of the shortage of services but also inequitable distribution of the services among the different sections of society. Some areas are better equipped with services and infrastructure facilities as compared to the other areas of the city. Besides, there is also inequitable distribution of services to various sections of population. Moreover, it is observed that services provided to the poor are below the norms in terms of quantity and quality".

Looking at the entire gamut, poor availability of basic infrastructures in urban India can be largely attributed to number of factors, which include:

- Rapid growth of demand for infrastructures
- Limited capacity of state/ local level authorities
- Ever increasing gap between demand and supply
- Availability of limited resources with the authorities
- Poor maintenance and upkeep
- Divorcing maintenance from creation of services
- Ineffective and inefficient management
- Obsolete and expensive technologies
- Substantial leakage /wastage during delivery
- Highly subsidized urban services
- Poor recovery and collection of service charges
- Lack of accountability
- Imperfect market conditions
- Non-involvement of communities
- Public sector monopoly in providing services

- Lack of will to rationalize service charges.
- Enormous increase in growth of population
- Lack of co-ordination among service providers
- Unplanned and haphazard development
- Irrational norms and standards for services
- Urban poverty

SUGGESTED APPROACH

Considering the role and importance of infrastructures in accelerating the pace of socio-economic development, improving productivity, improving quality of life and minimizing poverty, provision of infrastructures in urban areas needs highest priority. A duel strategy will be essential to provide appropriate level of infrastructure. The strategy should include, minimizing the network of services by rationalizing urban development process and to provide them in an integrated manner. This would involve regulating the physical spread of cities and making them more compact besides re-defining land use planning and population density norms. Urban development process accordingly would require modification to facilitate the provision of these services covering all sections of society. In addition, appropriate strategies would be essential to remove all roadblocks which hamper provision of such services with innovative techniques adopted to improve their availability. In order to achieve the objective, following suggestions are made:

Making Cities Compact/Smart

Infrastructure focused cities have to be compact which are planned, designed and developed as a vertical and inward looking cities. No horizontal and outward looking city can be compact. Creating compact city would essentially involve promoting high density development for providing large built up area using minimum land. Horizontally spread cities are known to be cost intensive, energy and land inefficient because of larger spread of infrastructure/ services and road network. Horizontal spread of city leads to larger travel demand calling for large and complex mechanized transportation, making the city large consumer of resources and energy, generating green house gasses, creating more pollution, adversely impacting the health and quality of life of the residents besides increasing the cost of development due to high infrastructure cost. Horizontal cities invariably lead to numerous operational and management problems besides making the city environmentally /infrastructurally unsustainable. Compact cities on other hand offer distinct advantages in terms of saving precious land resource, economy in development/ infrastructure, energy efficiency, promoting pedestrianization, cycling and mass transportation with least dependence on personalized vehicles. Compact cities are known to make city life supportive of social living and overcoming the two worst gifts of urbanization including travel and traffic. Planning vertical cities would however, require new state of art approach. Present approach to city planning would have to be re-defined with new order of development controls put in place. It would also require new planning norms and standards for land use and supportive amenities and basic services. Planning vertical cities would ensure that basic principles of city planning are not sacrificed and city would be planned and designed to promote highest order of quality of life, provide high order of productivity and ensure availability of basic services/ amenities to lead an optimum life. Cities of Singapore and New York have clearly demonstrated the distinct advantages of vertical development in promoting quality of life and higher order of operational efficiency. Planning vertical cities would be desirable and essential because India has only 2.4% of global land with 16.7% of global population to hold/support, which would require land resource to be preserved, conserved, protected and used in a most optimum manner for ensuring sustainability and survival of the country.

Preparing Better Master Plans

Preparing realistic and better Master Plan, on priority and time bound basis, for all urban settlements would be critical in order to ensure the provision of all basic infrastructures to all the inhabitants in an integrated manner. Most of the urban residents are facing deprivation in the provision of basic services because of absence of any statutory framework guiding the future growth and development of urban area. Gaps/ overlapping of services and infrastructure are the outcome of absence of a pre-defined growth pattern for cities. In fact there is need to prepare a master plan for the infrastructure development of each city as integral part of the city Master Plan. Preparing Master Plan would be a pre-

requisite not only for promoting orderly growth and development but also making adequate provision and ensuring the availability of the critical physical and social infrastructure in the urban settlements. Planned development offers best option for providing state of art, self-sustaining, qualitative, efficient network and services delivery mechanism for urban sector.

Adopting New Technologies

To improve the availability of infrastructures in urban areas, the technology identified and used would need considerable improvement. Outdated technologies used in creating services have resulted in wastage of precious resources. Accordingly, state of art new technologies, which are efficient and cost-effective need to be adopted for creating infrastructure and services so that optimum use of available resources is made. Decentralization could also be used as a mechanism to ensure economy in the provision of services. Provision of sewerage could be taken as an example , which can help in using treated water to be reused in the local area rather than doing at the city level involving higher cost and larger service network.

Community Participation

Involving communities would require focused attention so as to ensure appropriate provision and maintenance of infrastructures. Upkeep and maintenance of open spaces and garbage disposal along with sanitation are the few areas where community can play a key role. Communities should be made active partners in planning, designing, creation and maintenance/ upkeep of assets to make them sustainable over a larger period of time. Communities can also be used in raising resources for financing the provision of infrastructure at the local level.

Making Higher Budgetary Allocation

Infrastructure sector in the past was monopolized by the public sector. However, priority attached to the sector was found to be very low, as indicated by the outlay made by the public sector in the past. In the second five year plan the funds earmarked for this sector was merely 0.65% which rose to 1.38% in the Eighth Five Year Plan. Due to low budgetary allocations made, availability of resources has not been commensurate to the actual demand and as such provision of infrastructures in the urban areas has suffered enormously. If productivity of urban areas is to be leveraged, the investment in the public sector has to be of higher order. High Powered Committee, constituted by MOUD, Government of India has suggested increasing investment in urban infrastructure from 0.7 %of GDP in 2011-12 to 1.1 per cent by 2031-32 in order to make available higher order of resources to meet the projected demand of investment for urban infrastructure over the 20-year period estimated at Rs 39.2 lakh crores besides Rs 19.9 lakh crores to meet the O&M requirements for new and old assets pan India.

Involving Promoters and Real Estate Developers

Private sector needs to be involved in a big way in the creation of social and physical infrastructures in the urban area. Technological innovations have permitted low-cost supply options and increasing range and quality of services. In addition, new technologies have considerably reduced the cost of providing these services making the infrastructures commercially viable for the private sector. Thus private sector should be given appropriate role by making them co-parceners in the creation/provision/operation of local level services and amenities. Involving private sector in urban development through granting permissions/licenses to develop colonies/townships, offers immense opportunities for creating local and city level facilities. These services can be funded by the internal development carried out by the promoters at their own level whereas city level infrastructure can be created through contributions made in the shape of External Development charges. Gurgaon, Panchkula and Faridabad in Haryana have been able to generate enormous resources on account of EDC charged on the area developed by private developers . Haryana model of resource generation through private sector can be used with certain modifications to provide quality infrastructure in urban areas.

Promoting Public - Private Partnership

Infrastructure development could also be leveraged through public - private partnership. In such a partnership the advantages of both the sectors could be used for creating an enabling environment in which creation of infrastructures becomes easy and profitable. Constructing ring roads, super - highways

are the emerging examples of infrastructure creation under this arrangement.

Contracting Out

System of contracting out of urban services to private agencies is very popular in western countries. Such a system can be considered for adoption in India to improve operational efficiency and quality of services. Possible services which may be covered under the scheme could be solid waste management, sanitation, development and management of green or recreation spaces, roads and street lights. Rajkot municipality contracted out number of municipal services to private firms and community groups, which has brought in considerable operational efficiency in service delivery besides lowering operational cost, varying from 9 to 40 percent.. Property valuation, if contracted out to professional agencies, can bring in large revenues to local bodies. However, contracting out would require well defined and transparent guidelines to be put in place for selecting competent, efficient and well meaning contracting agencies having appropriate experience, expertise, skill and resources to carry out those services effectively and efficiently without public harassment.

Inter-Agency Coordination

Co-ordination among various agencies responsible for providing infrastructures and services in urban sector is another critical area which requires focused action on priority. Generally infrastructures created by one agency are often damaged by another agency operating in the urban area. Roads are generally laid first and when water supply and sewer pipes are laid, roads already laid are dug/ damaged requiring re-laying at huge cost. Similarly while laying down telephone lines, installing electric lines, making improvement in road network, road infrastructures are damaged. Thus laying of services should be planned in a coordinated manner and all services should be laid as per a pre-drawn programme so that no damage is done to developed infrastructures. Master Plan of infrastructure should be available with local authority and before laying of services prior permission of local authority should be made mandatory. Damage, if any, caused to infrastructure should be rectified on the risk and cost of the department doing such damage. Urban local bodies should be declared as nodal agency and given the task and responsibility to ensure effective coordination between various development agencies.

CONCLUSION

Deficiencies in physical infrastructures deeply constrain the contribution which a city can make to the national economy, whereas lack of social infrastructures adversely impact quality of life. Inadequate infrastructure imposes greater economic burden than has been previously understood, causing lower production levels, production delays and under-utilization of productive capacity. These problems further result in lower returns on investments, lower profits and eventually cause considerable loss to community and nation. The effect of poor infrastructure can have serious implications on the poor and informal sector which employs 90% of the work force. Cities with inadequate infrastructure cannot provide the essential incubator functions in which small entrepreneurs can flourish. Accordingly, informal sector has emerged as biggest sufferer. Innovative mechanisms would have to be evolved which would not only help in rationalizing the urban growth but also go a long way in generating adequate resources for creating basic infrastructure in the city area which in turn should be able to attract and leverage sufficient investment adding to its productivity and capacity to generate higher order of employment. Habitat-II-1996 rightly mentions that sustainability of urban areas cannot be attained without providing adequate infrastructure and services besides ensuring the availability of the services at an affordable price.

Role of private sector would be critical but it would be folly on our part to make assumptions that private sector would do everything. In terms of infrastructure development, debate is not whether the private sector should do everything rather it is about how governments can use their limited resources most effectively to bring about a desired outcome. By providing right framework and making strategic use of their resources, government agencies may be able to leverage substantial resources from the private sector. The moot question would be achieving a critical balance between the public and private sector interests. While encouraging private sector, the larger public interest have to be adequately safeguarded and protected against any undue exploitation.

Government of India through JNNURM spent resources to the tune of 1,25,000 crores to improve, upgrade and provide infrastructure and quality of services etc. for the 63 identified cities of the country. Government of India now under 100 Smart City Mission has earmarked funds to the tune of 50,000 crores to make them smart besides another 48,000 crores under AMRUT (Atal Mission of Rejuvenation and Urban Transformation) to develop appropriate level of infrastructure related to water supply, sewerage facilities and Sewerage management, storm water drains, pedestrianization, mass transportation, parking and developing/upgrading green spaces/ parks etc. These resources need to be utilized in a manner that they usher an era of providing basic services to all urban residents. However, challenges of providing appropriate level of infrastructure in the urban areas will be the most formidable task, which would be staring at the planners, administrators and agencies involved in planning, development and management of urban areas. Our capacity and capability to meet these challenges, effectively and efficiently, would hold the key and determine the future growth and development of Urban India.

REFERENCES

1. Mathur, Chandra, Singh, Chattopadhyay; Norms and Standards of Municipal Basic Services in India, NIUA WP 07-01, April, 2007, PP 1,5,6..
2. Spatio-economic Development Record, Vol. 19 No. 1, Jan-Feb, 2012, PP 10,11.
3. Gupta Jit Kumar, 'Strategy for Planning and Designing Smart Cities in India'- Published paper
4. McKinsey Global Institute, "India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth", April 2010.
5. 'Report on Indian Urban Infrastructure and Services'; Ministry of Urban Development, Government of India, 2010
6. Gupta Jit Kumar; 'Urban Infrastructure Development-Some Innovative Approaches'- Published paper

SMART INFRASTRUCTURE IN URBAN DEVELOPMENT

Dr. Mutyala R. Prakash*

Abstract

Cities in the world are growing in their number, geographical sizes and population. This pattern has not spared India. Urban and regional planners conventionally applied gravity models to assess these changes and suggested the reversal of rural population in their original settlements. The skewed population pointing out the peak at urban settlements and the two tails ending at the rural settlement is an age old concept and theory.

The present paper attempts to innovate the 'Theory of Repulsion' opposed to the 'Gravity Theory of Urban Settlements' attraction. In this concept the author fully justifies the differential pattern of inputs in the smart cities. The hard core of cities have highest investment in infrastructure followed by middle level in urban peripheries and least in the low populated settlements. Though the investment in core of the cities are high they do extend their influence on the less populated urban agglomeration and rural areas as the technology related to digital world are not limited to its, boundaries while they reach nook and corners of any geographical areas. The examples are the television towers, mobiles masts and cloud technologies. The paper concludes to calm down the critics of smart cities that investment in smart infrastructure does not mean that they are confined to population of cities only but they tend to serve the rural and urban conglomeration areas.

INTRODUCTION

The present paper deals with review of problems associated with Smart Cities in India and the world. The professionals in the field of planning and engineering are aware that mere growth of population of a city is not solely responsible in exerting pressure on main land (city core). It is the population of neighbourhood , which is called as hinterland population which exerts additional pressure on the infrastructure of a city. A city is known by its Local Self Government geographical boundary which is being superimposed by the Urban Development Authority jurisdictional boundary. In reality these two boundaries are highly notional and theoretical in its existence. The real boundary of city is much larger than the Municipal Area which encompasses by the Urban Development Authority. Prakash[1] called such boundary as urban region. The real boundary is a dynamic and falls beyond even urban development authority jurisdictional limits.

The relevance and argument over what makes an urban region, is sensible in the context of smart infrastructure analysis of cities because one is bound to go wrong in understating the city boundary due to co-existence of Municipal Area and Urban Development Area in some cities like, Delhi, Kolkata, Mumbai, Chennai, Bangalore, Ahmedabad ,…,etc. There has been continuous pressure of population due to the migration in to these cities from rural settlements on one hand and on the other the pressure from the urban neighbourhood, also called as hinterland, periphery , city agglomeration, and suburbs. As a result any achievement or progress in development of main cities get totally defeated by the growing pressure of population from these contiguous areas and migration from other far flung human settlements. Though theoretically planners ascertain that they have considered the projected population of the city while planning for smart infrastructure, seldom in Indian context , these claims

**Director, Institute of Development Planners and Researchers, Gandhinagar*

are true, fragile and non existing to prove such an argument, by even simple methodologies.

Though it is matter of concern to us, that we are unable to constrain the growing pressure on existing infrastructure of cities, still no strategies found to be worthy in place to mitigate the rural migration into the cities. India is fully encountered with the growing sizes of cities and unable to service the population within the cities. If one draws a skew diagram placing population density in hinterland on X axis and distance to main land from surrounding settlements in hinterland on Y axis, one might find that the skewness of urban sprawl indicate shrinking of peaked point and expansion of two tails in the diagram. This signifies that the population density is increasing in neighbourhood proportionately more than the core of the city region. It is true that along with density of population, one might notice that the investment density also indicate similar scenario, as neighbourhood settlements attracted more capital investment in the form of industries, shopping malls, and capital intensive entertainment units but totally depend on the social infrastructure of main land. This is also true in case of capital investment in real estate , housing and farm housing units. Thus the neighbourhoods planning and development becomes most demanding or else the pressure on main city would keep increasing which might create innumerable problems to the smart city's infrastructure.

GRAVITY MODEL

Gravity Model in regional planning explains adequately [2] the quantum of PULL that gets generated from rural settlements surrounding a city, which mounts pressure on infrastructure resources of a city. In the model the distances between settlements can not be tampered with, however the model supports the reduction of population and activities of both mainland and neighbourhood to reduce the PULL effect. While reduction of population is no way a success in context to Indian demographic pattern, one is left with the choice of reducing trip generation between mainland and its hinterland settlements which seem to be feasibility.

THEORY OF REPULSION MODEL

This theory is an original innovation of the author the first publication is sought through Journal of Indian Building Congress. The concept of repulsion has origin from the science of physics. Every object has gravitation pull due to the natural existence of gravity from our planet. The pull effect of gravitation can be repulsed by force temporarily similar to jets which can pull miles away from earth surface working contra to the gravitational force. For the purpose of application of 'Repulsion' towards smart cities , the author endeavours to build the argument by means of logical deduction and simple logistic system, as testing of hypothesis on Repulsion Model is elaborate and the present paper has limitations to allow a full-fledged algorithms .In brief the theory is contra to the gravity model where the forces of attract is staggered by means of eliminating trip generation to main city; lest keeping the population parameters unaltered. This is known in management science as 'Interventional System'.

CONCEPT OF PULL OR ATTRACTION

The pull effect in urban regional planning can be observed from intensity of trip generation analysis widely acknowledged in transportation Models as mother of spatial planning. The trip is defined as travelling of distance from Point Ai=1,2,3,…,n to Aj=1,2,3…,n by an object no matter whether it is living or non living entity. These trips are visible and accountable through a spectrum of a unit called as 'PCU' (per car unit). The per car unit has a standard having length and width of an average motor passenger car. The PCU for another type /mode of vehicle or object which is being determined based on some sort of generalised scaling system , like a 10 ton truck may have PCU units as 5 while a smallest truck could be 0.75, an autorickshah as 0.25 and motor cycle as 0.10. The paper constrains; further to extend argument on PCU fixation as the length of paper has limitations.

QUANTIFICATION OF PCU

Every PCU which performs trips is being quantified on time scale which comprises of 'fixed point' similar to land's 'bench mark' on rail lines or roads corresponding to particular second, minute, hour and date (DD/MM/YY).By summing up PCU per hour the model calls it as gravitational pull between settlements which could be quantified in a matrix form as (Pij) . The Repulsion Theory also supports the argument that the pull effect is more

for those settlements nearer to city core which could be quantified by relation (Pij/Dij)= Kij, where P is pull effect and K is absolute pull effect, i=1,2,3,…n and j=1,2,3,…,n, being origin and destination respectively. 'D' is the distance between one to one settlements. For simplification the model considers, only roads and rails and not air and shipping PCUs, assuming they are covered by road and rail as most of the products are to be further transported to cities by road or rail.

CAUSE AND EFFECT OF TRIP GENERATION

An opinion survey revealed that the trip generation by people falls; by and large in to the categories as described at Table 1. From this one can plan the neighbourhood to reduce the trip generation which is main focus in this paper to plan a smart infrastructure in city mainland and its periphery. In the Table 1 the details pertain to typical trips made by the individuals which forms the important basis for generating the trips from the surrounding settlements to the main city and vice versa.

Table 1: Trip Generation Results Based on Opinion Survey of Indian Population

	Trip	Percent-age	Revers-ible	Non Reversible
1.	Health	5		true
2.	Rail Travel	1		true
3.	Air Travel	1		true
4.	Work place	40		true
5.	Relatives	2		true
6.	Friends	3		true
7.	To sell	10	true	
8.	To buy	10	true	
9.	Legal	1	true	
10.	Office works	5	true	
11.	Entertainment	2	true	
12.	Education	15	true	
13.	Religious	5		true
	Total	100	43	57

The Table 1 shows some of the trips are reversible which means a trip can be staggered if the neighbourhood is optimally planned. The net result is drastic reduction of pressure on main city infrastructure. The trip generations can be brought down further by providing the effective internet, mobile, and other electronic related infrastructure in neighbourhood settlements coupled with digital office and cyber educational system in the city. The people must get the same satisfaction of services in their respective homes, as if they visited physically some of the places mentioned at 7 to 12 located at core city

SMART INFRASTRUCTURE PLANNING IN CITIES

Government of India has identified recently some 100 or more cities and qualified them to be eligible to draw the central grants; amounting to 1000 crore in the financial year 2015-2016. Some of these cities in this category are very large, a few of them are medium sized and rest are small size cities. It would have been appropriate to release grants to these cities, after obtaining the technical report similar to the scheme of growth centre 1990-2000 as all the cities can not be equated at par to avail equal central grants. This is justified on account of differential economic, social, and geographical system prevailing in each of the cities which are different from one another. The growth centre scheme was closely identical to smart cities and they were vetted by designated financial institutions like IDBI, IFCI and others with reference to the technical and financial feasibility analysis. It might have opted to include private partnership and banks as shareholders in the funding of smart infrastructure in the these cities for enabling better accountability. Towards selection of smart city, no involvement of professionals or enabled pre-appraisal ever was carried out though the country has highly skilled appraisal experts to carry out such assignments. As a result the people are not aware of the project outlines of smart cities with respect to smart infrastructure which is the theme of present seminar. Let us examine the planning of smart infrastructure by the United Kingdom which has enacted several Legislative Bills in British Parliament in in the beginning of the year 2016. Some of the Bills are further reviewed of those pertaining to smart infrastructure and one nation economy in implementing the various smart infrastructure components.

SOME LESSONS FROM THE U.K IN CONTEXT TO INDIAN SMART CITIES

In the year 2016 the U.K has passed several legislative Bills in their parliament pertaining mostly to the schemes akin to our smart cities. Two significant bills are relevant.

- Neighbourhood and Infrastructure Bill 2016-17 (The U.K)
- National Infrastructure Commission Bill 2016-17 (The U.K)

NEIGHBOURHOOD AND INFRASTRUCTURE BILL (U.K)

The U.K has been witnessing frequent water logging and floods in several parts of the country in the past decade. Most of them are scary in the neighbourhood as the neighbourhood settlements, lagged behind having weak infrastructure (i) before floods incidence and (ii) inadequate rescue systems inplace after floods. It is also noted that the dependence of the neighbourhood population has been increasing on cities like London, Manchester, and others especially for job opportunities and business (sell and buy). Besides these two the educational institutions mostly private sector found to neglect the neighbourhoods as some of the educational institutions find it difficult to attract students due to weak infrastructure. Following are the gist of infrastructure requirement in the neighbourhood for which the above bills were enacted in the year 2016 by British Parliament Legislature focussing on Neighbourhood Planning of Infrastructure. The main focus of smart infrastructure is immediate requirement for Neighbourhood Planning and Development which included following.

- Extension of fast broadband facility
- Mobile network with additional capacities of mobile masts/equipment
- Modern transport links includes tube trains
- Generation of highly skilled rural work force
- Access to quality education
- Educational support system like scholarships and part time jobs
- Expanded apprenticeship and strong conditions for rural business growth.
- Enterprise zones in rural areas
- Better regulations and improved planning for rural business
- Easier to live and work in rural areas
- More addition to housing units
- Increased availability of childcare –Greater local control on child welfare
- Regional planning beyond Urban Development Authority Areas/Municipal Borough
- Critical infrastructure planning including drainage, water supply
- Ensure durability of infrastructure through high quality standards

From the above contents it is evident that unless one plans for better Neighbour hood , the entire pressure builds up on existing and planning infrastructure of cities there by lending the infrastructure run in to the thin layer. This is evident from the recent happening in Indian cities like, Chennai, Mumbai, Bangaluru, and Gurgaon during the monsoon and torrential rains. The large cities can not remain as prosperity islands and one must enable the neighbourhood to prosper along side with major cities, so as to ensure balanced development.

HOUSING AND PLANNING ACT 2016 (U.K)

Though the Royal Town Planning Institute is enforcing the housing and planning regulations from time to time, there is a need to strengthen the housing and planning in neighbourhood settlements making them competitive to major urban centres. The emphasis of the bills enacted, is to provide the housing lots along with the upgradation of infrastructure in rural areas. It is interesting to notice that the U.K Government has understood the need for neighbourhood development as it forms the integral part of an urban area like the London metropolis. The aim is to reduce the dependence of the neighbourhood areas' pressure on main city's infrastructure. The bill enables to implement land registry system having the provision to enable privatization on temporal scale.

NATIONAL INFRASTRUCTURE COMMISSION BILL (U.K)

It has been noticed that there are multiple agencies dealing with issue concerning infrastructure and often they tend to look for direction of the government once a major catastrophe arises. There is concerted effort to bring uniformity and social balance in the country by offering the same quality of infrastructure which otherwise are available for only portion of population. If the gap widens, then the people tend to move into the cities which is the case in India cities . Following are the outlines of role and functions of the National Infrastructure Commission in the U.K.

- To enable one nation economy model
- Effective neighbourhood planning
- Compulsory purchase of land with adequate compensation of land acquisition
- Formation of National Infrastructure Council to own the accountability, in case of delays or damages to infrastructure quality and programmes.

LESSONS TO BE LEARNT BY INDIA FROM THE U.K EXPERIENCE

With regard to smart infrastructure development in India, there are different 'School of Thinkers' numbering I to IV.

- Smart cities and infrastructure development in existing cities
- Smart cities and infrastructure development by totally rebuilding our existing old cities with neighbourhood planning .
- Smart cities and infrastructure development in new area similar to the growth centre schemes.
- Curbing trip generation in to the cities

The choice at I and II amounts to some amount of demolition of existing structure in the cities which might land up in to the judicial process thereby delaying the entire scheme for several years. However, it is rather impracticable task to implement the smart city without removing a brick or two from already constructed buildings in existing cities. The neighbourhood planning require the enactment of laws by the Parliament similar to the ones cited in the case of the U.K. The choice III seem to be much easier to implement as one will start with scratch the entire building up a new smart city. For this purpose India should think in lines of the U.K in constituting the National Infrastructure Commissioner or Authority which would function similar to the role being performed by the National High Way Authority. Indian National Infrastructure Authority (INIA) being the constitutional body, it will coordinate with other agencies related to infrastructure and state governments to enable the smart city infrastructure is being built. INIA will ensure that one economy model of the U.K is followed as the INIA will have to work with interstate and state governments to build smart city infrastructure components, so as to enable uniformity in implementation of smart cities. The school of thinkers IV promote the means to curtail the trip generation in to the core of cities, by enabling smart infrastructure in neighbourhood. Alternatively the trips to cities be made costlier by introducing entry tickets to enter in to core of the cities. A parallel example can be drawn from experience of the London City. There is entry ticket for vehicles which is to be purchased in person or on online, so as to enter in to the delineated central London area. These tickets are valid for pre-booked time of entry. Once the time is lapsed, then the person has to buy another ticket to remain in the central London area. The entry ticket restriction has reduced significantly the vehicular trips in the core of London city and also decongested the vehicular traffic. It is also easy for the administration to control and restrict the vehicles once the capacity of central London area is exhausted with regard to parking and density of vehicular traffic. This might provide strength to repulsion model which is being worked by the author with more significant technical inputs.

CONCLUSION

India may follow the legislature of British in passing the legislative bill in Indian Parliament in constituting National Infrastructure Commission reporting to the Prime Ministers' office. The commission be given the constitutional powers to implement the smart cities without which the very concept and implementation of smart infrastructure may not be effective as India is a large country with several States in its Union and having significant

diversity. India needs to plan for one nation economy if smart cities are to be successful. The 'Theory of Repulsion' will catch up the attention of administrators in years to come, as this theory is originated from empirical analysis and British experience of entry tickets system to core city area, to curb trip generation. The Government of India may consider to prepare separate master plan for each of the smart cities in view of implementation of 100 smart cities in India.

REFERENCES

1 Mutyala. R Prakash Futuristic Urban Planning of Smart City Regions– Published in IBC Built Environment Nov-Dec 2015 Vol.1 issue 6 page 19

2 M. R Prakash, Some Contribution to Regional Planning Models Gujarat University 1982

TECHNICAL SESSION - II

WATER MANAGEMENT

SMART WATER MANAGEMENT

GAURISHANKAR DUBEY*

Abstract

Water is different from other natural resources. After all, there are substitutes for many resources, including oil, but none for water. Water is 100% natural, zero % substitutes. India is facing a looming water crisis that has implications not only for its 1.25 billion people, but for the entire globe.

India's demand for water is growing even as it stretches its supplies. Water infrastructure is crumbling, preventing the government from being able to supply drinking water to its citizens even after 67 years of Independence.

Pollution is rampant due to unfettered economic growth, poor waste management laws and practices. Although many analysts believe that demand will outstrip supply by 2020, there is still hope for India. Water scarcity in India is predominantly a manmade problem; therefore if India makes significant changes in the way, it thinks about water and manages its resources soon, it could ward off, or at least mollify, the impending crisis.

India has the power to avoid this dark future if people take action immediately: start conserving water, begin to harvest rainwater, treat human, agricultural, and industrial waste effectively and regulate how much water can be drawn out of the ground

INTRODUCTION

Water constitutes one of the important physical environments of man and has a direct bearing on his health. Water is crucial to life on earth. Yet for many people across the planet, getting access to clean, safe drinking water is a challenge. The United Nations says that by 2025, 1.8 billion people will be living in areas "with absolute water scarcity."

Water is precious to man and therefore WHO refers to "Control Water Supplies to ensure that they are pure and wholesome as one of the primary objectives of environmental sanitation". Water may be polluted by physical, chemical, and bacterial agents. Therefore, protected water supply is a essential requirement of public health of a community.

Many facets are involved in tackling the problem of providing protected water supply to all communities at the minimum cost and in the shortest possible time. The situation has since changed considerably. Per capita use of water has increased, sizes of human settlements are increasing at faster rates and industrial and agricultural uses of water have increased considerably. Irregular and inadequate rains, as also the pollution of surface and ground waters have rendered the problem of meeting rising demand, increasingly difficult and expensive.

WATER RESOURCES IN INDIA

In India, water is considered a "free gift of nature" and therefore charging for water is not liked by the people. Providing water supply was not considered to be a commercial or even no-profit-no-loss activity. No doubt, water is still a free gift of nature but it is so in "as is where is" condition. When it is desired that water, as is available in nature, should be made safe for drinking and transported to the points of consumption, it becomes a "Commodity" i.e. acquires economic value. The product, delivered

* *Formerly ED, SAIL & Sr Advisor, JSPL, New Delhi*

to the point of consumption, is called potable water and it has production cost. It is to meet the water quality standards required for human consumption as per World Health Organization (WHO).

India has 18% of the world's population but has only 4% of water resources. The world's annual per capita availability of water has decreased from 6042 cum in the year 1947 to 1545 cum in 2011. Annual per capita availability of water was 1861 in 2001. Annual per capita availability of water will further reduce to 1340 cum by 2025 and to 1140 cum by 2050. (Table.1)

Table 1: Headed Towards Water Scarcity

YEAR				
Population (million)	2001	2011	2025	2050
	1029	1210	1394	1640
Per Capita availability (cubic metre/year	1816	1545	1340	1140

Source – 2013, Water in India Prospects, Situation and UNICEF

As per World Bank Report dated 03.05.2016, there is need for enhancing efficiency of water used in India. According to one estimate, groundwater pumping accounts for no less than 4 to 6% of India's carbon emissions. Depleting ground water level in India may be a real worry if one looks at the future demand of water in India. It is estimated that the country would need 1180 billion cubic metre (BCM) of water annually by 2050. India, at present, has potential of 1123 BCM of utilizable water with 690 BCM coming from surface water resources and remaining 433 BCM from groundwater resources. In view of this projection, the country would not be able to meet its demand unless it recharges its aquifers and uses water more efficiently and judiciously.

PRESENT SCENARIO

India lost 50% of its lakes and wetlands to other land uses between 1911 and 2014. The country continues to lose wetlands at an annual rate of 2-3%. Our seas, lakes, rivers, streams and nullahs are still abused by the public and treated like garbage dumps. Every water body in India is abused on a daily basis by our citizens. The tragedy of India's water scarcity is that the crisis could have been largely avoided with better water management practices. There has been a distinct lack of attention to water legislation, water conservation, efficiency in water use, water recycling, and infrastructure. Historically water has been viewed as an unlimited resource that did not need to be managed as a scarce commodity or provided as a basic human right.

The incidence of urban floods is on the rise because of depleting wetlands and rivers. In 2006, 22 cities in India reported floods. The number went up to 35 in 2007. From Kashmir to Chennai, almost every urban centre in the country has reported cases of urban floods. A logical impact of this unplanned urbanization is that almost all important rivers today carry water that is unfit for human consumption. Additionally, several small rivers and tributaries today have either gone extinct or have been reduced to a nullah that carries industrial effluents.

Poor waste water management and sewerage cover is responsible for the alarmingly high pollution in all important rivers. Industries are one of the main causes of water pollution today with more than 70% of all industrial waste dumped untreated into water bodies.

Access to drinking water remains one of India's biggest challenges. This issue is reinforced each day by a growing population, rapid urbanization and the growing demand for water from agriculture, energy and industry.

Access to drinking water is recognized to be, above all, a question of public and domestic health. According to UNICEF, only a quarter of the total population in India has drinking water on their premises and nearly three-quarters of all diseases in India are caused by contaminants in the water supply.

Due to the amenities of typical urban life, such as flush toilets, washing machines and dish washer, people living in cities tend to lead more water intensive lives. The urban population has doubled over the past 30 years, now representing 30% of India's total population and is expected to reach 50% of the total population by 2025. Population growth is going to accelerate the water crisis in India, especially as more and more people move into the cities and become

part of the middle class. Because the rivers are too polluted to drink and the government is unable to consistently deliver freshwater to the cities, many urban dwellers are turning to groundwater, which is greatly contributing to the depletion of underground aquifers.

Rural citizens face a similar crisis. Currently 30% of the rural population lack access to drinking water and of the 35 states in India, only 7 have full availability of drinking water for rural inhabitants. Most people who live in rural areas demand less water for day-to-day living than people living in cities, and the majority of their water demand comes from agricultural needs.

WATER SANITATION

Next to air, water is necessary for survival of life on land and below water (aquatic life). Water is turning to be a scarce commodity. It is because of over exploitation of water, mismanagement and contamination by the inadvertent polluting activities of industries and allied bodies.

Climate change is expected to exacerbate the problem by causing erratic and unpredictable weather, which could drastically diminish the supply of water coming from rainfall and glaciers. As demand for potable water starts to outstrip supply by increasing amounts in coming years, India will face a slew of subsequent problems, such as interstate and international conflict.

India's water crisis is predominantly a manmade problem. India's climate is not particularly dry, nor is it lacking in rivers and groundwater. Extremely poor management, unclear laws, corruption, and industrial and human waste have caused this water supply crunch and rendered what water is available practically useless due to the huge quantity of pollution. In managing water resources, the Indian government must balance competing demands between urban and rural, rich and poor, the economy and the environment. However, because people have triggered this crisis, by changing their actions they have the power to prevent water scarcity from devastating India's population, agriculture, and economy.

It is to be stated that a water supply system has to be created since it is essential for sustenance of life on land and below water. Water is a prime natural resource, a basic human need and precious national asset. Planning and development of water resources need to be governed by national perspectives.

INDIAN CONSTITUTION AND WATER MANAGEMENT

The Constitution of India has placed water in the "State List" vide Article 243 of Twelfth Schedule (74th Ammendment) Act, 1992, (w.e,f.01.06.1993). Therefore, the states can enact any legislation regarding water like (a) water supplies, (b) irrigation and canals, (c) drainage, (d) embankments, (e) water storage and water power excepting the regulation and development of interstate rivers and river valleys. The role of Central Government is limited to policy formulation and tribunal formation to adjudicate water dispute between/among states. The states have delegated the function of water and sanitation, among others, to the Urban Local Bodies (ULBs).

The National Water Policy, 1987 has directed that adequate drinking water facilities should be provided to the entire population both in urban and rural areas by 1991; that irrigation and multipurpose projects should invariably include a drinking water component wherever there is no alternative source of drinking water and that drinking water needs of human beings and animals should be the first charge on any available water.

For India, the problem began in the 1970s, when major donors encouraged the government to provide farmers with free electricity for irrigation. The subsidies were manageable at first, and achieved their goal of boosting food production in states like Punjab, Haryana, Rajasthan, Gujarat and Maharashtra.

But the policy removed the incentive for farmers to limit the amount of water they pumped. They had to invest only in installing the actual pumps – and they did so willingly, resulting in a total of 23 million water pumps today.

This profligacy has taken a serious toll on groundwater levels, forcing the tube-wells from which the water is pumped to be installed ever more deeply. According to the Third World Centre for Water

Management, the amount of electricity required to pump water in India has doubled – and, in some cases, even tripled – in the last decade alone, as tube-wells have moved from 10-15 metres (32-50 feet) to 200-400 metres (650-1300 feet) deep. The increasing depth requires 3-4 times more horsepower for each pump.

WHAT IS THE WAY FORWARD

Under these conditions, state water ministries have few options for making groundwater irrigation sustainable. With the relentless increase in electricity subsidies, which are squeezing the energy sector, it is difficult to devise effective policies to stem over-pumping.

The water sector will have to react to developments in the energy and other sectors, over which, despite close ties, it has very limited control. Coordinating the various sectors' policies effectively will be difficult, to say the least. The water sector must adopt all unconventional options, including recycling wastewater and desalinating ocean and brackish waters.

It may sound daunting, but the reality is that these challenges are surmountable – if, that is, our leaders commit to tackling them. We already have the needed technology, know-how, experience and even financing. With strong political will, sustained pressure from an informed public and a "can do" attitude from water professionals and institutions pursuing intersectoral cooperation, not only of India's but the world's water-management problems can be addressed effectively.

As India evolves from an agrarian economy into one led by more rounded manufacturing and services, a new set of challenges have emerged. Today's cities have problems of increasing population, lack of physical and social infrastructure, environmental and regulatory requirements and increased costs. We will have to learn to identify new and smart ways to manage the complexity of urban living problems.

Currently, the industrial sector, which is one of the biggest consumers of water, is supplied fresh treated potable water. They can easily use waste water treated up to the secondary level. As much as 80% of the water being supplied to cities is right there. It only needs to be treated and supplied to industries. Good potable water that industries get can be swapped for residential and drinking purposes.

Out of a 1,000 MLD supplied to a town, nearly 800 MLD is coming back as sewage. Out of this, almost 500 MLD can be treated and supplied to industries, thermal power stations and water city parks. This can solve water shortage problems in almost every town. The authorities will have to evolve a better way of dealing with waste water and sanitation.

Nagpur's Water Mission

Nagpur is India's first city to have outsourced water supply to a private operator under the PPP model for 25 years and ensure that its residents get 24-hour safe drinking water. For this project, the private company invested 30% of the estimated project cost, 70% grants came from the JNNURM scheme, shared by both the state and the Central government. The project was initiated by the Nagpur Municipal Corporation. This project was showcased as the model case study for other cities at the launch of AMRUT (Atal Mission for Rejuvenation and Urban Transformation) and Smart City initiative.

Turning the Sea into Drinking Water

In Israel, IDE Technologies, a company specializing in water treatment, is looking to the sea to ensure a secured supply of fresh water. The company says that worldwide, it supplies 3 million cubic meters of "high quality water" every single day. Their Sorek Project is the planet's largest and most advanced Sea Water Reverse Osmosis (SWRO) desalination plant. Present power consumption for desalination of water is 3.5 kilowatt hours per cubic metre; it can reduce to about 2.5 kilowatt hours per cubic metre.

Access to drinking water is a concern that everyone in India faces, rich or poor. By distributing pressurized and potable water via taps, 24 hours a day and 7 days a week, we can ensure that everyone has equal access to this precious resource. As long as the will is there, it is possible. The time to take initiative has arrived.

CONCLUSION

Strategies for bringing about sustainability in the water supply system are as follows:-

- Supply side management,
- Demand side management constructive
- Leakage management and reduction of non revenue water
- Rain water harvesting
- Supply side Management:

i) All habitants en route to get water.

ii) Surface water and ground water to be used in conjunction.

iii) Mapping and digitization of water supply network for distribution. Hydraulic modeling to be adopted for rationalizing pipe networks and ensuring equitable pressure.

iv) Intensive and continuous public campaigns for awareness on all related aspects- the real worth of water, health and economic losses due to polluted water, wastage and even shortages.

v) Installation of waterless urinals for gents in every home and office.

- Demand side Management

i) Adoption of universal consumer metering and volume based tariff.

ii) Over consumption of water to be controlled by escalating tariff blocks. This will be for sustainable consumption and revenue generation as well.

iii) Tariff should have separate "energy surcharge" per unit of water supplied/delivered.

iv) Water supply shall be 24X7.Theft and leakage can be easily revealed in 24X7 supplies.

v) The utility/ULB to levy meter rent (preferably as % of water consumption)

vi) The Utility/ULB to have depreciation fund/ sinking fund at about 5% of assessment/bill and these funds may be utilized towards replacements and repairs.

vii) Incentives for recycled/treated water.

- Leakage Management and Reduction of Non Revenue Water

i) Universal metering to be adopted.

ii) Free connections should also be metered and regulated such as free supply up to a pre-determined quantity.

iii) For leakage, theft identification and their control-water supply staff to be made responsible.

- Rain Water Harvesting (RWH)

i) RWH and Recharge to be made mandatory.

ii) At each ward, a system of ground water table monitoring wells may be developed.

This will indicate efficiency of RWH and warnings against excessive exploitation of ground water.

iii) Ground water recharge areas to be delineated, mapped and protected.

iv) Low level check dams in local nullahs, drains and streams should have the facility for storing rain water and improving recharge areas.

It is possible to reverse the trend and make India a water sufficient country. The suggestions as enumerated above are to be undertaken in letter and spirit. We should strictly adhere to the principle of 3Rs (Reduce, Reuse and Recycle) for use of water.

We must focus on addressing our water-supply problems as if our lives depended on it. We must act now. Time and water are both running out.

BIBLIOGRAPHY

1. www.urbanindia.nic.in
2. Down to Earth ANNUAL Issue 2015 State of India's Environment 2015
3. AMRUT
4. The Hindustan Times dated 04.06.2016 & 25.06.2016.
5. World Bank.2016"High and Dry: Climate Change, Water and the Economy."
6. www.un.org/sustainabledevelopment/ sustainable-development-goals

DELHI URBAN FLOODING – AN OVERVIEW

MUKESH KUMAR*, MOHAMMED SHARIF,**V K JAIN,*** AND SIRAJUDDIN AHMAD****

Abstract

Incidences of urban flooding have been on the rise for the past several years. Rapidly expanding urban areas, particularly the metro cities such as Delhi are facing problems due to lack of infrastructure to accommodate exponentially growing population. In the last two decades, the rate of population outnumbered the rate of infrastructure development. In Delhi, thousands of unauthorized colonies and slum areas came up on low lying areas without leaving any space for basic facilities. Unplanned urbanisation has increased the vulnerability of Delhi to urban flooding. The present paper describes the existing drainage system of Delhi. A critical analysis of deficiencies causing urban flooding in Delhi has been carried out in this paper. Several measures have been suggested to mitigate the problem of urban flooding in Delhi.

INTRODUCTION

During the last decade, there has been a significant rise in the incidences of urban flooding in different parts of India. Major cities like Hyderabad in 2000, Ahmedabad in 2001, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Ranchi and Jamshedpur in 2008, Guwahati in 2010 and Channai in 2015 were severely affected by urban flooding that resulted in huge loss of life and property(NCRPB-2016). Urbanisation is a major cause of urban flooding as it increases the peak flow and reduces the time of concentration (Wheater and Evans2009). A study conducted in Santiago, Chile concluded that the conversion of green space in built-up areas resulted in increased flood risk. (Krellenberget al. 2013). In developing countries, the devastation caused by urban flooding is more as compared to developed countries largely due to high population density and unwarranted ecological intervention. In last 25 years there were more than three million deaths and only 10% of these were in developed nations(Bedritsky, 1999). The impact of urbanisation on meteorological variables and increase in very heavy rainfall frequency has been studied by various authors, including Guhathakurta et al. (2011), Ghosh et al. (2009) and Goswami et al. (2006).

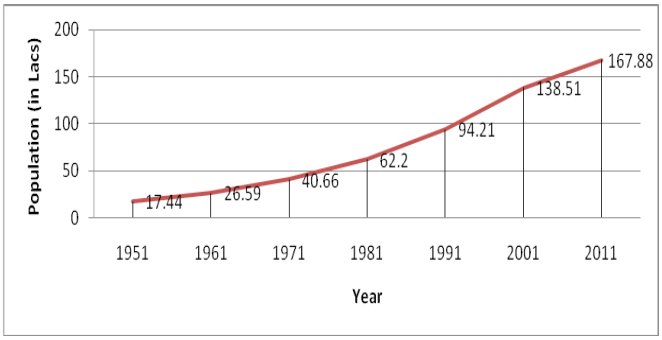
In recent years, Delhi has witnessed large scale migration from other parts of the country, particularly Uttar Pradesh, Punjab, Haryana, Rajasthan and Bihar. This has resulted in a heavy concentration of population around expanding fringes causing tremendous stress on socioeconomic systems. De et al. (2013) found an increasing trend of very heavy rainfall (≥125mm) at Safdarjung and Palam airports of Delhi. During the period 1970-2006, incidents of heavy rainfall ((≥125mm) were 14 at Safdarjung and 9 at Palam while incidents of phenomenal rainfall ((≥150mm) were 6 for both stations. On 27th July 2009, 124 mm rainfall in 12 hours with a peak of around 40mm per hour created chaos in Delhi.On 15th Sep.2011 the flooding of the international airport in Delhi affected aircraft operations for several hours (NCRPB-2016)

DELHI GEOGRAPHY AND CLIMATE

Delhi has a geographical area of 1483 km2, and is situated between 28034'N latitude and 77007'E longitude. It is urbanized rapidly with an urbanized area of 46.21% (1991) to 75.09% (2011). In addition to being the political capital of India, Delhi is a major centre of economic activities of northern

*Executive Engineer, Irrigation & Flood Control Department & Research Scholar, JMI, Delhi **Professor, Jamia Millia Islamia, New Delhi ***Chief Engineer, Irrigation & Flood Control Department, Government of Delhi ****Professor, Department of Civil Engineering, Jamia Millia Islamia, New Delhi

India (Census of India, 2011). Rate of increase of the urban area was about 62.5% during the last two decades (Economic Survey of Delhi, 2014-15). The population of Delhi increased from 13.85 million in 2001 to 16.78 million in 2011. The population of Delhi during different decades is shown in Figure 1.



(Source, Census of India, 2011)

Fig. 1 Population Growth in Delhi

A United Nations report on World urbanization prospects (United Nations, 2007) projected a population of 22.5 million in 2025 for the city of Delhi, which is third highest after Tokyo and Mumbai. The population density of North-East, East, North and Central Delhi is very high, which makes these areas highly vulnerable to urban flooding. Delhi is surrounded on the east and north by Indo-Gangetic alluvium plain, by Aravalli hill ranges on the south and Thar- desert on the west (Delhi Disaster Management Plan, 2015). River Yamuna enters Delhi from the north near Palla village and travels about 50 km before leaving Delhi near Jaitpur. The climate of Delhi is semi-arid with summer temperatures normally ranging from 27.60C to 44.20C and winter temperature normally ranging from3.50C to 22.20C. Relative humidity is relatively less from October to mid-June compared to the monsoon season (Pandit, 1998). The average annual rainfall is about 600mm, of which about 75-80% occurs in monsoon (Daily Report-2016, I and FC department, government of the national capital territory of Delhi; DSAPCC20,15).Around half of Delhi is already built up and about 13% is covered by forest, wildlife, ridge, and drains. By 2021 it is expected that built-up area will increase to 65.94%, leaving around 20.9% for disposal of solid waste, Metro/utility services, agriculture zone and 13.16% of natural features.(MPD-2021, 2014)

EXISTING DRAINAGE SYSTEM

The drainage system of Delhi is effected by the storm water from neighbouring states because it passes through Delhi before its final disposal. Seventeen drains from west and one drain from the east bank out fall into Yamuna River. In Delhi, the ridge forms the main watershed with areas east of the ridge draining in the Yamuna while in the west, water joins the Yamuna through Najafgarh drain. Storm water passing through small rivulets, link and trunk drains, is finally discharged into the Yamuna. Delhi can be divided into five drainage sub-basins namely; Najafgarh, Alipur, Shahdara, Kushak-Barapulla and Mehrauli.

Najafgarh Sub-Basin

Najafgarh basin covers the southwestern parts of Delhi in addition to large tracts of Haryana land. Najafgarh basin can further be subdivided in Najafgarh block, Kanjhawalaarea, MCD area and Delhi Cantonment area. The main drains of the sub-basin are Najafgarh, Mangeshpur, Nasirpur, Nangloi, KarariSuleman and Palam drains. The Najafgarh drain together with its link drains an area of more than 1300km^2. It originates from Najafgarh Jheel and joins Yamuna down stream of Wazirabad barrage covering a total length of 57.4km. Najafgarh Jheel is a natural depression, having a catchment areaof 567 km^2 and receives some water from Haryana and Rajasthan as well.

Alipur Sub-Basin

It is bounded by Yamuna on the east, tail distributary of the western Yamuna canal (WYC) on the west, Shah Alam Bund on the south and drain No-8 of Haryana on the north with a basin area of around 170 km^2. Storm water from adjacent catchments, north of Delhi-Haryana border also comes to Alipur Basin. It is drained by Bawana Escape, Drain No. 6 and Burari drain along with other minor drains. Bawana escape is the major drain of the basin with a catchment areaof around 181 km^2. The link drains of Bawana escape are Ghoga, Sanoth, Narela, Naya Bas and Alipur link. In addition to disposing off storm water, it also acts as an escape for tail distributary. Burari creek and Burari drains are the other important drains. Urban discharge from the Model Town area is received by the Burari drain.

Shahdara Basin

It is bound by Hindon on the east, Yamuna on the west and Uttar Pradesh on both north and south. The basin is below the high flood level of Yamuna. Marginal embankments, namely Shahdra marginal (SM) and left marginal bunds (LM) were constructed in 1955-56 to protect the area from frequent flooding. Drainage system in Trans Yamuna area was made to improve the situation with Trunk Drain (TD) No I and II. TD No. 1 originates from North of arterial highway while TD-II originates from North of GT Road near Delhi-UP Border. TD-I and TD-II join near Gazipur village and the Gazipur drain flow parallel to the Hindon cut canal, passes through Chilla regulator before its outfall into river Yamuna, in the form of Shahdara Outfall drain. Hence, the entire Trans Yamuna area has only one gravity outfall point down stream of Okhla Barrage.

KushakNallah- BarapullaNallah System

The length of Kushak and Barapulla drain is around 12.87 km and 2.23 km, respectively. The drains carry flashy discharge on account of considerable run off generated from urbanized areas and sloppy hilly areas. Most of the drainage channels in the NDMC areaout falls into this system. The KushakNallah enters SMCD area near INA market and Defence Colony Nallah joins it.

Mehrauli Basin

The MehrauliBasin is located on the southern part of Delhi and covers area of around 160 km^2. It can be further divided into three. A hard rocky area on the ridge near Chirag Delhi, Kalkaji, Tughlakabad and Chattarpur area, Alluvial plain on the north-eastern side of Mehrauli ridge extending up to Agra canal and Submergible Khadar Land situated between the left bank of Agra canal and river Yamuna. Several Nallas from the ridge carry storm water from rocky terrain and agriculture area into NajafgarhJheel, from the North West corner into Najafgarh drain, from the northern slope in Chirag Delhi drains. Some drains discharge directly into Agra canal. (NCRPB, 2016, Delhi Drainage Map-1976, Flood Control Order,2016, Delhi Drainage Master Plan, 1976)

CRITICAL ANALYSIS OF DEFICIENCIES

Various meteorological (heavy rainfall, temperature), hydrological(soil moisture condition, ground water level, infiltration rate, impervious/ concrete cover, availability of drainage network and its characteristics etc.) and human factors (change in land use, encroachment on drainage network, climate change, urban micro climate, back flow of water from river to city, inefficient drain network etc.), are responsible for urban flooding. (NDMA,2010). During 2015, 163 areas were identified as vulnerable, where repeated water logging was noticed. The majority of aforesaid waterlogging points is underpasses, flyovers, intersection of roads and isolated stretches of roads. (Flood Control Order-2016).Heavy rainfalls badly affect road transport system and bring it to halt at various stretches. Incidents of water logging also occur in unauthorized colonies, not having a proper drainage system well connected to trunk drain, low lying areas etc.Some of the causes of Delhi urban flooding are as follows

Natural Causes

- Unusually heavy rainfall, due to south-west monsoon, western disturbance and thunder storms.
- Climate change phenomenon resulting in more intense rainfall events.
- Urban heat island effect due to built-up surfaces and modified the hydrological process by cloud condensation nuclei from air conditioners, industries and vehicles.
- Topography of Delhi is almost flat and extremely gentle gradient over the area which restricts the gravity drainage network.

Anthropogenic Factors

- Explosive population growth resulted in rapid urbanisation during last two decades. The previous drainage plan was prepared by the I&FC Department with final reports submitted in Feb. 1981. 750 km^2 area is already urbanised and it is expected to be 980km^2 (MPD-2021, 2014). Although MPD-1976 had proposed to review the drainage Master Plan in 2001 but the work was carried out by different agencies in a piecemeal approach rather than a comprehensive manner.
- Embankments were constructed during the period 1955-78, on both sides in the entire

reach of Delhi to prevent frequent flooding. These bunds act as barriers between river and adjoining areas. Now there are only 18 outfall points, of which 17 are on the west side while one is down stream of Okhla in the eastern side. Hence storm water has to travel large distances before its out fall into the river through a network of drains.

- Delhi has a large number of thickly populated slum and unauthorised colonies often located in lowlying areas, which do not have adequate sewage, drainage and other basic facility. Utilisation of waste water is only 21% of estimated sewage generation (Economic Survey of Delhi, 2015). It results in huge quantity of sewage making its way intothe drainage system, resulting in a rapid siltation load for which drainage system is not designed.
- Blockage in drains due to large scale dumping of solid waste and plastics in storm water drains from neighbouring areas / colonies. Open drains are treated as solid waste dumping ground, which clog them and reduce their draining capacity. Cow dung from dairies, solid and liquid waste from industries is also responsible for reduced capacity of drains.
- Disappearance of several water bodies has reduced the water retaining capacity of basins. Concretisation is leading to more runoff due to less water absorption. In the absence of storage most of rainfall flows out into the drains, resulting in an increase in peak discharges.
- Encroachment on drains not only reduces the drain's capacities, but obstructs the effective dusting operation, in the absence of space for movement of men and machinery on drain banks. Development on the banks of drains / channels has left no space for augmentation and maintenance.
- Inefficient drainage structures like blocked bell-mouths, chocked connecting pipes between road side drain and bell-mouth.
- Some trunk drains of Delhi are interstate in nature. Like TD-I brings storm water from UP areas, and Shahdara out fall drain passes through Noida in UP.Some drains originate from Haryana. In Trans-Yamuna storm water is to pass though syphon at Chilla regulator where Hindon Cut Canal passes over the storm water drain. Judicious operation of the barrage in coordination with the UP Irrigation Department is essential to avoid flooding in Trans Yamuna areas.
- Large scale covering of storm water drains has been carried out either for roads, parking space or to prevent the foul smell from drains. Most of the covered drains do not have access for carrying out desiltation works. It has not only obstructed the natural process of self-purification of waste water, but covered portion also becomes difficult to desilt.
- In the absence of sufficient space in adjoining colonies, service lines like, water, sewer, telephone and electricity lines are laid in drains or on banks, which reduce the carrying capacity and adversely affect maintenance operations.
- Threats of flood increases with decrease in water holding capacity. Urbanisation, population and industries are primary contributors to the problem (Narula et al. 2001). Hence there is a large scope of artificial recharge and roof top rainwater harvesting, which will reduce the stress on the drainage system.
- Multiple agencies are responsible for the construction and maintenance of drainage systems. MCDs, DDA, NDMC, cantonment board handle drainage system of the colonies in their areas including road side drains., PWD owns sixty feet and above width roadside drains, while I&FC Department has 61 trunk drains with design discharge capacity generally more than 1000cusec. Proper coordination among agencies is essential.

POSSIBLE SOLUTIONS

The major contributors for Delhi urban flooding are anthropogenic causes rather than natural causes. Careful analysis of the causes of urban flooding shows that immediate measures are needed to prevent it. Some of the measures suggested are as follows.

- Isolated low lying pockets, flyovers, road intersections, isolated road stretches, need local pumping systems with adequate capacity sumps and pumps.

- Existing encroachment should be removed by framing an appropriate policy by conducting special derives. Fresh encroachment should not be allowed on drains.
- Sewage should not be allowed in storm water drains. Sewage coming out of unauthorised colonies should be trapped to take it to the nearest sewage treatment plant.
- Main cause of flooding of roads is blockage of bell-mouths, due to road sweeps pushed into them. Scavengers should be instructed not to push road sweeps into bell-mouths. Mechanised sweeping could be an alternate with afforestation and grassing on Katcha portion to check soil erosion. Horizontal bell mouths are more effective than vertical for trapping rain water.
- In the absence of efficient solid waste collection system, huge quantity of solid waste makes its way into drains. It hinders free flow and reduces the carrying capacity of drains. Motivation by reducing processing fees for dumping at MCD sites and penalty provisions with their strict implementation could be an appropriate option. House to house collection system also needs to be strengthened to ensure solid waste disposal at SLF sites.
- Desilting operation of all drains irrespective of the agency should be completed well before monsoon season, i.e. May31 every year. RWAs, NGOs and other local public representatives may be involved in the monitoring mechanism along with displaying drain-wise progress on the internet.
- Covering of drains should be avoided to the extent possible. In unavoidable scenarios removable slabs could be used.
- One constraint in developing a sustainable flood prevention and control mechanism is non-availability of data for sufficiently long periods. Collection of data for analysis and study of catchment behavior is necessary to evaluate changes and their consequential impact on urban floods.
- To establish urban flood early warning system for Delhi, India Meteorological Department should establish a local network of automatic rain gauge stations for real time monitoring. Civic agencies, particularly drain owning agencies should be a part of monitoring mechanism.
- Back flow occurs in some drains like Jahangirpuri Drain even when water in the river is below danger level at the Old Railway Bridge. High floods having gauge around 207 m results in back flow through all drains, hence regulators are necessary on all out falling drains.

CONCLUSION

The Urban flooding mechanism is very complex and city specific. Hence, solutions shall also be city specific. Infrastructure development of Delhi could not match with the pace of population growth and its infrastructural requirements. Large number of slums and unauthorised colonies came up in undeveloped low lying areas. Later, considering popular sentiments, these unauthorised colonies were regularised and bare minimum basic facilities of water, sewer, roads, drainage have been provided. However, in the absence of proper planning these areas suffer from several problems, including frequent waterlogging even during moderate intensity rain storms.

Storm water drains in Delhi are usually neglected because the number of rainy days is limited. Storm water drainage systems should be treated as an important part of urban infrastructure. Thickly populated and highly urbanized nature of the city puts tremendous pressure on civic infrastructure and services like drainage. Preventive measures, as suggested above are necessary along with regular review, since solutions cannot be static due to the rapidly changing physical, economic and environmental conditions. It should be kept in mind that the cost of taking preventive measures is only a fraction of value of loss and disruption of normal life caused by urban flooding.

REFERENCES

1. Chandramouli, C., and Registrar General. "CENSUS F INDIA 2011."(2011).
2. Economic Survey of Delhi 2014-15, Govt. of NCT of Delhi, New Delhi. delhi.gov.in/wps/wcm/connect.
3. World Urbanization Prospects (2007): The 2007

Revision,Dep. of Econ. and Soc. Affairs, U. N., New York. (Available at http://www.un.org/esa/population/publications/wup2007/2007wup.htm)

4. NCRPB(2016), Functional Plan on Drainage for National Capital Region, Ministry of Urban Development, Govt. of India.
5. NDMA(2010), Management of Urban Flooding, National Disaster Management Guidelines.
6. Wheater H, Evans E. Land use, water management and future flood risk. Land Use Policy. 2009 Dec 31;26:S251-64.
7. Krellenberg K, Müller A, Schwarz A, Höfer R, Welz J. Flood and heat hazards in the Metropolitan Region of Santiago de Chile and the socio-economics of exposure. Applied Geography. 2013 Mar 31;38:86-95.
8. Bedritsky, A. I. "The impact of weather and climate on economic development and sustainability." Bulletin of the World Meteorological Organization 48, no. 2 (1999): 175-181.
9. Goswami, BhupendraNath, V. Venugopal, D. Sengupta, M. S. Madhusoodanan, and Prince K. Xavier. "Increasing trend of extreme rain events over India in a warming environment." Science 314, no. 5804 (2006): 1442-1445.
10. Ghosh, Subimal, Vishal Luniya, and Anant Gupta. "Trend analysis of Indian summer monsoon rainfall at different spatial scales." Atmospheric science letters 10, no. 4 (2009): 285-290.
11. Guhathakurta, P., O. P. Sreejith, and P. A. Menon. "Impact of climate change on extreme rainfall events and flood risk in India." Journal of earth system science 120, no. 3 (2011): 359-373.
12. De, U. S., G. P. Singh, and D. M. Rase. "Urban flooding in recent decades in four mega cities of India." J. Ind. Geophys. Union 17, no. 2 (2013): 153-165.
13. Delhi Disaster Management Plan, Draft (2014-15), Issued by Delhi Disaster Management Authority, Govt. of Delhi, Revenue Department, website- http://www.ddma.delhi.gov.in
14. Pandit, M. K. "Yamuna River Rejuvenation Plan-Riparian Ecosystem, Phase-I Report." Centre for Inter-Disciplinary Studies of Mountains & Hill Environment (CISMHE), Delhi (1998).
15. DSAPCC(2015), Delhi State Action Plan on Climate Change, Department of Environment, Government of Delhi.
16. Daily Report-2016, issued by I&FCDeptt Govt. of NCT of Delhi. Available on website-ttp://delhi.gov.in/wps/wcm/connect/doit_irrigation/Irrigation+and+Flood+ Control/Home/Flood+Control+Room/
17. MPD(2021), Master Plan of Delhi-2021, as published in Gazette of India, PartII section 3, sub-section(ii), extraordinary, notification no. S.O.141(E) dt.7.2.2007.
18. NCRPB(2016), Functional Plan on Drainage for National Capital Region, issued by National Capital Region Planning Board, Ministry of Urban Development, Government of India.
19. Narula, Kapil K., Frank Wendland, DD Bhujanga Rao, and N. K. Bansal. "Water resources development in the Yamuna river basin in India." Journal of Environmental Studies and Policy 4, no. 1 (2001): 21-34.

SMART AND SUSTAINABLE URBAN WATER MANAGEMENT TECHNIQUES

NARENDER SINGH*

Abstract

Water is the most essential factor for the existence of life throughout the globe. The rapid growth of urbanization is putting a thrust on the available water resources and compel us to advent the smarter solutions for their optimal utilization. Urban water can broadly be categorized as fresh water, waste or grey water and storm or rain water. It is need of the hour to incorporate smart and sustainable techniques within an urban habitat so as to optimize and conserve the available water in an effective and efficient way. The various intelligent and eco-friendly techniques are being used for the management of the fresh, grey and storm water in an urban habitat. Firstly, the technique for fresh water supply management includes smart and leakage proof urban water grids, smart metering system and sensor operated water efficient fixtures. Secondly, the technique for grey water management includes bucketing, grey water diversion device and grey water treatment and recycling technique. Finally, the technique for storm water management includes rain water harvesting and separate pipeline network for sewerage and storm water.

In this paper, efforts have been made to elaborate drawbacks of existing urban water management system along with finding the smarter and sustainable solutions for the water management of an urban habitat.

INTRODUCTION

The people are migrating continuously from rural to urban areas in search of better opportunities and thus putting burden on the existing amenities in the cities. Water is one of the most essential amenities of an urban habitat and life could not be imagined without water. Therefore, it is desirable to revolutionize the existing approach of water management with smarter solutions so as to optimize the available water for urban development in the real sense.

There are mainly three types of water management required for the development of urban habitat as given in fig. 1.

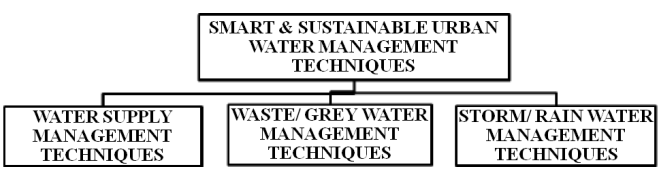


Fig. 1: Smart & Sustainable Urban Water Management Techniques

WATER SUPPLY MANAGEMENT TECHNIQUES

The different techniques being used for the management of fresh urban water are as discussed below.

Smart and Leakage Proof Urban Water Grids

The total availability of water resources is currently under great stress due to climatic changes, and continuous increase in water demand linked to the urban population increase. A smart water grid (SWG) is an innovative way to monitor water distribution network. It is a two-way real time network with sensors and devices that continuously and remotely monitor the water distribution system as shown in fig. 2. Smart water meters can monitor the key parameters such as flow, pressure, temperature, quality, consumption, and energy usage. Some of the advantages of smart water grids are better understanding and analysis of the water networks, leakage detection, water conservation, water quality monitoring, and a lower cost to the consumers.

**Executive Engineer, PWD (B&R) Br. Dadri, Haryana*

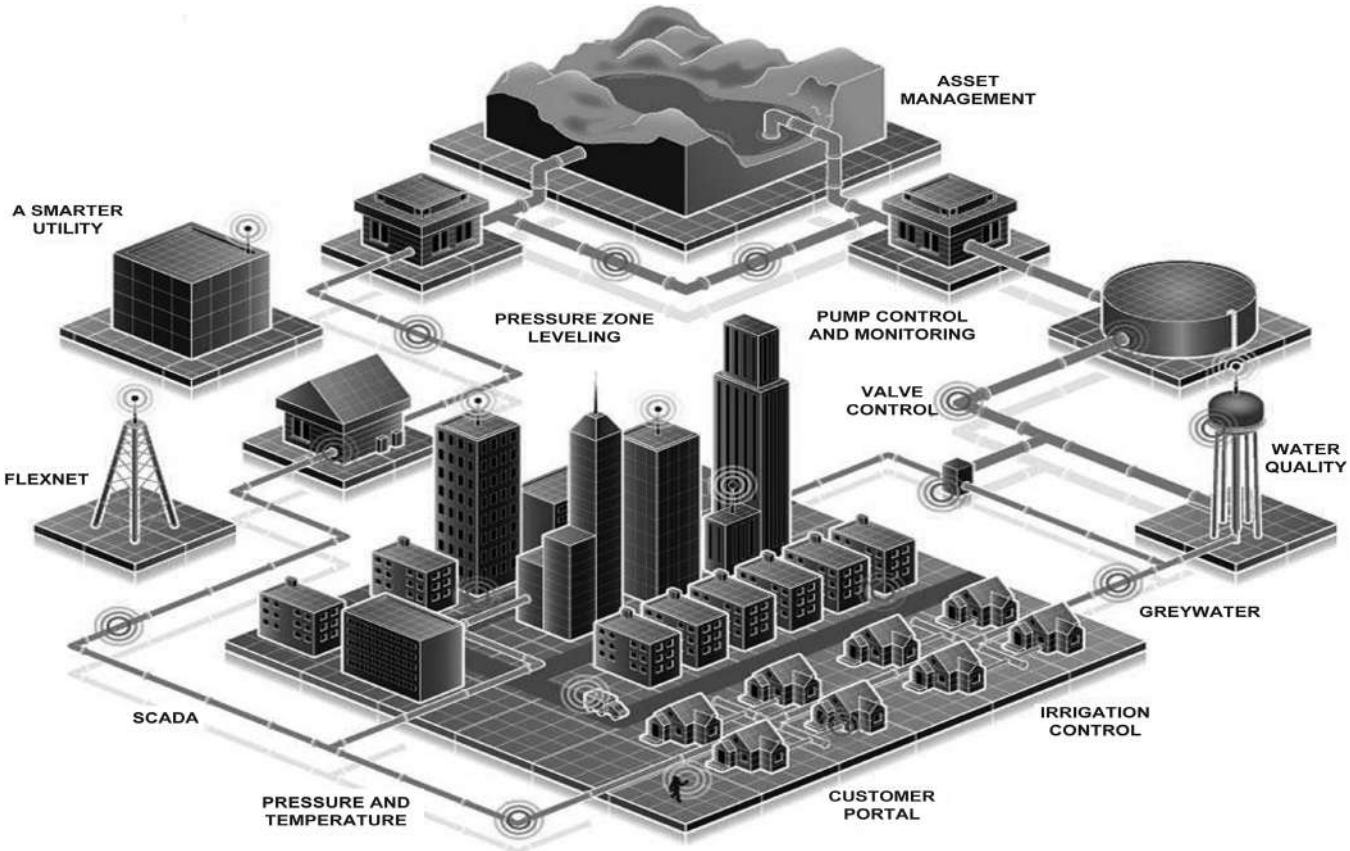


Fig. 2: Smart Water Grid System

Current urban water infrastructure is aging and deteriorating. Water networks are vast and consist of various components (pipe segments, pumps, valves, etc). These components vary in age, and material type. With the passage of time their performance and efficiency decreases, making them prone to failures and leakages. Because water networks are so vast and hard to access, the municipalities may not have a complete inventory of their assets, or be aware of any leakage in the systems. Smart water grid has now been established as a revolutionary tool for the urban administration to deal with the existing distribution challenges in an effective and efficient way.

The interface of smart water grids with natural systems such as rivers, lakes, and reservoirs is also a key component of "smart and sustainable" approach to the use of available water resources. These natural components are subjected to climate variability and single event can disrupt the daily operations. Floods, droughts, and disasters such as typhoons and forest fires can affect the water quality at the source. Robust systems should have alternative supply sources when facing scarcity of resources or changes in water quality. Deep understanding of the network vulnerability and preparedness for disaster prevention will definitely contribute to the "smart and sustainable" reputation of smart water grid system.

Smart Metering System/ Network Monitoring Methods

Just like any other network or system, water distribution networks require operation, maintenance, and personnel. Older water meters are analog and require municipality personnel to visit a residence and record the water reading. As technology is advancing, new tools and techniques can be implemented to help water grids run more efficiently. There are several water infrastructure monitoring methods as discussed below.

Automated Meter Reading

Automated Meter Reading (AMR) is a method of obtaining water meter readings through radio transmitted signals. Manufacturers developed

encoder registers that produce electronic output for radio transmitters and other data logging devices. This method is faster and less invasive compared to traditional data collection. The collected information includes the serial number of the meter and the volume of water consumed.

Advanced Metering Infrastructure (AMI)

Electric Power Research Institute (EPRI) have developed the advanced metering infrastructure, that remotely and continuously collects and transmits information to service provider and consumers. It can be implemented for electric, gas, and water networks. The meters transmit electric, gas, water information through an available network. Some examples are Broadband over Power Line (BPL), Power Line Communications (PLC), Fixed Radio Frequency (RF), and other public networks such as landline or cellular networks. The information is received by Meter Data Management System (MDMS) that is responsible for data storage and analysis.

Supervisory Control and Data Acquisition (SCADA)

SCADA is a computer-controlled system that helps to monitor and control processes. This system acquires information from remote devices such as pumps, valves, transmitters, and others. The Host software system can communicate and control these devices remotely. SCADA Host platform are equipped with displays, alarms, and can store received information. These systems are commonly used in industrial processes such as manufacturing, transportation, energy management, building automation, and other fields where real time operational data can be used to make decisions. It is important to understand that SCADA systems require human interaction as personnel will be controlling and monitoring processes. This will require training and certain skill sets. SCADA systems consist of four levels of components/ communication: field instrumentation, programmable logic controllers (PLCs) and remote telemetry units (RTUs), Comms/ Telemetry, and SCADA Host (Fig. 3).

Security issues are not concentrated around the SCADA system itself. The whole network is vulnerable as communication devices are located in the field and may be easily compromised by a trespasser. This would require fences, surveillance cameras, and/or personnel. More precaution would need to be taken with access to SCADA host to make sure that viruses cannot be transferred with things like a USB drive. Smart Water Grids are SCADA and AMI systems, where information is gathered from sensors within the distribution network, which is then transmitted to a central location.

Even though smart water infrastructure has a large upfront cost, it will yield large monetary savings associated with water and energy conservation, reduction in operational inefficiencies and other expenditures. Table 1 shows global savings associated with smart water grid implementation, as reported by Sensus (2012). Sensus is a leading utility infrastructure company offering smart meters, communication systems, software and services for the electric, gas, and water industries. The company has its headquarters at Raleigh, North Carolina, U.S.A.

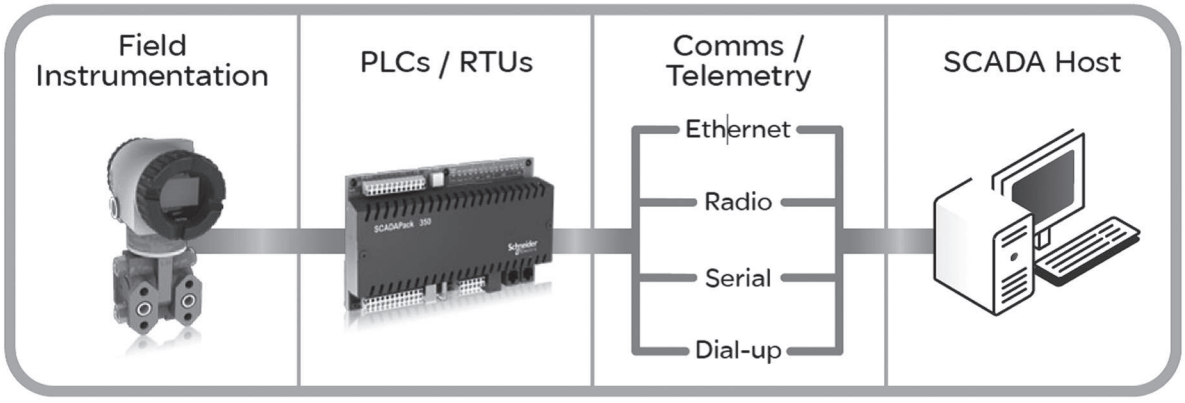


Fig. 3: SCADA System Overview

Table 1: Global Savings Associated with Smart Water Grid Implementation

Category	Savings as Percentage of Baseline Cost		Description
Leakage and Pressure Management	2.3 - 4.6	(3.5%)	Reduction in leakage levels by precise detection of leaks; predictive modeling to estimate potential future leaks and pressure managment
Strategic Capital Expenditure Prioritization	3.5 - 5.2	(12.5%)	Improved dynamic assessment, maintenance, replacement, planning and designing of network to optimize spending on infrastructure needs
Water Quality Monitoring	0.3 - 0.6	(0.4%)	Automatic water sampling, testing and quality monitoring; reduction in costs from labor and truck rolls for manual sample collection
Network Operations and Maintenance	1.0 - 2.1	(1.6%)	Real-time, automated valve/pump shutoff to facilitate flow redirection and shutoffs; more efficient and effective workflow planning
Total Smart Water Savings Opportunity	**7.1 - 12.5**	**(7.4%)**	

$U.S. billion

These savings would then be used to reinvest in network upgrades, or can be reflected in lower rates to consumers. Sensus (2012) estimated that 7.1 to 12.5 billion dollars can be saved globally by utilities via implementing smart water technology solutions. They describe that savings would result in improved network assessments, planning, and monitoring. This is not surprising because improvement in monitoring will increase the knowledge of the state of water distribution systems. Timely monitoring will help to reduce the amount of water lost and prevent impending failures.

Installing Sensor Operated Water Efficient Fixtures

Reducing water consumption and improving water efficiency in buildings is a major step towards sustainable urban water management. We can all contribute towards saving water in our homes with actions that are simple yet efficient. Installing water efficient fixtures in toilets and kitchens could be the first step to save the water as discussed below.

Dual Flush Toilets

A significant way to save water in buildings is to replace existing single flush toilets with dual flush toilet. The dual flush toilets use 4.5 liters on full and 3 liters on a half flush than the normal flush toilets.

Sensor Operated Urinals

These detect the presence of people through movement sensors or door switches combined with an electronic delay to stop flushing for a set period after flushing.

Sensor Taps

These taps cut off water supply when the hands are removed from under the tap, or when the preset timing of 30 or 60 seconds is reached, whichever is earlier.

Water Efficient Showerheads

These deliver water at 9 liters per second or less than that. Further, showers can also be fitted with digital read out meters that show the user the amount of water being consumed and the duration of the shower.

Front Loading Washing Machines

In general, front loading washing machines are much more water efficient than top loading machines.

WASTE OR GREY WATER REUSE/ RECYCLING TECHNIQUES

Grey water is all waste water that is discharged from a house, excluding black water (toilet water). This includes water from showers, bath tubs, sinks, kitchen, dish washers, laundry tubs, and washing machines. It commonly contains soap, shampoo, toothpaste, food scraps, cooking oils, detergents and hair. Grey water makes up the largest proportion of the total waste water flow from households in terms of volume. Typically, 50-80% of the household waste water is grey water. If a composting toilet is also used, then 100% of the household waste water is grey water. The opportunity exists for appropriately treated grey water to be reused for a variety of different end uses, such as irrigating gardens and flushing toilets. This will reduce the demand on normal ground and surface water supplies. There are three techniques for grey water reuse/ recycle as discussed below.

Bucketing

A bucket can be used to manually reuse grey water (e.g. collecting shower and laundry water for reuse). Bucketed grey water can be reused for irrigation of gardens, lawns and outdoor pot plants, toilet flushing and washing machine use. Manual bucketing reuses low volumes of grey water. Accordingly, only low quantities of contaminants will be applied to the soil and there is a limited ability for runoff to neighboring properties or waterways. It is important that manual bucketing be undertaken with due care so as to ensure the public health and environmental protection.

Grey Water Diversion Device

A grey water diversion device (GDD) diverts grey water without storage or treatment, it incorporates a hand activated switch or tap to divert the grey water to the garden or the sewer. Grey water from a GDD must only be reused in gardens via sub-surface irrigation. This technique may only be used in single residential domestic dwellings because other residents would not have been exposed to the pathogens through personal contact and due to risk of spreading disease through the community.

Grey Water Treatment and Recycling Technique

In this technique, the waste or grey water is collected from bath tubs, showers, bathroom sinks and washing machines and drained into surge tank, where it is filtered and disinfected. The treated grey water is then pumped to roof storage tank and supplied to toilets for flushing as shown in Fig. 4. Waste water from the toilet is connected to the building drain, which connects to the septic tank or municipal sewer of the city.

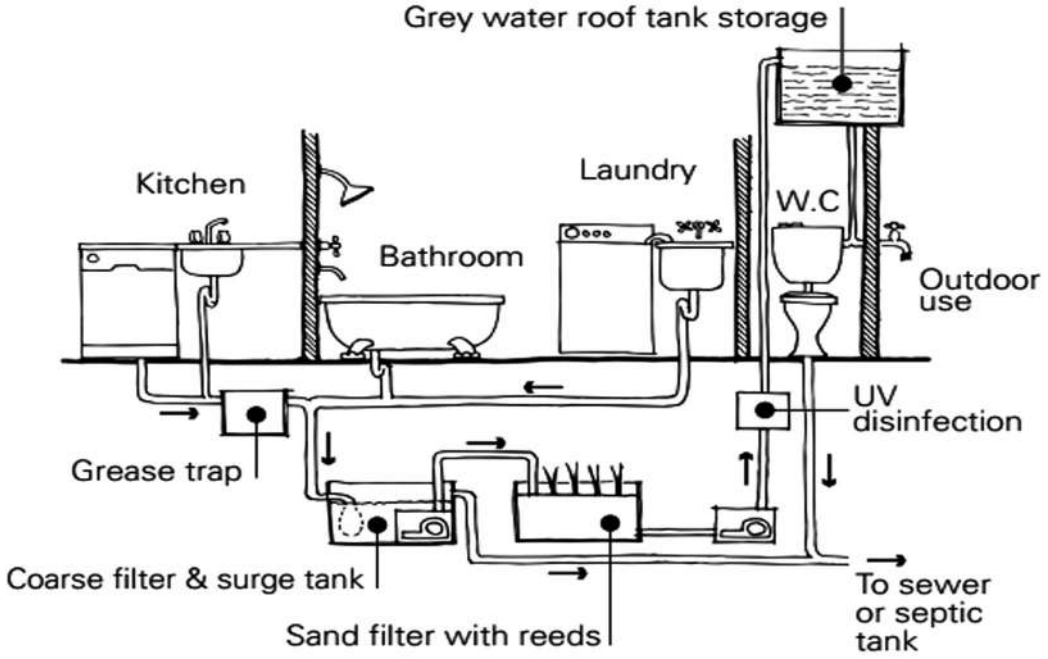


Fig. 4: Grey Water Treatment and Recycling Technique

Reuse and recycling of grey water should be supported and encouraged by development authorities to conserve the available water resources. However, this has to be accomplished without compromising public health, causing unacceptable environmental impact, or downgrading the amenities of urban habitat.

STORM OR RAIN WATER MANAGEMENT TECHNIQUES

The ground water is depleting day by day, whereas the rain water is creating a big problem in the urban areas due to non availability of space to drain the runoff/ surplus water. The concept of construction of recharge wells in the buildings and along the roads will definitely helps to recharge the ground water and resolve the drainage problem of urban habitat. The rain water harvesting through storm water drain could be done by installing recharge wells (Fig.5a) or by constructing percolation trench (Fig.6b) along the roads. A recharge well of 1.0 m diameter and 6.0 m depth has the capacity to store around 5000 litres water and recharges the ground at a rate of 2500 to 10000 litres per day.

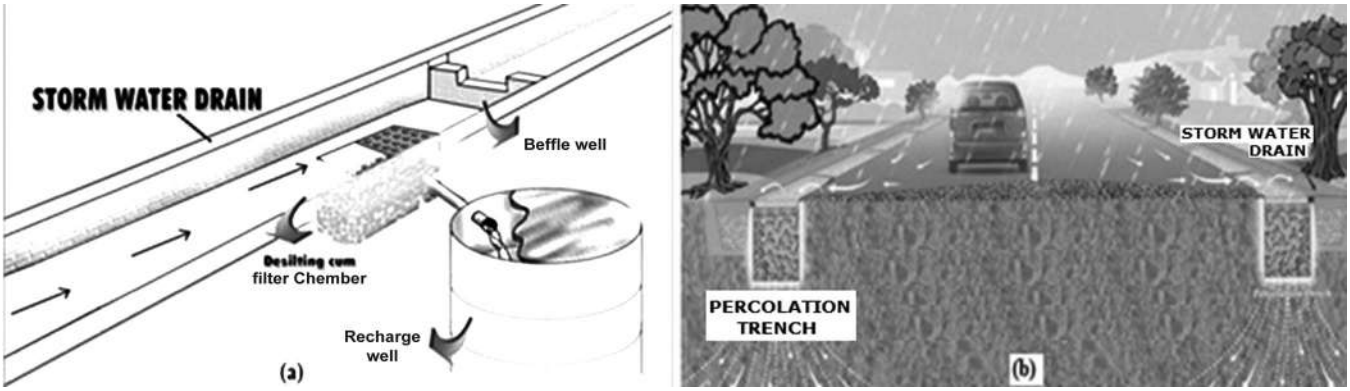


Fig. 5: Ground Water Recharge Techniques along Roads

The technique for rain water harvesting in buildings is known as "roof top rain water harvesting". The roof becomes the catchment, and the rain water collected from the terrace of building can either be stored in a tank or diverted to artificial recharge system (open well, bore well, recharge pit or shaft) as shown in Fig. 6.

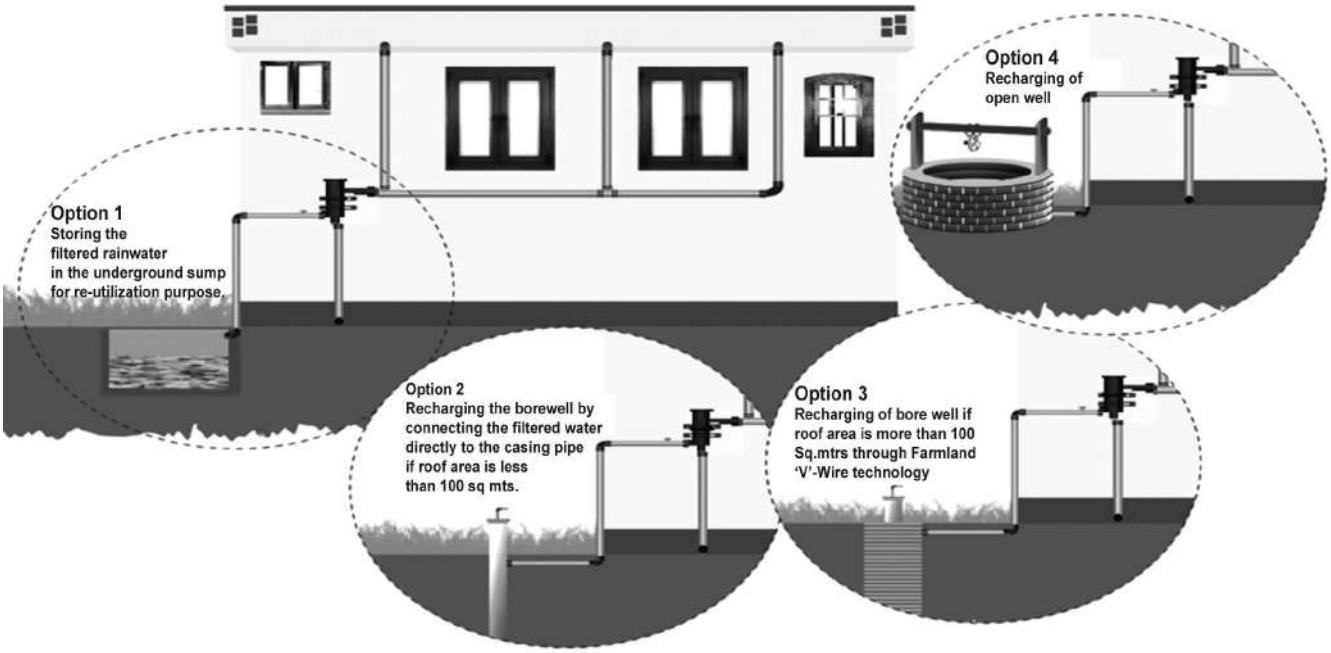


Fig. 6: Ground Water Recharge Techniques in Buildings

Separate Pipeline Network for Sewerage and Storm Water Collection

In a typical urban setting, every time someone flushes a toilet, rinses a plate, takes a shower or washes their clothes, the waste water goes through a private sewerage pipe to sewerage main line. In an intelligent and eco-friendly urban habitat a separate system for sewerage and storm water is to be implemented. All waste water from inside premises should enter the sewerage system to be transported to a sewage treatment plant where it is treated before being discharged into a local water way. During rains, the run-off from roofs, streets, gardens and other outdoor areas flows through a separate pipe/ storm water system and discharged directly to local water ways without any treatment as shown in Fig. 7.

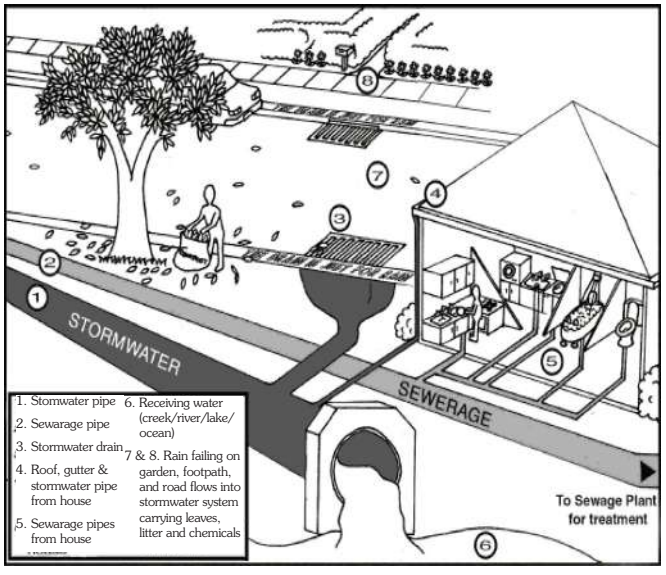


Fig. 7: Separate Pipeline Network for Sewerage and Storm Water Collection

Thus a separate pipeline network for sewerage and storm water in an urban habitat has proved to be cost effective, efficient and environmental friendly.

CONCLUSION

The trend of migration of people from rural to urban areas is a key issue for urban development. The various water resources are depleting day by day due to rapid growth of urbanization. Therefore, it is necessary to manage the urban water in an intelligent and sustainable way so as to achieve the urban development in real sense. The government authorities should enforce the latest and sustainable technologies to manage the urban water.

REFERENCES

1. IS: 15797-2008, Roof Top Rain Water Harvesting -Guidelines
2. IRC SP-42-1994, Guidelines for Road Drainage
3. Manual-2002, Rain Water Harvesting and Conservation, Government of India, CPWD, New Delhi
4. Narender Singh, Sustainable Design for Developing Affordable Housing, Journal of Indian Buildings Congress, 23 (1), 97-102, 2016
5. Narender Singh, Smarter Solutions for Developing Smart Cities in India, Journal of Indian Buildings Congress, 22 (1), 113-118, 2015
6. Pierre Y. Julien and Olga A. Martyusheva, Smart Water Grids and Network Vulnerability, Smart Water Grid International Conference 2013, 12-14 November 2013, Incheon, Republic of Korea
7. www.sensus.com
8. www.cgwb.gov.in
9. www.yourhome.gov.au
10. www.cseindia.org/userfiles/greening
11. www.environment.nsw.gov.au/stormwater

RECYCLE AND REUSE OF WATER – A NEW PARADIGM SHIFT IN WATER INFRASTRUCTURE

SONIKA VADHERA* AND ARVIND SHARMA

Abstract

Water is essential to continued economic development and well-being of humans. Identifying a new and sustainable water source for any city is essential. Many cities in India are experiencing unprecedented growth due to increasing industrial and commercial activities around the cities. This has attracted a lot of investors and migration from rural areas, thereby increasing the water demand. This puts a lot of stress on the existing freshwater sources of most of the cities.

With dwindling water resources and increasing risk of future water shortages, many cities require successful implementation of an alternative water source. This paper evaluates one such alternative water source, i.e. water recycling and reuse. The paper covers the social aspects of a successful water recycle and reuse scheme including some case studies and how a water recycling scheme can be applied in India.

INTRODUCTION

With the increasing population, there has been an unprecedented increase in water demand. Recycled water presents itself as an excellent alternative source to supplement the growing water needs. There is an absolute need for the public from all ages of six to sixty to reimagine water. Water reuse is not a new technology. In fact unplanned indirect potable reuse has been in practice ever since the inception of our planet. For centuries, humans have been discharging used water directly into the streams and rivers, and the same water is withdrawn downstream for potable and non-potable uses. As it is known, one city's wastewater plant discharges the water in the rivers which is taken by another water treatment plant in another city downstream and this cycle continues. All water on the earth has been used and reused uncountable number of times.

One may question the possibility of rain water harvesting or conservation, but we must understand that reclamation and reuse of water resource is still essential, especially in context of spatial and temporal variability of rainfall coupled with the climate change scenario.

Recycled water is a sustainable source of water that can be used by a water utility to diversify the existing water portfolio. Currently, all major cities in India are reliant on a single source of water (surface water or groundwater or a mix of both) to meet their drinking and non-drinking water demand. The lack of integrated water resource management which can help in utilising recycled water to meet the non-drinking demand results in inefficiencies in the water system. It is also known that both surface water and groundwater are not very sustainable. Recycled water, on the other hand, presents an excellent opportunity as it is not dependent on rain. As long as water is consumed by the people, recycled water is generated and it can be used and reused multiple times.

Using the latest technology in water reuse, we can supplement the natural water cycle and fasten the process since nature can't provide all the water that is needed for all the infrastructural development in a country like India.

The public needs to understand that the water is judged by its quality and not history. Public acceptance is the key to widespread reuse but we are our own worst enemy. To have a successful

**Assistant Engineers, Water Business Group, CH2M HILL (India) Pvt. Ltd, Noida*

implementation of this water reuse, communication is of utmost importance. Once the public understands the concept, acceptance can be achieved.

This paper defines the various types of water reuse programs and how they can be implemented in India with a dedicated focus on what role public education and information communication and technology (ICT) can play for successful implementation. The objective of this paper is to reach out to not only the common people, but also the public agencies and make them understand the concept of public education outreach and engagement (EOE) programs.

TYPES OF WATER REUSE PROGRAMS – CONCEPTS AND DEFINITIONS

To explain this concept in detail, it is important to understand the two types of water demand. Drinking water demand or potable water demand refers to those activities where water comes in direct contact with the human body. Activities like cooking, washing utensils, bathing and drinking are examples of drinking water demand. Non-drinking water demand or non-potable water demand are all other activities like industrial process, heating and cooling, construction and road making, firefighting, toilet flushing etc.

As understood, water reuse program can also be classified based on the two types of water demand. However, water recycle programs can be broadly classified into three types:

- Direct Potable/Drinking Water Reuse (DPR/ DDWR) – This refers to the planned addition of highly-treated recycled water that is fit for drinking water use by direct connection into the existing water conveyance system and delivery to the customers/end users. Although it presents excellent opportunities in capacity building and building of public trust in water recycling, it also poses threats of public health incidents and power supply reliability. At present, this type of water reuse program has only operating example in Windhoek, Namibia and even though it has a low cost, this is not recommended for India.
- Indirect Potable/Drinking Water Reuse (IPR/ IDWR) – This refers to the planned addition of highly-treated recycled water that is fit for drinking water use by indirect connection to bulk raw water storage or river/waterway before conventional water treatment and delivery to the customers and end users. This is similar to the DDWR in terms of its opportunities and threats, however, it has been observed that stakeholder engagement and public acceptance activities are easier to achieve in the case of an indirect drinking water reuse program. IDWR is the most common and least controversial drinking water reuse formats. It is widely practiced in many parts of the world, however, it is not recommended for India as a short term strategy because it is considered difficult to engage public directly for a drinking water reuse in India
- Non-Drinking Water Reuse (NDWR) – This refers to the supply of fit-for-purpose recycled water for non-drinking uses via a separate or dedicated recycled water conveyance system to customers or end users.The key strength of this concept is the public acceptance, however, the cost of duplicated infrastructure and/or retrofitting infrastructure in old areas is one of the major weaknesses of this water reuse format. This presents an excellent opportunity for new areas where reticulation systems are not in place as well as for areas with higher density of industrial and commercial customers. NDWR is the most common form for water recycling. The public acceptance and stakeholder engagement activities are straightforward and easiest to achieve. It is a potential candidate for water reuse in India and is highly recommended.

It may be noted that water can be treated to achieve the finest quality standards but the cost of treatment may be large. Depending on the same, it is essential to know the product water uses and design the treatment technology accordingly.

In India, at present, Jaipur city is planning for a large scale non-drinking water reuse program where close to 60 MLD of treated wastewater/treated used water will be conveyed to upcoming residential and industrial development in the south east part of the city.

SOCIAL ASPECTS

The use of Information Communication and Technology (ICT) in today's world is the easiest media

to reach out to public of all styles, age and abilities. The public 'education outreach and engagement' (EOE) plans are multi-modal so that reaching all types of learners and end users is easily achievable. The cone of learning and experience as developed initially in 1946 to demonstrate the value of audio/ visual media learning provides the framework for a successful multi modal learning programme.

The basic objectives of public EOE programs are to provide adequate information and context; encourage communication and dialogue; build and maintain trust; ensure fairness; and promote internal motivation and commitment. In addition, these EOE programs must explain the need for water reuse, caused due to the demand and supply deficit. It should then further elaborate on the safety of the water and the quality of the product water and show that it is sustainable from an environmental, economic and social perspective.

To enhance the public acceptance of water reuse, best of technology, social science, communication and science engagement is required and the use of social media websites, other interactive blogs and the like can help a great deal in doing so. Through the use of the right platform of technology, one can provide adequate information and context as well as encourage discussion and dialogue. Apart from taking aid from the electronic media, conducting interactive sessions with the public on days like World Water Day, World Environment Day etc. may help in building public's trust.

Cities like Singapore, San Diego, and Perth etc. actively practice water reuse and have implemented public outreach programs by creating a destination attraction that generates understanding on multiple levels. San Diego developed visitor centres and in Perth, the small visitor experience showed a complete 20% increase in acceptance of reuse technologies pre and post visit.

Public Utilities Board of Singapore (PUB) manages the entire water cycle from sourcing, collection, purification and supply of drinking water to treatment of used water and turning it into NEWater (the name given by PUB for their treated wastewater) as well as drainage of stormwater. In 2003, they also opened a NEWater Visitor Centre that targeted youngsters and was very visitor friendly with multimedia interactive games and videos. The idea behind opening such a centre was to provide first-hand experience of the NEWater plant operations and the technology behind this concept. Singapore has also used marketing and branding its product by giving it a different name and logo to make it stand out. They also partnered with external stakeholders like Singapore Cooperation Enterprise and other green clubs in colleges and universities to reach out to a wider population through all means of communication.

Using social media sites like Facebook and Twitter have also helped in achieving successful water reuse rates. Agencies like Public Utilities Board of Singapore, Orange County Water of California have actively used these websites to reach out to people. Apart from the use of ICT, it is also important to align these water reuse programs with the leaders like the Prime Minister, Water Resource Minister, etc. as leadership alignment builds the trust of public in the concept of water reuse. Liaison with the media and engagement with stakeholders are also attributes of a successful public education program.

CASE STUDIES

Case Study I - How Orange County's Approach to Outreach Influenced Public Acceptance of Advanced Water Recycling

Orange County Water District (OCWD) constructed a new 265 MLD advanced wastewater purification facility that takes treated sewer water which would have been wasted to the ocean and purifies it to near-distilled quality. Some of the benefits of their scheme were to reuse a water resource, expand the sea water barrier and increase the water supply reliability.

Their strategy to reach public was to research, plan, execute, evaluate and then repeat the process. OCWD observed that women, mothers, minorities and elderly were key audiences and face to face presentation were the best. It was observed that using the word 'purified' over words like 'reclaimed', 'reused' etc. resonated better and stimulated a positive trust in the agency.

Public agencies and their product water are brands that

should be protected. Reputation and transparency is quintessential to gain public trust and it matters how an organization gains public acceptance. Conducting face to face presentations and meetings as well as organizing tours or distributing water samples plays a key role in implementing successful EOE programs.

Case Study II- Water Reuse Research Foundation (WRF) Social and Policy Research

WRF organized and published a series of workshops and reports/papers on water reuse and its related research. The WRF publications talk about practices to receive fair consideration in water supply decisions; how to develop interactive, web-based vocabulary and images that will aid water communities to interact with the public; and addresses the health and safety issue of the recycled water.

It can be observed that words and images influence the people's willingness to drink reclaimed water as well as providing non-stigmatizing factual background leads to informed decision making.

CONCLUSION

To enhance the public acceptance of water reuse, best of technology, social science, communication and science engagement is required and the use of social media websites, other interactive blogs and the like can help a great deal in doing so. Through the use of the right platform of technology, one can provide adequate information and context as well as encourage discussion and dialogue. Apart from taking aid from the electronic media, conducting interactive sessions with the public on days like World Water Day, World Environment Day etc. may help in building public's trust.

SUSTAINABLE WATER MANAGEMENT

KESHAO GURUMUKHI* AND VIJAY K. SALUJA**

Abstract

Sustainable Water Management for human settlements, agricultural, and environmental systems is integral to a continued social and economic development process. Sustainable management plans should focus on stakeholder's involvement, water reclamation, re-use and recycle of waste water that will reduce stress during drought periods as well as in drought prone regions. Long-term economic development is clearly linked to ecology and environmental system, demographic forces implementing, effective policies that result in reduced population growth and focus on restoration and protection of water resources, climate change etc.

INTRODUCTION

India has a vast biological, geographic, and climatic diversity with geographic area of 329 Mha and excluding bodies of water, it's total land area is estimated at 297 Mha. Northern border stretches 2,500-kilometer along Himalayan mountains. Melting snow and glaciers provide continuous flow for numerous rivers running south of Himalayas into a vast plains dominated by river Ganges, Yamuna and its tributaries.Heavy rains are causing frequent floods in north India whereas southern India consisting largely Deccan Plateau is flanked by the Western Ghats running along the west coast and smaller stretch of Eastern Ghats on east coast. The Deccan rivers are rain fed and fluctuate in volume and some of these are not perennial.

Annual precipitation including snowfall over the country is about 4000 billion cubic metres (BCM) besides another 200 BCM from rivers flowing in from other countries. Water resources in various river basins are estimated to be 1869 BCM, of which the utilisable volume of water has been estimated to be 1086 BCM including 690 BCM of surface water and 396 BCM of ground water. The rest of the water is lost by evaporation or flows into the sea and goes waste. The utilisation of water is expected to be 784 to 843 BCM by the year 2025. Although "the present utilisation level is only about 53 per cent, the availability of water is highly irregular. It is not available in places of need, at times of need and required quantities. It is evident from the current experience that about one- third of the country's area is drought prone. The south and western parts comprising the states of Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu and Karnataka are drought prone states. On the other hand, north and north-eastern regions including states of Uttar Pradesh, Bihar, West Bengal and Assam are subjected to periodic flooding.

URBANISATION SCENARIO IN INDIA

As per population census urban population has been increasing fast over the last few decades and expected to be about 40 % of 1350 million total

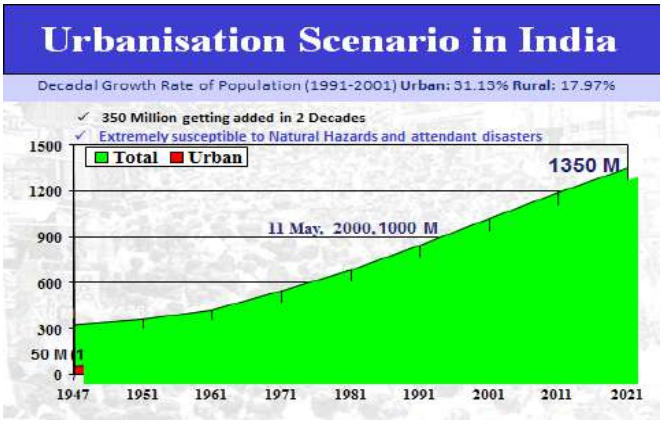


Fig.1 Urbanisation Scenario

**Former Chief Planner, Govt. of India, Min. of U.D. and presently Consultant, New Delhi*
***Former Chief Engineer, NDMC*

population of the country by the year 2021 as shown in Fig. 1 and 50% by 2031 i.e. about 750 million out of approx. 1500 million people. It is revealed that in two decades of 2001 – 2021 there will be addition of 350 million people in India coupled with industrialisation and also for the establishment of many other economic activities. This indicates huge progressive demand for water supply for domestic as well as other activities both in urban and rural areas.

WATER RESOURCES

Water is the fundamental requirement for human life and well-being, thus proper management of water resources is a method to improve agriculture, economic productivity, reduce poverty, health and water-related diseases. The total consumption of water in 1974 was 38 mhm and in 2025 consumption level will be 95 mhm, very close to 92 %, the maximum utilizable potential of the country. The availability and consumption of water for various activities has been shown in table 1 and 2.

Table 1 : Water availability, utilizable potential and demand pattern at National Level as per National Commission on Agriculture (in mhm)

Availability			Utilizable			Utility pattern and demand for 2025			
SW	GW	Total	SW	GW	Total	Year	SW	GW	Total
178	50	228	68.41	35.58	103.99	1974	25.00	13.00	38.00
						1985	38.42	17.40	51.82
						2025	70.88	24.80	95.68

Table 2 : Pattern of present utilization and future requirement of water : 1985 and 2025 (mhm)

Water use by purpose	Utilization 1985			Future estimated requirement : 2025		
	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total
1. Irrigation	33.14	17.34	50.48	61.17	34.27	65.54
2. Net consumption for	0.79	0.06	0.85	3.53	0.43	3.96
(a) Domestic & Municipal Supply	0.22	-	0.14	0.82	-	0.82
(b) Industrial use	0.14	-	0.14	0.82	-	0.82
(c) Thermal Power Generation	0.43	-	0.43	1.50	-	1.50
3. Pisciculture	-	-	-	2.79	-	2.79
4. Forestry	-	-	-	2.21	-	2.21
5. Livestock Need	0.49	-	0.49	1.18	-	1.18
Total Demand	34.42	17.40	51.82	70.88	24.80	95.68
Total Utilizable Flow (Available)	68.41	35.58	103.99	68.41	35.58	103.99
Demand as Percent of Utilizable Flow	50.3	48.9	49.8	103.6	69.7	92.0

In view of the above scenario, it is difficult to specify the year by which the demand would exceed the maximum utilizable potential. However, it is certain that we would soon be facing severe water crises and also very serious problems in a span of next 20-30 years unless remedial measures are not taken up at all levels. At local/regional level the problems of water scarcity may be witnessed much earlier either due to non- availability of adequate water resources (even after tapping of available water resources) or degradation of surface and ground water bodies due to industrial/domestic pollution or may be both.

In urban/industrial towns, both these factors will play a vital role, as growing population will not only reduce per capita availability, but at the same time would cause pollution of the existing water resources if sufficient control measures are not taken for its prevention. In arid and semi-arid areas, the problem is/will be mainly due to non-availability of water resources. In domestic sector, the organized water supply is limited to urban areas, whereas rural population has to make their own arrangement to procure water for their daily requirements in the present situation. Even in urban areas, with rapid pace of urbanization and industrialization in last two decades, the organised water supply does not cover up the entire urban population and also the per capita availability of water is much below the stipulated standard adopted by planners for planning and management of urban areas. We also need to understand the demographic forces to implement the effective policies by the Government which would result in reduced population growth through various programmes as in the next two decades (by the year 2031) the urban population will be almost double i.e. 50 % of the total projected population of the country.

The shortage of water is mainly due to over exploitation, excessive use and unequal access to water among different social and income groups in view of short supply, increasing demand, large scale pollution and uneven distribution, there is an urgent need to adopt some corrective measures for balanced and a reasonable supply of water. Some of the suggestions for conservation of water resources are as under:-

- Curbing reckless and unscientific use of water resources and minimising their wastage

- Undertaking water audit to curb leakages and replacing age-old pipes
- Promoting recycling and reuse of water for other domestic activities
- Controlling water pollution and purifying polluted water for agricultural and industrial purposes
- Diverting flood water to water deficient and drought prone areas
- Creation of more water storage reservoirs
- Making arrangements for inter-basin transfer of surface water
- Adopting measures to raise underground water level
- Adopting such methods of irrigation which require minimum water such as drip irrigation
- Curbing reckless drawl of ground water and develop techniques of recharging and augmentation
- Solving problem of water logging, salinity, water pollution and for maintaining ecological balance
- Preparing water budget on regional and national level
- Storing rain water for use during dry seasons i.e. rain water harvesting.

India receives about 3 trillion cu.m of water from rainfall. This is a huge resource and perhaps largest in the world. Yet, about one third of the country's area is drought prone. A fundamental strategy in sustainable water management is to integrate water management goals into physical, social and economic planning. It includes agriculture management, overall land use planning, forest resources utilization, protection of coastal zones and marine environments from land based activities. It can assist planners in achieving more efficient and effective water use as under:-

- **Water Conservation Strategy**

Conjunctive use of surface and groundwater should be encouraged to shorten the water use and alleviate the degradation of water and soil resources. Various technologies for groundwater recharge such as use of dug-wells, ponds, water harvesting structures in drains and rivers should be studied for feasibility.

- **Rainwater Harvesting**

Rainwater harvesting is defined as a method to induce, collect, store and conserve local surface run-off for agriculture and domestic use in arid and semi-arid regions. Basically, for run-off inducement, vegetation management, surface treatment and chemical treatment are involved. Vegetation management is more effective in areas having an annual rainfall of more than 280 mm. Arid zones are beset with water shortage caused by low annual rainfall. The problem is often overcome by the introduction of irrigation provided surface. An efficient drainage system is necessary to maintain a favourable salt balance for crop growth. Broadly, micro catchment water harvesting and run-off farming, water harvesting are the main run-off collection methods. The aim of micro catchment water harvesting strategy is to store sufficient runoff water during the rainy season, so as to meet the water requirements of crop growing. Other method is to collect the rain water in small digs and then recycling it. Appropriate water conservation strategies, such as rainwater conservation by terracing slopes and different means of water storage, including underground storage will differ according to the characteristics of the region and are particularly important in arid areas.

- **Irrigation Management**

Other potential measures include improvements in irrigation management, such as lining canals and using high- efficiency irrigation systems to prevent land degradation through salinization and water-logging. Using treated waste-water for irrigation increases the fresh water available for other uses, including the maintenance of healthy aquatic ecosystems. Decreased use of fertilizers in agriculture can reduce the need for expensive treatment of water from nearby water bodies to make it suitable for human use.

- **Watershed Management**

One of the simplest strategies to improve both water supply management and water quality is to protect watersheds through maintenance of naturally vegetated buffer strips along streams, river channels and around lakes. Plantation of trees will further improve holding capacity of the sub-soil water.

There is a difference between watershed and

a river basin. According to one group of thought, the area that drains water into a river is described as watershed and the boundary line between adjacent watersheds is called the divide. The other group defines the area drained by a river as catchment area or river basin. The river basin is larger than a watershed and covers the total area that drains through the river and its tributary system. Therefore, watershed management must be considered as a process of participatory planning, implementing, monitoring and evaluating a course of action involving natural, human and other resources. The holistic soil conservation and watershed management approach should consider those physical, socio-economic and institutional linkages that exist between upstream and downstream of a river basin or watershed.

- **Wetland Preservation**

It is an important element of watershed protection. The resulting gains in water quality and natural water storage which can reduce the need for, and therefore, the costs of water-treatment and storage downstream. In every region where there is a scanty rainfall, the wetlands should be created and also protected.

Fig. 2: Effluent Treatment Plant

- **Establishment of Effluent Treatment Plant**

Installing an effluent treatment plant (Fig.2) is the first step to control industrial pollution. The effluents are treated according to various standards such as river standards, inland water-bodies and sewer standards, depending on where the treated water has to be drained and further allowed to seepage into the soil.

- **Community Participation**

Community involvement in the construction, operation, maintenance and funding of water systems should strengthen village institutions. On the other hand, women's organisations must organise awareness programmes which will enable the women to realise the scarcity of water and consequently take steps to conserve it (Fig.3). It is also necessary to participate in creation of ponds or waterbodies in each of the settlement to store rain water for future use by the community for various purposes. Similarly the tree plantation programme should be run at community and school level to balance ecology and climate. Organising public awareness programme and constant encouragement through newspaper and media by public authorities can turn the situation of water crisis in their favour.

Fig. 3: Organising Awareness Programmes

SUSTAINABLE DEVELOPMENT OF WATER RESOURCES

Sustainable development of water resources refers to reducing the usage of water and recycling of waste water for different purposes such as cleaning, manufacturing, and agricultural irrigation in such a way that water demands of future generations are not hampered.

Social Solution

Water conservation programmes are typically initiated at the local level by Municipality and Village-panchyat. Common strategies include public outreach campaigns, tiered water rates (charging at higher prices as water use increases), or restrictions on outdoor water use such as lawn watering and car washing.The settlements in dry climate often require

installation of xeriscaping or natural landscaping in new homes to reduce outdoor water usage.

Household/Domestic Solutions

Water-saving technology for the home includes:

- Low-flow shower heads sometimes called energy-efficient shower heads as they also useless energy,
- Low-flush toilets and composting toilets. These have a dramatic impact in the developed world, as conventional western toilets use large volumes of water.
- Use of raw, saline (sea water) or rain water for flushing toilets.
- Reuse of wastewater or adopt recycling systems
- Adopt high-efficiency clothes washers
- Weather-based irrigation controllers
- Using low flow taps in wash basins
- Conserve water by landscaping native plants shortening consumption
- Not running the faucet while brushing teeth or taking shower

Commercial Solutions

Many water-saving devices (such as low-flush toilets) that are useful in homes can also be useful for business water saving. Other water-saving technology for businesses includes:-

- Infrared or foot-operated faucets, which can save water by using short bursts of water for rinsing in a kitchen or bathroom.
- Pressurized water brooms, which can be used instead of a hose to clean sidewalks.
- X-ray film processor re-circulation systems
- Cooling tower conductivity controllers
- Water-saving steam sterilizers, for use in hospitals and health care facilities.
- Rain water harvesting: it means capturing rain, where it falls or capturing the run off in your own village or town,and taking measures to keep that water clean by not allowing polluting activities to take place in the catchment areas. Water harvesting can be undertaken through variety of ways:
- Capturing runoff from rooftops
- Capturing runoff from local catchment areas
- Capturing seasonal flood waters from local streams and
- Conserving water through watershed management.
- Developing water reservoirs or lakes/ponds storing rain water for use

Agricultural Solutions

For crop irrigation, optimal water efficiency means minimizing losses due to evaporation, runoff or subsurface drainage while maximizing production.

- An evaporation pan in combination with specific crop correction factors can be used to determine how much water is needed to satisfy plant requirements.
- Drip Irrigation: Drip irrigation is also known as trickle irrigation or micro irrigation. It is an irrigation method which saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes and emitters.

CONCLUSION

A well known proverb says that water is life and absolutely a precious natural resource for the survival of our planet. There is no other substitute to water and hence, sustainability of this resource is most essential and need to be protected and conserved from its misuse, wastage, pollution and excessive use. There is an urgent need to adopt corrective measures as suggested above and draw an action plan, so that, reasonable supply of water can be assured to meet the future demand of mankind for various purposes. Relative measures like public awareness, publicity through media and community level group discussions have to be a regular feature to learn, understand and follow necessary steps by all concerned for the sustainability of the available water resource.

REFERENCES

1. K.T. Gurumukhi, Indian Building Congress Seminar on Water Management in Urban Centres, July 21-23, 2005, New Delhi.
2. UNEP, 2012 Report on Water Resources Management.

ROLE OF RECYCLED WASTE WATER FOR DRINKING IN SMART CITES

O.P. Gupta vsm*, Vijay Gupta** ,Chandan Gupta*** Vaibhav Gupta**** and Abhishek Gupta*****

Abstract

The U.N. warns that half the world population will face water scarcity by 2030, accelerated by climate change and population growth. Shortages on such a scale would threaten food production, as well as a health crisis through increased exposure to unsanitary water, which already kills millions each year through waterborne diseases such as cholera and diarrhoea. As the shortages become more extreme and water supplies are cut, it has raised awareness that we need to find alternative resources.

Waste water (also referred Sewage) treatment is the process of removing contaminants from wastewater, primarily from household sewage. It includes physical chemical and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of waste water treatment is usually a semisolid waste or slurry, called sewage sludge, that has to undergo further treatment before being suitable for disposal or land application.

In this paper the authors have attempted to discuss the "Role of Recycled Waste Water for Drinking in Smart City".

INTRODUCTION

Pressure on drinking water resource is growing. Over the last several decades, regional and local water shortages are becoming increasingly common. Recycling of wastewater is not something that's simply at the level of convenience but is going to be affecting every country, every society. Avoiding future clashes over water, the alternate is to drink treated wastewater.

In some parts of the world, the wastewater that flows down the drain, including toilet flushes is now being filtered and treated until it's as pure as spring water, if not more so. It might not sound appealing, but recycled water is safe and tastes like any other drinking water. Wastewater is much more than toilet water, of course. If an average city recycled all its wastewater, it could reduce 60% water it needed. Recycling wastewater for irrigation and other non-drinkable uses is already common. It is actually the same technology used to treat drinking water supplies that have become contaminated and it has been around for years.

NEED FOR RECYCLING OF WASTE WATER

More than 97 percent of Earth's water is saline, unfit for drinking. Of the remainder, more than 2% is frozen in glaciers and icecaps, leaving just 1 percent of all the water on our planet fresh. About 0.01% of that 1 percent resides in lakes, rivers and other waterways; the rest 0.99is in aquifers beneath the surface or trapped in soil.

Control of water resources is also a point of friction along already-contentious borders between Israel and Jordan, India andPakistan, and Turkey and Syria. Some experts think that water may supplant oil as a major spark of future conflicts. "Water is becoming a geopolitical conflict".

**Former Chief Engineer. MCD and Sr. Advisor, CIDC, New Delhi **General Manager (Highways) M/s S.A. INFRA STRUCTURE Consultants Pvt Ltd. Noida (UP) ***M.D, Manya Consultancy Services, Delhi, ****Highway Consultant, New Delhi *****B. Tech, Final Year , Northern India Engineering College, New Delhi*

No city can develop as a Smart City till it has enough clean water for drinking, agriculture and industrial processes because Smart City's economy relies heavily on exports, ensuring that there is high-quality water to make electronics and other goods. In general, none of the proposed Smart Cities are self-sufficient in water requirements. They mostly depend on the neighbour states / city for their water requirements. Under normal situation all goes right despite a historically cordial relationship. Politicians occasionally threaten to use water as leverage against the other State / City. Alternate is water Independence – leading to recycling of waste water for drinking. The treated water, is entirely safe to drink. It is so clean that it can be used in industrial processes that require extremely pure water.

The case for recycled wastewater is strong considering the experiences of other countries in the world. In 2012 National Academy of Sciences study found that U.S.coastal cities could increase their water supply by 27 percent with treated wastewater. Singapore offers an example.

Namibia's capital, Windhoek, which faces regular droughts, began sending recycled water from sewage directly into its water system in 1968 and continues to do so today. Windhoek is still the only city in the world directly reclaiming treated waste water affluent for drinking for the past 35 years. Windhoek, situated in the centre of Namibia, is one of the most arid place in Africa

The practical experience at Windhoek demonstrates that a direct waste water recycling system can be a practical, responsible way of augmenting potable water supplies in arid regions, but it requires comprehensive planning, training and on-going commitment for its continued success.

In Australia, which faced severe droughts for most of the 2000s, many cities are embracing water reuse.

TYPE OF WATER RECYCLING

Water recycling is often characterized as "unplanned" or "planned".

- A common example of unplanned water recycling occurs when cities draw their water supplies from rivers, that receive wastewater discharges upstream from those cities. Water from these rivers is reused, treated, and piped into the water supply a number of times before the last downstream user withdraws the water.
- Planned projects are those that are developed with the goal of beneficially reusing a recycled water supply.

Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. As for any water source that is not properly treated, health problems could arise from drinking or being exposed to recycled water if it contains disease-causing organisms or other contaminants. Recycled water is used for not potable (not for drinking) as well as for potable (For drinking) purposes.

ENVIRONMENT BENEFITS OF WATER RECYCLING

Water recycling provides tremendous environmental benefits by providing an additional source of water. Apart from this the environment benefits of recycled water are:

- It decreases diversion of fresh water from sensitive ecosystems and also decreases discharge to sensitive water bodies
- It is used to enhance wetlands and riparian (stream).
- It reduce and prevent pollution, because pollutant discharges to oceans, rivers, and other water bodies are curtailed, the pollutant loadings to these bodies are decreased.
- Application of recycled water for agricultural and landscape irrigation can provide an additional source of nutrients and lessen the need to apply synthetic fertilizers.
- It saves energy, because as the demand for water grows, more water is extracted, treated, and transported sometimes over great distances which can require a lot of energy.
- It saves the energy, because more energy required to pump the water to the surface. If the local source of water is ground water, the level of ground water becomes lower as more water is

removed.

- Tailoring water quality to a specific water use also reduces the energy needed to treat water.
- The water quality required to flush a toilet is less stringent than the water quality needed for drinking water and requires less energy to achieve.
- Using recycled water that is of lower quality for uses that don't require high quality water saves energy and money by reducing treatment requirements.

STAGES OF TREATMENT OF WASTE WATER

• Pre-treatment

Pre-treatment removes all materials that can be easily collected from the raw waste water before they damage or clog the pumps and sewage lines of primary treatment clarifiers. Objects commonly removed during pre-treatment include trash, tree limbs, leaves, branches, and other large objects.

• Primary Treatment

In the primary sedimentation stage, sewage flows through large tanks, commonly called "resettling basins", "primary sedimentation tanks" or "primary clarifiers". The tanks are used to settle sludge while grease and oils rise to the surface and are skimmed off. Primary settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank where it is pumped to sludge treatment facilities. Grease and oil from the floating material can sometimes be recovered for soap making.

• Microfiltration

After primary treatment, Microfiltration is next in which the water flows through a series of tubes containing filters with microscopic pores, each 500 times smaller than the thickness of a human hair. Whilewater flows into the tubes and microbes and all but the smallest solids are filtered out and don't pass through the tubes.

• Reverse Osmosis

Reverse Osmosis, is a technology used in a wide range of water purification technologies to produce drinking water. Reverse Osmosis uses high pressure to force water through a plastic membrane with pores so small that even dissolved salts typically cannot get through.

• Ultraviolet Lamp

Although Reverse Osmosis is usually enough to reliably remove all contaminants, the water flows past ultraviolet lamps to ensure that it is completely sterilized. The treated water is entirely safe to drink. It is so clean that it can be used in the industrial processes that require extreme pure water. By growing recycled water production and imposing regulations to encourage water conservation, Smart City can become water independent.

NEW TREATMENT TECHNOLOGIES

• Bioreactor

Traditional membrane bioreactors are already used in many modern waste waters treatment plants. They shorten the conventional sewage treatment process by adding a membrane to the aeration step, where aerobic bacteria, those that consume oxygen to respire, break down the organic matter in sewage. By sending the water through a membrane, follow-up settling and filtration steps are not necessary. After passing through a membrane bioreactor, water is clean enough to be discharged or can be used for irrigation.

• Anaerobia Membrane Bioreactor

According to the Institute of Environmental Science and Engineering, based in Singapore, anaerobic membrane bioreactor could lower the cost of wastewater treatment and its environmental impact. An anaerobic membrane bioreactor, uses bacteria that don't need oxygen to breathe, so oxygen is not bubbled through the reactors, thereby reducing treatment costs. And they can consume more solid waste, reducing the amount requiring costly disposal. In the right configuration, they also release less methane than conventional membrane bioreactors.

• Microbial Fuel Cell

A microbial fuel cell consists of two chambers of water separated by a membrane. A wire connects two electrodes, one in each chamber. On one side, anaerobic bacteria feed on sewage. As they break

the organic matter down, they produce electrons and positively charged hydrogen atoms called protons. The electrons flow to the electrode and across the wire, generating an electrical current. At the same time, the protons pass through the membrane and into the other chamber, where they combine with the electrons flowing into that electrode and with oxygen in the solution to make pure water.

PRECAUTIONARY MEASURES REQUIRED IN RECYCLING WASTE WATER

Odor Control

Odors emitted by waste water treatment are typically an indication of an anaerobic or "septic" condition. Early stages of processing will tend to produce foul-smelling gases, with hydrogen sulfide being most common in generating complaints. Large process plants in urban areas will often treat the odors with carbon reactors, a contact media with small doses of chlorine, or circulating fluids to biologically capture and metabolize the noxious gases. Other methods of odor control exist, including addition of iron salts, hydrogen peroxide, calcium nitrate, etc. to manage hydrogen sulphide levels.

High-density solids pumps are suitable for reducing odors by conveying sludge through hermetic closed pipework.

Sludge Treatment and Disposal

The sludges accumulated in a wastewater treatment process must be treated and disposed of in a safe and effective manner. The purpose of digestion is to reduce the amount of organic matter and the number of disease causing microorganisms present in the solids. The most common treatment options include anaerobic digestion, aerobic digestion, and composting. Incineration is also used.

Sludge treatment depends on the amount of solids generated and other site-specific conditions. Composting is most often applied to small-scale plants with aerobic digestion for midsized operations, and anaerobic digestion for the large-scale operations.

Environment Aspects

Many processes in a wastewater treatment plant are designed to mimic the natural treatment processes that occur in the environment, whether that environment is a natural water body or the ground. If not overloaded, bacteria in the environment will consume organic contaminants, although this will reduce the levels of oxygen in the water and may significantly change the overall ecology of the receiving water.

Recent evidence has demonstrated that very low levels of specific contaminants in wastewater, including hormones (from animal husbandry and residue from human hormonal contraception methods) and synthetic materials such as phthalates that mimic hormones in their action, can have an unpredictable adverse impact on the natural biota and potentially on humans if the water is reused for drinking water.A significant threat in the coming decades will be the increasing uncontrolled discharges of wastewater within rapidly developing countries.

Effects on Biology

Waste water treatment plants can have multiple effects on nutrient levels in the water that the treated sewage flows into. These nutrients can have large effects on the biological life in the water in contact with the effluent.

PREPARING PEOPLE FOR USE OF WASTE WATER FOR DRINKING

Technologies being developed make wastewater recycling more efficient and less expensive, but people have a strong aversion to consuming potentially contaminated food or drink.

Aversion to human waste is universal across all cultures. Putting wastewater into rivers and aquifers, not water pipes, can be more expensive but maybe useful for gaining public acceptance. An endorsement by a trusted group, like the NGO for waste water reuse can also reduce stigma. Third tactic is a public awareness campaign that emphasized the economic and national security benefits of making the country's water supply more independent for Smart City.

PUBLIC AWARENESS TO ACCEPT RECYCLED WASTE WATER

Public relations are key as recycled water schemes have been historically shot down by public disgust at the concept. This had been most vividly

shown in the World, where- ever such initiative had started. Australian city of Toowoomba in 2006 when local activists represented by the group "Citizens against drinking waste water / sewage" defeated plans to introduce recycled sources, citing health risks and emotive factors

However, after knowing that the technology used for treatment of the contaminated water is the same as recycling waste – water and further when acknowledged that the quality from waste water is very good, as good or better than the tap water in any city in the developed world. The public attitudes changed. Public in large accepted the recycled waste water for drinking.

FUTURE OF RECYCLED WASTE WATER

Waste Water can become a major defence against the projected scarcities of this country. The World Water Council projects that recycled waste water will be a normal source of drinking water in cities around the world within 30 years and much of the infrastructure and technology is already in place. It's up to us now to get used to it.

CONCLUSION

The Windhoek experience has proven over 35 years that it is possible today to augment drinking water supplies through direct recycled water in a safe and responsible way. However, it is recommended rather to use an indirect recycling scheme if it is allowed by geographical circumstances, like storing recycled water in an aquifer. A multi-disciplinary team approach should be used if a recycling /reuse scheme is going to be implemented to ensure that the technology employed is operating properly and that the necessary monitoring is conducted to ensure that the product is safe for its intended use. Policies and regulations on a national and local level are needed for proper support to ensure the long-term safety and sustainability of such projects.

TECHNICAL SESSION - III

WASTE MANAGEMENT INCLUDING C & D WASTE

CHALLENGES IN MUNICIPAL SOLID WASTE MANAGEMENT IN DELHI

K. P. Singh*

Abstract

This paper focuses on the present status of Solid Waste Management, its effects on public health and environment and measures for effective disposal of municipal solid waste in Delhi in conformity with the modified 'Solid Waste Management Rules, 2016'. The unprecedented growth in population together with urbanization, change in life style and consumption pattern have put tremendous pressure on the civic services, including solid waste management in urban habitat.

The paper confers upon the existing scenario, planning, practices, projects and innovations along with the various initiatives undertaken by North Delhi Municipal Corporation in improving the quality and efficiency of solid waste management in Delhi. Owing to the scarce land in Delhi and tremendous pressure on the existing Sanitary Land Fill (SLF) sites, Municipal Corporation is having no alternative except to opt for waste technologies instead of cheaper land filling options. In order to minimize the projected quantity of municipal solid waste by 2021, various technological options are to be explored with respect to sweeping, collection, segregation, transportation and disposal of MSW.

INTRODUCTION

The city of Delhi with a population of around 18 million is one of the biggest metropolises of the world. One of the major goals of the Government is to make Delhi a well managed; clean and hygienic city. The urban population increases @ 3.5% per annum and the per capita waste generated in the city increases @ 1.3% per year. Cleanliness is the most vital indicator of good urban management process. Solid waste management of the city is the prime responsibility of all three Municipal Corporations of Delhi. The area covered under the municipal corporations is about 1395 sq. km, out of which 604.54 sq. km area falls under the jurisdiction of North Delhi Municipal Corporation which consists of six zones, namely City Zone, Sadar Pahargnaj Zone, Karol Bagh Zone, Rohini Zone, Civil Lines Zone and Narela Zone. The Ministry of Environment and Forest (MoEF), Government of India has made the legislative rules for the management of municipal solid waste titled 'Municipal Solid Waste (Management & Handling) Rules, 2000' (called MSW Rules), now revised as 'Municipal Solid Waste Management Rules, 2016'. These rules apply equally to every municipal authority regardless of its size and make them responsible for collection, segregation, storage, transportation, processing and disposal of MSW. Accordingly, the North Delhi Municipal Corporation has undertaken sweeping, collection, segregation, storage, transportation and processing/disposal of the municipal solid waste of the areas falling under its jurisdiction.

Besides three municipal corporations, the New Delhi Municipal Council and Delhi Cantonment Board are also performing their obligations towards Solid waste management in their respective areas such as New Delhi (also called Lutyen's Delhi) and Delhi Cantonment area respectively.

EXISTING SCENARIO

The unprecedented growth in population together with change in life style and consumption pattern have put tremendous pressure on the civic

**Engineer-in-Chief, North Delhi Municipal Corporation*

services, including solid waste management i.e. generation of municipal waste in the city. The different settlements in part of the city namely planned colonies, urbanized villages, unauthorized-regularized colonies, resettlement colonies, JJ clusters, human settlements, industrial estates etc. create the environmental degradation. The average per capita municipal solid waste generation is around 500 gm per day. The area of the city under North DMC generates around 3000-3500 MT of solid waste per day. Under the provisions of DMC Act it is the duty of owner/ occupier of every premises situated in any portion of Delhi to dispose the municipal solid waste at the nearest receptacles/dustbins/dalaos. The function of solid waste management comprising of sweeping, collection, storage, transportation and disposal of garbage is accomplished by a separate department called 'Department of Environment Management Services (DEMS)'. The Safai karamchries sweep the road and footpath, collect the waste and deposit the same in municipal receptacles/dalaos/dustbins. The garbage generated by the colony/neighboring area is transported to the Sanitary Land Fill (SLF) sites by loading it mechanically. Municipal solid waste is transported to two SLF sites namely SLF, Bhalaswa and Engineered SLF, Narela-Bawana, where it is compacted/dressed/levelled by bulldozers and converted into compost and refuse derived fuel (RDF) material.

North DMC has moved a step ahead in the direction of 'Reduce, Recycle and Reuse' concept (3Rs), wherein it has been organizing Bhagidari Workshops for segregation of municipal solid waste at the source i.e. house hold level with its stake holders namely RWAs, house wives, eco clubs, sanitation staff, NGOs, rag pickers etc. It has trained more than one lakh personnel in the different Bhagidari Workshops.

In the direction of organized effective solid waste management following initiatives have also been taken:

- Collection and transportation of municipal solid waste of five zones under Public, Private Partnership Mode having GPS based, surveillance/monitoring system;
- Prepared Master Plan for disposal of municipal solid waste for next 20 years;
- MCD has entered into an agreement with World Bank for extraction of green house gases from the existing land fill sites and to further claim carbon credits. For quantification and viability study processing has already been initiated;
- Feasibility study for pilot project of 200 MT for intergraded treatment facility through bio mechanization process has been carried out;
- Distribution of best practice manual for the citizen of Delhi.

BROAD STRATEGIES

Broad strategies for handling Municipal Solid Waste are enumerated below:

Collection/Storage

Community Bins/Receptacles

Presently, the North DMC has provided dhalaos and receptacles/community bins at different locations in the colonies/areas for collection and storage of municipal waste. It is proposed that a space measuring 100 sqm may be provided on every 8 to 10 thousand population in the colonies/areas to cater to the needs of storage of garbage. In addition to this, spaces measuring around 200 sqm are to be provided for segregation of different kind of non-biodegradable waste.

New Initiatives for Door-to-Door Collection

North Delhi Municipal Corporation has introduced the door-to-door collection of municipal solid waste by auto tipper with private participation in two zones. The solid waste is collected from the households and transported to land fill site directly.

Fig: 1: Auto Tipper for Door-to-Door Waste Collection

Attendance Office

The collection of solid waste is one of the crucial components of the solid waste management. To have effective control in the field as well as on the work, a small office of Assistant Sanitary Inspector, consisting of 100 sqm is to be provided in each colony to have effective employee's attendance system and interface with the Residents Welfare Association.

Facilities for Kabariwalas/Rag-Pickers

It has been observed that the recyclable waste is being sold to Kabariwalas, which is subsequently recycled depending upon its uses. It would be necessary to have at least two markets in each zone for all 06 zones of North DMC i.e. recycling centers/kabari markets are to be developed by the DDA or MCD to reduce and re-use the recyclable part of the municipal garbage. For developing this kind of facility, space of about 1000 sq.mt. shall be required.

Transportation

Workshop and Parking Facilities

A space for providing adequate shelter for repair and maintenance of vehicles and other heavy equipments is required to have effective transportation system. To rationalize the pace of garbage generation, it is required to have 2200 vehicles (NEERI report), for which parking and workshop facility in the existing as well as new colonies likely to come up by 2021 is required to be provided.

Transfer Stations

To have effective and economical transportation system, intermediate transfer stations are required to be made. It is proposed that at least land for six transfer stations measuring 5000 sq.mtr. each may be provided in each of the 06 zones.

Disposal

Landfill Sites

Presently, the solid waste is being dumped at two SLF sites, namely Bhalswa site and engineered SLF Narela-Bawana site created by the concessionaire on the land provided by the North DMC. The landfill site at Bhalswa has attained saturation and outlived its normal life. The department proposes to reclaim the SLF site, Bhalswa for which the case is under process. As per Solid Waste (Management & Handling) Rules, 2000 notified by the Ministry of Environment and Forest, Govt. of India, the Engineered Sanitary Land fill sites are required to be developed in each direction of the city to have economical and effective solid waste management. Recently, the Hon'ble Supreme Court of India in its order has pointed out that at least 10 garbage processing facilities are to be provided. The requirement of land for development of engineered S.L.F. site should preferably be in low lying areas and the agency/ North DMC would be developing it with proper liner for gases and leachates management as per guidelines issued by the Ministry of Environment and Forest, Govt. of India. The approximate area of each landfill site should at least take care of next 20-25 years and garbage intake capacity of 2000 M.T. daily and the area of proposed land for SLF should preferably be around 1500 acres in totality.

Processing Facilities

For developing processing facilities for different kind of waste and specialized waste, like Slaughter House Waste and Cow dung, Composting/ Pellets etc. by opting various technologies, space measuring about 10 acres for each facility is required. All these processing facilities are likely to come up on public private partnership basis, as they are highly capital-intensive units.

ACTION PLAN

On account of limited land resources in the NCT of Delhi and tremendous pressure on the existing SLF sites, MCD is having no alternative except to opt for waste technologies instead of cheaper land filling options. In order to minimize the projected quantity of municipal solid waste by 2021, various technological options are to be arrived at.

Sweeping

The sweeping on existing roads and streets are being carried out. The North DMC had planned to provide mechanical sweeping system through mechanical sweepers on the roads having right of way of 60' and above, but it somehow did not

work due to various reasons and the department has decided to stop this work for the time being.

Fig: Daily Road Sweeping

Segregation

The most effective and logical point of segregation is at the source. The North DMC has organized awareness campaign among different group of people as part of introduction of segregation at house hold level into bio-degradable and non-biodegradable. This initial segregation will enhance the probability of reduction of waste by biological process and will have positive effect on quality of product i.e. green manure.

Thereafter, before reaching to community bins the recyclables materials like metals, papers, plastic etc. out of the remaining non-biodegradable most of the material is likely to be utilized in waste to energy plants via RDF for otherwise along with dairy waste and thus the process of segregation will be instrumental in reducing the waste quantity going for land filling.

Onus has been cast on private concessionaire in five zones to comply with the segregation programme in phased manner in line with 3Rs concept (Reduce, Recycle and Reuse) by organizing awareness campaigns amongst RWAs and involving rag pickers in safe organized manner.

Disposal

The disposal of Municipal Solid Waste is done at two SLF sites, namely Bhalswa and Narela-Bawana.

MCD is also eyeing the technologies such as Plasma Gasification, Pyrolysis, incineration etc which can reduce the quantum of residual waste to be land filled as well as promoting local level composting with a purpose to restrict the growth of waste going to land fill sites. On success, the life of land fill sites will be enhanced considerably.

STATUS REPORT OF THE SANITARY LAND FILL SITE, BHALSWA AND INTEGRATED WASTE POCESSING/DISPOSAL FACILITIES AT NARELA-BAWANA, NORTH DMC.

Sanitary Land Fill Site, Bhalswa It is situated near Mukarba Chowk and has an area of approximately 40 Acres. This site was started during the year 1994 whereas the Municipal Solid Waste (Management & Handling) Rules, 2000 came into force during the year 2000. Basically, the Sanitary Land Fill, Bhalswa is a dumping site and it not a secured Sanitary Land Fill site. At present, about 2000 MT of MSW per day (50MT + 400 MT+300MT+300 MT+800 MT+150 MT) is being received at this site from City Zone, Karol Bagh Zone, Sadar Pahar Ganj Zone, Narela Zone, West Zone and APMC. This Sanitary Landfill site through got exhausted long time back and the height of fill at present is about 40 mtr above the general ground level, but due to non availability of any other alternative site, the present site is being continued, by raising the level of filling above the general ground level. Things have now come to such a pass that it is now getting difficult with each passing day to operate the present land fill site but having no other option this site has to be continued even at the risk of loss of human life and property.

Fig. Sanitary Land Fill Site at Bhalswa

Integrated Waste Processing/Disposal Facilities at Narela-Bawana Integrated Waste Processing/Disposal Facilities is set up at Narela-Bawana on 100 acres of land by the M/s Delhi Municipal Solid Waste Services Limited during the year 2011 and it is in operation. The capacity of this plant is to handle 2500 MT of Fresh Waste per day. The plant capacity is being gradually increased according to the waste generation time to time. At present about 1700 MT per day (900MT+800MT) is being received at this facility from Civil Lines Zone and Rohini Zone. This waste is being converted into compost and refuse derived fuel (RDF) material. However, in future it is planned to generate electricity from the RDF so generated from the garbage.

Fig. Composting Facility at Bawana

Construction and Demolition (C&D) Waste/ Debris/Malba Plant at Burari Construction and Demolition (C&D) Waste plant has been installed at Burari on 7 acres of land near Jahangir Puri by M/s ILFS at their own cost during the year 2009-10. The capacity of this plant is 2000 MT of C&D Waste/ Malba/ Debris per day or processing/recycling. At present about 2100 MT of C&D Waste per day (20+170+110+300+1300+60+110+30) is being received at this facility from Civil Line Zone, City Zone, Karol Bagh Zone, Sadar Pahar Ganj Zone, PWD, DMRC, CPWD and I&FC.

Common Land fill facility in NCR

A meeting of Chief Secretaries of Haryana, U.P. and Delhi was held in 2004 wherein no consensus decision could be taken to have common sanitary landfill site facility for catering the solid waste generated from the neighboring cities. As such, the proposal could not be got materialized. MCD is interested in developing common facility for sanitary landfill site by paying tipping fee by the user.

THE WAY FORWARD: PROPOSED SOLUTION

The MCD has already proposed in the MPD-2021 the area of land required for Sanitary Land filling in Delhi with the total garbage anticipated up to 2021. At present, the MCD has approached the Hon'ble Court to get land allotted from the DDA, which has by now allotted the following chunks of land at the following places:-

- Site No. A, adjoining proposed site of Slaughter House and Behind Delhi Metro Railway Land in Rani Khera: 6.02 Acres.
- Site No. B along side of under construction of 30 meter wide Road and adjoining proposed Electric Sub Station in Rani Khera : 33.62 Areas.
- Site No. C left side of proposed 30 meter wide road in Rani Khera: 16.47 acreas.

The MCD has already initiated proposals to help the land reclamation at the SLF site, Bhalswa, which has already achieved its height of more than 40 mtrs from the ground level; and there is no scope, at present, available to dump the garbage generated under the jurisdiction of North Delhi Municipal Corporation.

It is proposed to carry out exclusive public awareness programmes for segregation of garbage by the public at the door level and to carry the organic and in-organic garbage, separately. The MCD also intends to establish engineered SLF sites at the new sites, which are likely to be handed over by the DDA

The MCD is making efforts to find out the adequate land to establish new SLF sites where gas could be collected and utilized for domestic as well as commercial use.

The MCD also intends to organize the rag-pickers in shape of formal sector, i.e. from unorganized to organized with the help of the

NGOs interested in this matter. This would help the rag-pickers to earn better to live with dignity.

The MCD is making efforts to make mechanical sweeping successful by examining the causes of failure in the past and to remove such hurdles, so that the efficiency of sweeping the roads through Mechanical Sweepers could be improved and better sanitation would be given to the Delhi ties.

CONCLUSION

For Ideal waste management system in MCD, following requirements shall have to be met:

- High in municipal solid waste (MSW) collection efficiency
- Collection of MSW/waste from door-to-door
- Segregated garbage collection
- Mechanical sweeping of wider roads
- Hygienic and efficient transportation to processing/ landfill site
- Availability of adequate lands for solid waste management
- Vehicle tracking system of transport vehicles
- Integrated process including recycling/treatment facilities
- New technologies for collection, odour reduction, processing and treatment of MSW
- Reclamation and value extraction from existing dumping yards
- Conversion of existing dumping yards into engineered land fills
- Citizen friendly complaint redressal and monitoring system

MANAGEMENT, RE- USE AND RECYCLING OF C&D WASTE

Dr. Vimal Kumar*

Abstract

Re-use and recycling of C&D waste is no more a concept. It is a reality. It is being practiced worldwide. A few plants have started functioning in India. Technologies are available. Mindset has started changing. The formalization through legislative means supported by Standards, and Specifications of end products and transparent guideline by the Civic bodies can boost use of C&D waste, which would reduce pressure on natural resources and the environment.

This paper gives details of C & D waste plants both within the country and in rest of the world. Details of C&D recycling process and the road map for gainfully utilization of C&D waste in built environment is given in detail.

INTRODUCTION

The demand of building materials for 2021-22 has been reckoned by Building Materials and Technology Promotion Council (BMTPC) as cement 380 million tonne, steel 50 million tonne, bricks 600 billion numbers, aggregate 400 million cubic meters and timber 40 million cubic meters. Data show that there is a considerable amount of shortage of conventional and traditional building materials in India. Re-use and recycling of C&D waste would help in reducing cost of dwelling per family unit as well as reduce the pressure on scarce building material from natural sources, especially, sand, stone chips etc.

In many industrialized countries, C&D waste is being recycled and used for housing and infrastructure, for example, Germany, Netherlands, Japan, South Korea, Singapore, etc. Number of C&D waste recycling plants in operation in 2012 as reported by European Demolition Association for some of the countries are given in Table 1.

Table 1: Number of C&D Waste Recycling Plants

Sl. No.	Country	No. of plants
1.	Belgium	60
2.	France	50
3.	Netherland	70
4.	UK	120
5.	Germany	220
6.	Denmark	20
7.	Italy	43

In India, in many areas, due to over extraction of natural resources for building construction products such as sand, stone etc. there is a very tangible shortage of material. It is high time, C&D waste is properly recycled and used effectively to ease the pressure on natural resources as well as to provide economics.

INDIAN SCENARIO

In India, most of the old buildings are made up of good quality bricks. The foundations and walls are load bearing, except new constructions in major cities, which are concrete frame structures. When old buildings are demolished, the major demolition waste is soil, sand and gravel (26%), bricks and masonry (32%), Concretes (28%), metal (6%), wood (3%) others (5%). Bricks, tiles, woods and iron metal are sold for reuse / recycling. The balance materials generally go for landfills. The realization of seriousness of the problem of disposal of C&D waste in Indian cities has started recently. Most of the municipalities have

* *Secretary General, Centre for Fly Ash Research & Management (C-FARM), New Delhi and Former Head, Fly Ash Unit, & Mission Director, Fly Ash Mission, DST, GoI.*

started working towards re-use and recycling of C&D waste. C&D waste is generally consisting of concrete, broken bricks and the mixed dirt. As stated earlier the bricks, wood, iron, glass, plastics, electrical, plumbing items and bathroom / kitchen fillings, etc. are already being reused /recycled in India.

In Indian context, the problem of C&D waste is getting aggravated due to rapid economic growth leading to urbanization and industrialization. Large construction projects of housing, related infrastructure as well as industrial infrastructure projects are becoming very common site across the country. Development of economic zones, industrial corridors, reconstruction of old building structures adds to the magnitude of C&D waste. The population living in cities and urban areas has increased from 14% at the time of independence to about 30% (2011 census). The increase in absolute number is much more.

Stringent laws are being formulated by the municipalities but enforcement has it's limitations. Private contractors remove this waste to privately owned, low-lying land for a price, or more commonly, dump it in an unauthorized manner along roads or other public land. C&D waste from individual households finds its way into nearby municipal bins and waste storage depots making the municipal waste heavy, and degrading its quality for treatments such as composting or energy recovery. In addition, the C&D debris is being indiscriminately dumped along the roads, in nallah, low lying areas, vacant plots and other unauthorized places.

Statutory Regime

The major issue in Indian context is that at Government level itself there has been laxity. A study by Ministry of Environment and Forests during 2010 found that C&D waste has a potential use after processing and grinding. "But so for in India there has been little effort to manage and use it", the study said. Further, at national level, there has been less urgency to regulate, facilitate and manage C&D waste. It is very evident from the following facts:

- "2010 Working Committee Report on MSW Management recommended that C&D waste collection, utilization and safe disposal be addressed during amendment of MSW Management Rules. But there is no explicit dealing with C&D waste in draft MSW Management Rules 2013.

  The draft Solid Waste Management Rules, 2015 with a separate chapter on construction and demolition waste were published by the Central Government in the Ministry of Environment, Forest and Climate Change vide G.S.R. 452 (E), dated 3rd June, 2015. These draft rules are yet to be finalized. C&D waste Management Rules, 2016 have now been issued by MoEF&CC vide notification no. G.S.R. 317(E) dated 29th March, 2016.

  The rules delineate the duties and responsibilities of waste generator, service provider as well as administrative and statutory bodies with a time line.

- There are no specifications, codes, guidelines for C&D waste processing and recycling as well as the products manufactured from recycled waste. BIS has yet to bring out standard on these. However, IS: 383 the standard for coarse and fine aggregates for use in concrete has been revised during January, 2016, permitting use of recycled aggregates up to 25% in plain concrete, 20% in reinforced concrete of M-25 or lower grade and up to 100% in lean concretes of grade less than M-15. BIS has yet to bring out/ amend the standards of bricks, blocks, kerb stones, tile, ready mix concrete and concrete, etc. with use of recycled concrete aggregates/ recycles aggregates. Most of the prevailing standards state that the aggregates be from natural sources as per IS: 383. These standards need to state that manufactured and recycled aggregates can also be used as per IS: 383, Jan., 2016.

  Indian Road Congress (IRC) need to bring out standards and specifications for use of manufactured and recycled aggregates in construction of roads and allied structures.

Estimate of C&D Waste

No authenticated C&D waste data is available with any of the Government bodies / agencies; let it be Central or State Government. Figures being quoted by different Government agencies vary from 10 Mt -15 Mt a year. While Centre for Science and Environment (CSE) estimates 625 Mt / year generation of C&D waste.

C&D debris is generated by demolition/ renovation of housing stock. As per census of India 2011, the housing stock is:

Rural houses - 220, 695, 914
Urban housing - 110, 139, 853
Total - 330, 835, 763

Considering only the urban houses and with an assumption that the average area of a house is 75 sq. m. and that 5 per cent of housing stock comes for renovation a year. The annual C&D waste generated from renovation works out to 123.90 Mt taking 300 kg debris generation per sq.m area.

Thus, the total annual generation of C&D waste in India can be said to be in the range of 165-175 Mnt per annum during 2005-2013.

C&D Waste Recycling Plants

The Government and civic bodies are now very alert and active on the front of C&D waste management. Four plants, summarized below are operational for recycling of C&D waste.

Burari, New Delhi

India's first plant for recycling of C&D waste has been commissioned during 2009 at 10 acre site at Burari, Jahangirpuri in North Delhi by Infrastructure Leasing and Financial Services (IL&FS) under an agreement with North Delhi Municipal Corporation. The plant was initially set up to process 500 tpd C&D waste. Processing of 1200 tpd was achieved during 2014 and Delhi Pollution Control Committee has awarded the permission to expand the capacity to 2000 tpd.

The products being manufactured at this facility are sand, coarse aggregate, RMC, bricks, blocks, Kerbstones, pavement blocks, hollow bricks etc.

East Kidwai Nagar, New Delhi

M/S Enzyme India Pvt. Ltd. has set up C&D waste recycling plant in 2014 on PPP model with 100% by-back by NBCC with a capacity of 150 tpd at the project site of "RE-development of East Kidwai Nagar, New Delhi". The construction project involves demolition of 2444 existing houses and construction of 4747 houses covering 60 lakh sq. ft. area and commercial area of 12 lakh sq. ft. on a plot area of 86 acres with 12.7 lakh sq. ft. green area.

Shastri Park, New Delhi

Third plant in Delhi for recycling of C&D waste has been commissioned at Shashtri Park in East Delhi at 2.5 acre site to process 500 tonne C&D waste per day. The plant has been built in partnership with IL & FS, which would run it for 15 years before transferring it to EDMC. The facility will get mixed C&D waste from 15 designated sites of East Delhi.

Ahmedabad, Gujarat

Ahmedabad Enviro Projects Pvt. Ltd. (AEPL) has commenced a 100 tonne per hour capacity plant for recycling of C&D waste in phase wise from December, 2013. The plant is fully operational since June, 2014 and is located at Pirana, Ahmedabad.

Earlier Experience at Mumbai

Youth for Unity and Voluntary Action (YUVA), a non profit, non Govt. organization has recycled 1500 tonne of C&D waste during 2002-06 at CIDCO-YUVA Building Centre (CYBC), Kharghar. CYBC is a joint venture of City and Industrial Development Corporation of Maharashra Ltd. (CIDCO) and YUVA. The C&D recycling demonstration plant has manufactured building materials like bricks, blocks, paving blocks, concrete, sand substitute and coarse aggregates. The laboratory test results proved the quality of end products. The products were used by private builders. However, Govt. projects could not accept the products for want of standards, specifications and departmental approvals.

The estimated cost saving of building products manufacturers from recycled C&D waste was reported as given below in Table 2.

Table 2: Cost Saving in Recycled C&D Waste Products-CYBC

Building products	% saving
Solid block	25
Hollow block	30
Paving block (60 mm thick)	25
Paving block (80 mm thick)	20

Source: Project Report CYBC-Mr. N.M. Shirgonkar

The CYBC project of C&D waste recycling was shut down due to no support from the policy makers as well as the market.

QUALITY OF RECYCLED C&D WASTE PRODUCTS

The building construction products manufactured at Burari, New Delhi; Pirana, Ahmedabad and YUVA-CIDCO Centre, Mumbai have been taken up by various R&D and user agency's laboratory tests for quality evaluation. The building construction components manufactured at the C&D recycling plants such as bricks, blocks, paving blocks and kerb stones, etc. have satisfactorily met the requirements of 75-150 kg/cm2 compressive strength and water absorption below 20 per cent.

Use of fine aggregates and coarse aggregates manufactured by recycling of C&D waste has also been validated scientifically for part replacement of natural aggregates up to 50%. Illustrative results are given in Table 3 and 4 below:

Table 3: Results for Replacement of Natural Fine Aggregate by Recycled Fine Aggregate

S. N.	Replacement %	Compressive Strength as per IS-516 (MPa)			
		07 days	28 days	56 days	90 days
1.	0	25.93	38.98	46.14	52.00
2.	25	31.84	42.90	51.16	58.80
3.	50	34..27	46.14	53.87	61.82
4.	75	30.55	39.87	47.15	53.62
5.	100	24.77	37.97	44.42	51.30

Source: Nikhil Kaushik, V.V. Arora and P.N. Ojha, National Council for Cement and Building Materials, India

Table 4: Results for Replacement of Natural Coarse Aggregate with Recycled Coarse Aggregate

S. N.	Replacement %	Compressive Strength as per IS-516 (MPa)			
		07 days	28 days	56 days	90 days
1.	0	25.93	38.98	46.14	52.00
2.	25	26.28	44.48	51.59	55.29
3.	50	25.36	38.56	45.05	51.31
4.	75	22.80	36.42	41.54	45.50
5.	100	21.60	32.29	37.18	41.62

Source: Nikhil Kaushik, V.V. Arora and P.N. Ojha, National Council for Cement and Building Materials, India

Good amount of data has been generated on quality aspect of the recycled building construction products manufactured from C&D waste. Accordingly, Bureau of Indian Standards (BIS) has amended IS:383, the specification of coarse and fine aggregates in January, 2016, permitting part substitute of aggregates from natural source by aggregates manufactured from recycled debris, as given below in Table 5.

Table 5: Extent of Utilization Permitted by IS: 383(2016)

Sr. No.	Type of Aggregate	Maximum Utilization		
		Plain Concrete (%)	Reinforced Concrete (%)	Lean Concrete (Less than M-15 Grade) (%)
(i)	Coarse aggregate			
(a)	Recycled concrete aggregate (RCA)	25	20 (Only up to M-25 Grade)	100
(b)	Recycled aggregate (RA)	Nil	Nil	100
(ii)	Fine aggregate			
(a)	Recycled concrete aggregate (RCA) (See Note 1)	25	20 (Only up to M-25 Grade)	100

NOTES

1. It is desirable to source the recycled concrete aggregates from sites being redeveloped for use in the same site.
2. In any given structure, only one type of manufactured coarse aggregate and one type of manufactured fine aggregate shall be used.
3. While using manufactured aggregate as part replacement for natural aggregate, it should be ensured that the final grading meets the requirements specified in tables 7,8,9 of this standard.

C&D WASTE RECYCLING PROCESS

A line diagram of C&D waste recycling process is given in Fig.1 and the list of major equipments is at Table 6.

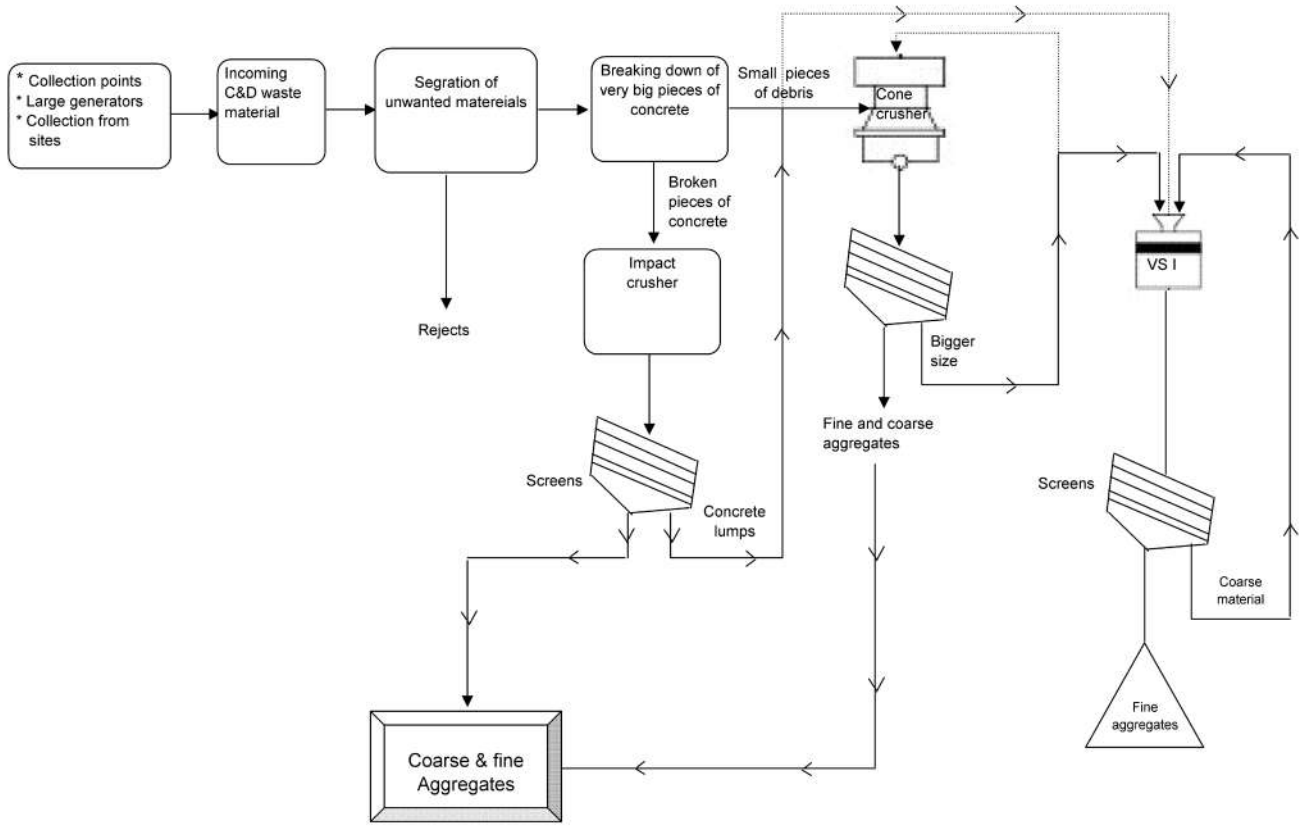


Fig. 1: C&D Waste Recycling Process

Table 6: Major Equipments for Recycling of C&D Waste

S. No.	Equipment
1.	Dump hopper
2.	Grizzly feeder
3.	Impact crusher
4.	Vibratory screen-1
5.	Cone Crusher
6.	Vibratory screen-2
7.	Grizzly set filters
8.	VSI crusher
9.	Vibratory washing screen/ log washer
10.	Hydraulic press for brick making
11.	Egg lying block making machine
12.	Paver block vibratory table/hydraulic press
13.	Tile making vibratory tables/ hydraulic press
14.	Kerb stone – Egg laying machine
15.	Ready mix concrete plant

SUGGESTIONS FOR SPECIFIC USES INCLUDING INTERNATIONAL PRACTICES

Suggestion for specific uses in housing along with list of possibilities of application of recycled C&D waste products including listing of usable building products/technology/ practices are:

- The re-usable items recovered specially during demolition or segregated from debris of new construction such as doors and windows, bricks, reinforcement from RCC components, structural

steel, electricals, kitchen and sanitary fittings, iron grills, partitions, wooden and other fittings and fixtures, etc. can be used in construction of low income housing.

Internationally, in developed countries, the re-usable items of C&D waste are certified for worthiness and quality by authorized inspection and certification agencies. In India, the assessment of quality of these items is made informally by the re-user (buyer) or by the skilled/ semi skilled worker/ mistry.

The inspection/ test/ certification of re-usable items may be institutionalized.

- Re-cycled C&D waste can be used to produce many products as listed below, that can be generally utilized in low income housing and related infrastructure.

(a) Sand for use in concrete and masonry

(b) Coarse aggregates for use in concrete

(c) Bricks, blocks, tiles

(d) Pavers blocks

(e) Kerb stones

(f) Pre cast items such as: slabs drain covers, manholes, manhole covers, louvers fins, pillars, for fencing, wall slabs, door/window frames, etc.

(g) Broken brick bats or other mix debris of size 10 to 80 mm be used for filling under the floors or in internal roads/ pavements.

(h) The waste fines and dirt at the recycling plant of C&D waste is, internationally, sent to MSW land fills. It is suggested that this material may be used in low income housing projects for plinth filling and landscaping.

Internationally, in developed countries, all the above said products are manufactured through fully automated process/ technologies. In Indian scenario, considering the current low volume of operations and the cost controls required, it is suggested to use semi-automatic processes/ technologies.

ROAD MAP FOR GAINFUL UTILIZATION OF C&D WASTE USABLE IN HOUSING SECTOR

The road map to maximize the re-use of C&D waste as well as that of the products manufactured from recycled C&D waste in housing is as given below:

Reuse of C&D waste

The items which are usable directly like doors and windows, bricks, reinforcement from RCC components, structural steel, electrical, kitchen and sanitary fittings, iron grills, partitions, wooden and other fittings and fixtures, etc. can be taken out with little extra care and efforts so that these items are not damaged much. All these items can be put into re-use without much processing. Sufficient precautions be taken specially during demolition and renovation to recover more of material that can directly be re-used. The re-using a waste item is a better service to the environment and the environment is saved from further impacts due to recycling activities.

Recycling of C&D waste

Once the re-usable elements have been segregated, the items like metal, glass, plastics, non usable waste items, etc. be removed and sent to remelters / re-processors or to land fill.

The balance debris can be processed to produce usable building materials such as:

- fine aggregate
- coarse aggregate
- ready mix concrete
- bricks/ blocks
- tiles
- paver blocks
- kerb stones
- pre-fab slabs .....etc.

The capacities created at recycling plants be such that it can accommodate the increase in C&D waste generation over next 10 years by installing additional balancing equipments and/or by extending the working hours.

As already advised by MoUD vide its circular dated 28th June, 2012 all states to set up C&D waste recycling facilities in all cities with population of over 1 million. As of March, 2016 such facilities have been created only in 2 cities i.e. New Delhi and Ahmedabad. The implementation of the directive may be facilitated through availability of funds and creation of market for reprocessed

building construction materials.

Sensitization and facilitation for re-use and recycling of C&D waste may also be taken up in cities of population less than 1 million to encourage such initiative. This is because mega cities and cities with million plus population account for only 23 per cent of urban population (Census 2011).

The agencies that generate C&D waste in bulk quantity may deliver the C&D debris at the recycling plant and others may deliver it at collection points.

Collection points be provided so that small quantity generator of C&D waste is not required to transport the debris to a distance more than 2.5 to 3.0 km.

The transportation cost and a part of processing charges may be paid by C&D waste generator. These charges may be on telescopic scale i.e. low charges for small volume generators.

The terms and conditions with the concessionaire and the fee levied to bulk producer of C&D waste are made available at a price at least 20% lower than corresponding materials from natural resources.

The easy availability and quality of recycled products be ensured.

As and when C&D waste recycling plant is commissioned at a city, it may be made mandatory for all construction activities to use a specified percentage of building construction materials manufactured from recycled debris.

The marketing and use of C&D waste items that have been segregated at the initial stages for re-use may be streamlined.

The successful experiences may be disseminated and replicated.

CONCLUSION

Re-use and recycling of C&D waste is no more a concept. It is a reality. It is being practiced worldwide. A few plants have started functioning in India. Technologies are available. Mindset has started changing. The formalization through legislative means supported by Standards, and Specifications of end products and transparent guideline by the Civic bodies can boost use of C&D waste, which would reduce pressure on natural resources and the environment.

REFERENCES

1. Alternate to Natural Sand for Concrete and Mortar by A.K. Mullick, Indian Concrete Journal, Vol. 89, No. 3, March 2015, pp.10-21
2. C&D Waste Survey, IL&FS Ecosmart, New Delhi, 2005
3. CPWD Guidelines for Sustainable Habitat, CPWD, March, 2014
4. Coarse and Fine Aggregate for Concrete (Third Revision), Specification, Indian Standard, Bureau of Indian Standards, New Delhi, January, 2016
5. Construction and Demolition Waste Management (Solid Waste), Environmental Building Guidelines for Greater Hyderabad – Ver. 1.2(2010)
6. Dealing with Rubble Trouble, The Hindu, August 18, 2015
7. Demolition and Construction Debris Recycling in Europe by S. Buchner and L.J. Scholten, European Demolition Association (EDA), 1992
8. Demolition Waste: A Resource in the Construction Sector, Amdavad Enviro Projects Pvt. Ltd. (n.d.) Retrieved from www.amdavadenviro.com
9. Demolition Waste: A Resource in the Construction Sector, Gulghane, A.A. and Khandve, P. (2015), Management for Construction Materials and Control of Construction Waste in Construction
10. Effective on Properties of Concrete using Construction and Demolition Waste as a Replacement of Natural Aggregate by Nikhil Kaushik, V.V. Arora and P.N. Ojha, National Council for Cement and Building Materials, India, March, 2016
11. Fixing Navi Mumabi, Brick by Brick, Mumbai Mirror, Jan2, 2016
12. GHMC Mulls Recycling Debris,TNN, Feb 13, 2012
13. Guidelines on Recycling, Use and Management of C&D Waste, Report ICI/TC/05-01, October 1, 2015

14. Housing Overview-Shortage and Development by Swami Dr. Tathagat Bharti, SS Publication, Bhopal, 1991 Edition, p.2.

15. Managing and Minimizing Construction Waste by Ferguson, J; Kermode, O.N.; Nash, C.L; Sketch, W.A.J. and Huxford, R.P., Institution of Civil Engineers, Thomas, Tefford Publications, U.K., 1995, pp. 1-60

16. National Buildings Construction Corporation Limited, Press Release, May 3, 2013

17. Rebuilding C&D Waste Recycling Efforts in India by S. Ghosh, Waste Management Word, October 8, 2011

18. Recycling and Reuse as a Basis of Sustainable Development in Construction Industry, Concrete for Environment, Enhancement and Protection by Handricks, Ch.F., 1956, E&FN Spon, pp. 43-54

19. Recycling of Demolished Concrete Masonry, Riem Report No. 6, by T.C. Hasan, 1992, E&PN Spon, London, Great Britain, pp. 316

20. Recycled materials in European Highways Environment-Uses, Technologies and Policies, Int. Technology Exchange Programme., US Dept. of Transportation, 2000

21. Reuse of Building Materials and Disposal of Structural Waste Material, by Pauw, C.D., Disaster Planning, Structural Assessment, Demolition and Recycling, Rlem Report 9, E&FN Spon, 1954 pp. 133-159

22. Toolkit for Solid Waste Management, JNNURM, Ministry of Urban Development, GOI, November, 2012

23. The draft Solid Waste Management Rules, 2015, MoEF&CC

24. Utilization of Waste from Construction Industry, Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi, 2001

25. Waste to Resource, Construction World, February, 2016

26. 2010 Working Committee Report on MSW Management, GoI

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN SMART HABITAT

Sandeep Kumar Sharma*

Abstract

Municipal Corporation of Delhi is primarily entrusted with the responsibility of solid waste management including collection, transportation and disposal. On average 8000 MT Municipal Solid Waste is generated daily in Delhi of which about 30 percent (i.e. 2000 to 2500 MT) is expected to be C&D waste. The C&D waste, when taken to the landfill site mixed with biodegradable waste is ultimately land filled thus reducing the capacity further of such landfill sites.

The intent of this paper is to access the feasibility of reducing, re-using and recycling of C&D waste. The paper also studies the characteristics of C&D waste and its utilization. A brief description of C&D Waste Facility at Burari set up by the North Delhi Municipal Corporation has been given in the paper. The instant work will be of immense help and importance to the organization as well as general public as it explores the possibility to generate value out of the C&D waste and reducing pressure on existing landfills. Hence the municipal corporation shall be benefited by saving land cost. Also, the revenue shall be generated by making use of C&D waste by recycling the same and hence the project shall be sustainable. At the same time, the pressure on the natural resources will be reduced. The model may be used to advantage by other municipalities also. The consequential social and environmental benefits have also been illustrated.

INTRODUCTION

Construction and demolition waste is mainly the waste debris generated from demolition of a building. The construction waste generally refers to unwanted material produced directly or incidentally by construction or industries. This includes building materials such as insulation, nails, residual concrete, brick bats, electrical wiring, and rebar, as well as waste originating from site preparation.

The Central Government of India has made the legislative rules for the management of municipal solid waste titled 'Municipal Solid Waste (Management and Handling) Rules, 2000' (called MSW Rules), now revised 'Municipal Solid Waste Management Rules, 2016'. These rules apply equally to every municipal authority regardless of its size and make them responsible for collection, segregation, storage, transportation, processing and disposal of MSW. On average 8000 MT MSW is generated daily in Delhi of which about 30 percent (i.e. 2000 to 2500 MT) is expected to be C&D waste. The C&D waste, when reach the landfill site mixed with biodegradable waste is ultimately land filled thus reducing the capacity of landfill sites. Certain components of demolition waste such as plasterboard are hazardous once land filled as it is broken down in landfill conditions releasing hydrogen sulfide, a toxic gas.

The promotion of environmental management and the mission of sustainable development have necessitated for the adoption of proper methods to protect the environment across all industries including construction. Construction by its nature is not an environmental-friendly activity. The hierarchy of disposal options, which categorizes environmental impacts into six levels, from low to high; namely, reduce, reuse, recycle, compost, incinerate and landfill. (Peng et al., 1997) (see Fig.1). Three main

**Assistant Engineer (Civil), North Delhi Municipal Corporation*

waste minimization strategies of reuse, recycle and reduction, are collectively called the "3Rs". To reduce construction waste generated on site, coordination among all those involved in the design and construction process is essential.

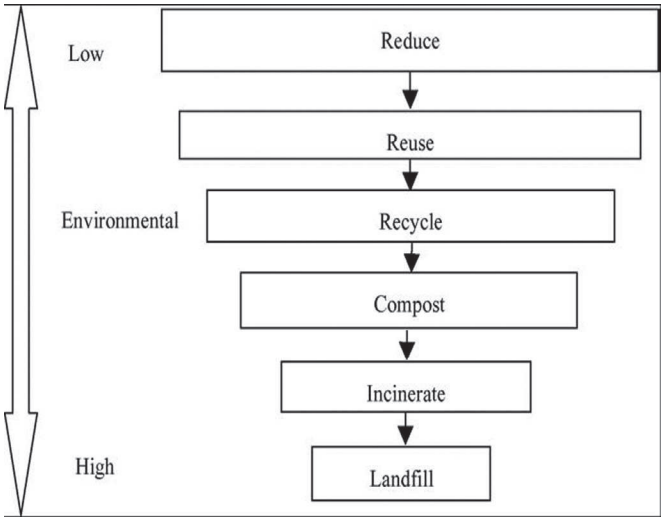


Fig. 1: Hierarchy of Construction and Demolition Waste (Peng et al., 1997).

Recycling, being one of the strategies in minimization of waste, offers three benefits: (i) reduce the demand upon new resources, (ii) cut down on transport and production energy costs and (iii) use waste which would otherwise be lost to landfill sites. Construction and demolition (C&D) wastes including demolished concrete (foundations, slabs, columns, floors, etc.), bricks and masonry, wood and other materials such as dry wall, glass, insulation, roofing, wire, pipe, rock and soil constitute a significant component of the total waste.

In order to successfully implement a viable C&D recycling system in this country, the Government, through its Environmental Protection Agency, should develop a National C&D Recycling Policy.

This Policy would promote the growth of C&D recycling, make the process more economically attractive, and help develop markets for the commodities that are generated. By establishing a National Policy, the Government would be stating that the recycling and reuse of C&D material is a beneficial societal goal, one that is good for the environment, good for the economy, and good for our country.

NEED FOR C&D WASTE MINIMIZATION

The natural resources are being consumed more rapidly than its generation. On the basis of an estimate there is 40% more consumption than its generation or in other words, the natural resources generated in 1 year 5 months are consumed in 1 year. There is need to evolve user friendly mechanism for proper management of C&D waste in order to retard the depletion of natural resources.

In all communities it has always been common practice to retrieve valuable materials from the arising waste, e.g. metals and building materials. In the recent past with an extensive "use-and-throw-away" philosophy, it has been recognized that we cannot continue this uninhibited use of natural resources and pollution of the world with waste. It is necessary to change our habits and to amend former common practices within the building and construction industry, as well as within other industries, households, etc.

In many industrial as well as developing countries, C&D waste is considered as harmless, inert waste, which does not give rise to problems. However, C&D waste consists of huge amounts of materials that are often deposited without any consideration, causing many problems and encouraging the illegal dumping of other kinds of waste. Whether C&D waste originates from clearing operations after natural disasters or from human-controlled activities, the utilization of such waste by recycling can provide opportunities for saving energy, time, resources and money. Furthermore, recycling and the controlled management of C&D waste will lead to land saving and better opportunities that will be created for the handling of other kinds of waste. There is a need to evolve user friendly mechanism for proper management of C&D waste.

GENERATION OF C&D WASTE

Construction industry in India is growing at a rate of twice the world average. Total construction market in India (PWC Estimates) for FY 2014 was over Rs. 900,000 crores. This creates sizable C&D waste. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum of which waste from Construction Industry accounts for 25%. Construction waste is bulky, heavy and is mostly unsuitable for

disposal by incineration or composting. The growing population in the country and requirement of land for other uses has reduced the availability of land for waste disposal. Re-utilization or recycling is an important strategy for management of such waste. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/ re-use technology in order to be able to conserve the conventional natural aggregate for other important works. Apart from mounting problems of waste management, other reasons which support adoption of reuse/ recycling strategy are reduced extraction of raw materials, reduced transportation cost, reduced capital investment on raw materials, improved profits and reduced environmental impact.

Significant quantities of waste are disposed at unauthorized / designated public locations. From these points, Municipal Corporation of Delhi is forced to evacuate C&D to the landfills. The quantum reaching the landfill is the quantity collected by MCD and does not reflect the actual generation. It also needs to be noted that most of the C&D is consumed internally for land filling and bricks, metal and wood are recycled.

The large portion of C&D waste is derived due to following activities:

- Demolition
- New Construction
- Rehabilitation

Other reasons for C&D waste generation are:

- Natural Disasters
- Technological Developments – For example, the production of building materials and goods involves surplus concrete elements, articles of wood etc., which can be classified as industrial waste.

MCD has designated sites at different locations in Delhi for collection of C&D waste.

PRESENT SCENARIO OF C&D WASTE DISPOSAL IN DELHI

For demolition of old existing buildings, the demolition contractors are normally engaged. A fair number of organized demolition contractors are available with demolition equipments, loaders, transportation arrangements and labour force and can be approached through telephone, e-mails or web sites by general public. For demolition of large old buildings or government/municipal buildings, the participation of contractors is invited through auction and the work is awarded to the contractor quoting highest bid considering the useable material and input cost of demolition. Demolition contractor specialises in planned deconstruction so that recovery of good material can be maximised for re-use. Recovery rate varies from 25% in old buildings to as high as 75% in new buildings. Items recovered during demolition are sold in the market at a discount with respect to price of new material. Sometimes, woodcarvings and marble structures are recovered from old buildings, which fetch very good price as Antique piece in domestic/export market. Although the responsibility of removing the waste is primarily of the builder or the owner, it is usually assigned to the demolition contractor. Items that cannot be re-used are disposed off to landfill site.

C&D WASTE FACILITY AT BURARI, DELHI

About the Project

As an initiative towards better management of C&D Waste in Delhi, a project has been set up by North DMC at Burari near Jahangipuri in the year 2009 for the collection and recycling the Construction and Demolition waste (C&D) and the same is in operation. This project was developed by IL&FS Environmental Infrastructure and Services Ltd (IEISL) with the collaboration of erstwhile MCD (now North DMC) as a pilot project. The project has been set up on a Public Private Partnership basis on approximately 7 acres of land provided by the MCD for a period of 10 years under concession agreement with IEISL. This is the country's first C&D waste recycling facility.

Till now, the facility has processed over 21.70 lakh tons of C&D waste since its inception in 2009, which would otherwise have been dumped illegally in the river Yamuna and other environmentally sensitive areas.

Highlights of the Project

- A unique large scale operating C&D recycling facility in the Country Compliant with MSW,

2000 Rules

- Engineered to process mixed Indian C&D waste
- Reduces usage of natural resources and enhances conservation
- Reduces sand mining from river banks
- Uses recycled sewage water at the facility and washing water is recycled, only 8-12% makeup water required
- Reduces burden on the landfill sites, saving precious urban land
- Reduces air pollution
- Able to recycle/recover about 98% of incoming waste
- A replicable Public Private Partnership model

Designated Dumping Locations for C&D Waste

In an attempt to streamline the disposal of C&D waste by general public the dumping sites have been identified by North Delhi Municipal Corporation in various zones as mentioned in Table 1.

Table 1: Location of Dumping Sites

S.No.	Zone	Location
1	CLZ	Azadpur
2		Inderpuri
3		Vidhan Sabha
4		Raj Pura Vidha
5		MCD Technical Lab
6		Civil Line
7		Old Hindu College
8		RTB Hospital
9	KBZ	NDPL
10		Loha Mandir
11		Ambdekar Gate
12		Moti Nagar Store
13		Pandav Nagar Store
14		East Patel Nagar Store
15		Naraina Vihar
16		Rajender nagar
17		Sindhi Park
18		Ramesh Nagar
19	SPZ	Azad Market Store
20		Old Rohtak Road
21		St. Staphan Rani Jhansi Road
22		Idgah Road
23		Pancuhkuiya Crossing
24		Sidi Pura
25		Qutub Road
26		Padam Road
27	Rohini	RUB Rampura

The C&D waste is transported through tippers from these sites to the recycling facility by IEISL normally in night hours. Many other agencies like DMRC, PWD, DDA etc. also dump the C&D waste at the facility.

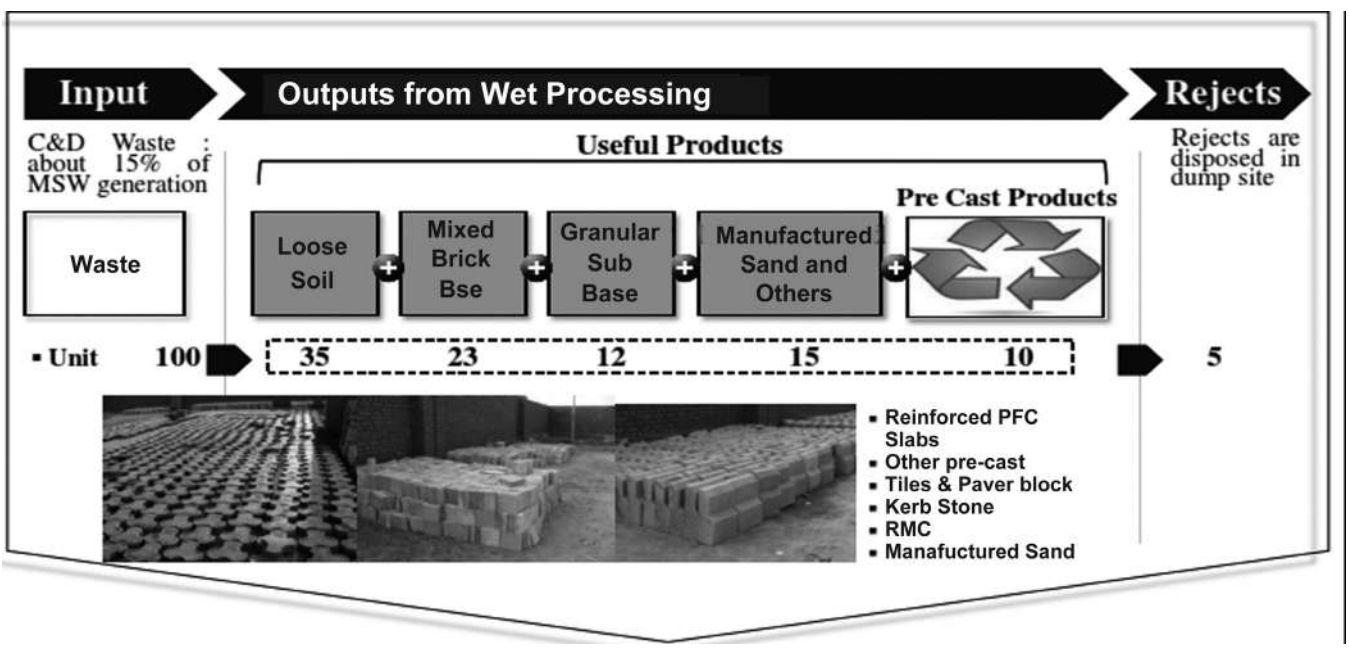
An Overview of Facility

The C&D waste recycling facility houses various equipments for processing the C&D waste such as crushers, screens, washing chambers etc. Fig. 2. The equipments for manufacturing of concrete blocks, cc pavers, kerb stones etc. are also installed in the facility. The operation of the plant is done round the clock in three shifts. The arrangements have been made to reduce the levels of PM 2.5 and PM 10 particulate matter by providing adequate sprinkler so as to protect surroundings from spreading pollution. The types and sources of C&D waste are given in Table 2. The useful materials obtained from C&D waste are given in Fig. 3.

Fig. 2: Equipments installed at C&D Waste Facility at Burari

Table 2 : Types & Sources of C&D Waste Collected at C&D Waste Facility

	Construction and Demolition Waste			
Waste Type	**Excavation Soil**	**Road work Waste**	**Demolition Waste**	**Complex Waste**
Resources	Excavation Activity	Road, Rail Network, Airport, Runway, Construction, Renovation, Demolition Activity	Building Demolition Activities; such as Residential, School, Hospital, Industrial Buildings	Construction, Excavation, Renovation, Refurbishment, Demolition, Roadwork and other Construction Related Activities
Components	Vegetable Soil, Soil, Sand, Gravel, Rock, Clay	Concrete, Broken Asphalt, Paving Stone, Sand, Pebble, Railway Traverse and Ballast	Concrete with Iron Concrete without iron Roofing Construction and Roofing Cover (Wood tile, isolation material), Wall materials (Bricks, Briquet, Stone) Stucco, Gypsum and other Materials	Concrete, Wall materials (Bricks, Briquet, Stone) Stucco, Sand, Pebble, Wood, Plastics, Ceramics, Metals, Paper and Carton



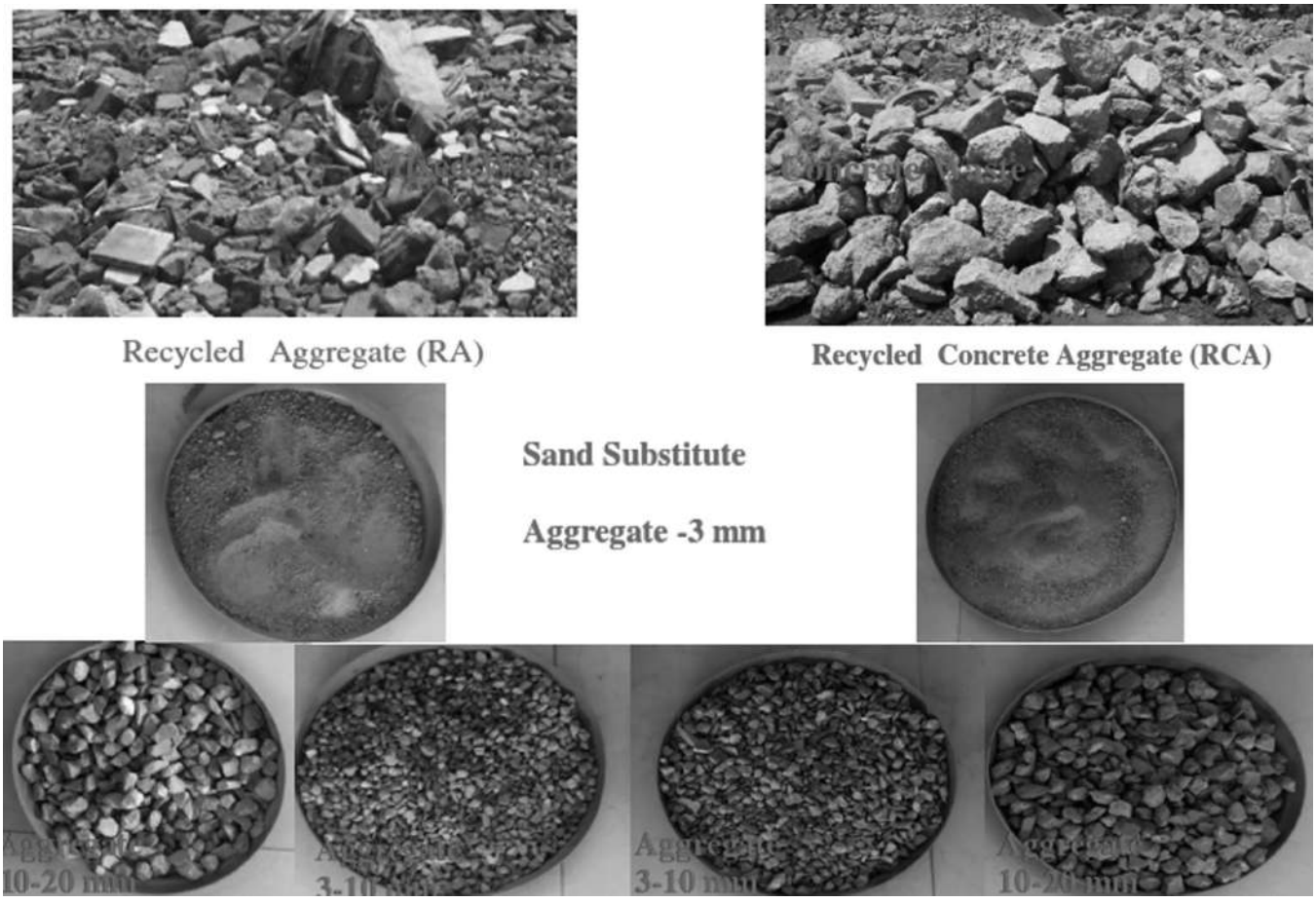


Fig.3: Material recovered from C&D Waste

UTILIZATION OF RECYCLED PRODUCTS

The output material received from C&D waste processing can be utilized in variety of engineering projects. The recycled products are also used for manufacturing of concrete blocks, cc pavers, kerb stones, precast slabs etc. Some potential use of recycled products of C&D waste are briefed herein under.

Use of C&D Waste in Embankment

The C&D Waste has potential for use as embankment fill material. As per MORTH specifications, the fill material for embankment shall have Plasticity Index (PL) value less than 45 and dry density shall not be less than 15.4 kN/m3 for use in embankment and it should not be less than 17.5 kN/m3 for use as subgrade soil. Powdered C&D waste fulfils these criteria and can be used either as embankment fill material of for subgrade construction. The MORTH specifies that the size of the coarse material in the fill shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the subgrade.

Use of C&D Waste in Base Course

Chemically stabilized waste material is used in base course. For this, powdered C&D waste can be stabilized using cement and lime.

Use of C&D Waste in Bituminous Layer

Aggregates like crushed stone and stone dust constitute about 94 per cent by weight of bituminous mix. The performance of the bituminous mix is governed by aggregate quality, i.e., mineral composition, surface texture and chemistry, amount and type of deleterious matter, size and shape of particles, durability characteristics, etc and gradation of aggregate. The properties such as water absorption and AIV of aggregates reclaimed from C&D waste are higher than the specified limits for its use in bituminous

layers due to the presence of brickbats, mortar pieces as well as tile particles. In case C&D wastes are used in top layers of the bituminous pavement (bituminous wearing course) failure may occur due to stripping because of high water absorption. Hence use of C&D aggregates in bituminous wearing courses like bituminous concrete, PMC, MSS or even in DBM is not advisable. However, these aggregates can be used in bituminous base course like bituminous macadam (BM) depending upon the feasibility.

Use of C&D Waste in Concrete Pavement

Concrete basically is a mix of two components – aggregates and binder of cement water paste. Aggregates to be used for making concrete should have adequate strength and resistance to exposure conditions and should not contain materials that will chemically react with the pate leading to deterioration of concrete. Aggregate which make up about 60 to 75 per cent of the total volume of concrete, are generally divided into two groups- fine and coarse. Studies show that C&D waste can be used in pavement quality concrete (PQC) as well as in dry lean concrete (DLC) mixes as a partial replacement of coarse aggregates.

BENEFITS OF C&D WASTE RECYCLING FACILITY

Apart from mounting problems of waste management, other reasons which support adoption of reuse/ recycling strategy are - reduced extraction of raw materials, reduced transportation cost, improved profits and reduced environmental impact. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/ re-use technology, in order to be able to conserve the conventional natural aggregate for other important works.

Besides the numerous economic benefits of C&D recycling such as increased landfill space, sound reuse of valuable commodities, and good resource stewardship, this effort will produce a number of ancillary environmental benefits.

By promoting the recycling and reuse of C&D materials, there will be decrease in the amount of emissions from trucks currently used to bring fill material to project sites, and transporting waste to the landfills, thereby decreasing "greenhouse gases" in the ambient air. Similarly, the more products produced from C&D materials, the less has to be buried in landfills. It increases the useful lives of our dwindling landfill space and also decreases air emissions from trucks being sent to these landfills.

Any time generated onsite materials are used, there is decrease in transportation costs which lead to save money on account of fuel bill. This cost saving can be passed on to the client and from there, through the entire economy. Monies made by demolition contractors through C&D recycling offset project costs just like salvage and scrap revenue. These savings can be passed on to the client and improve their overall bottomline.

Social Benefits

- A scientifically managed facility
- Employment opportunities to the nearby people of North Delhi
- A paradigm shift from illegal dumping to scientifically processing and recycling of Construction and Demolition
- Safe disposal of Construction and Demolition waste
- Saving of precious urban land where the waste would have been dumped
- Reduces the burden on the landfill sites in and around the city

Environmental Benefits

- Reduced use of natural resources will increase their life cycle and conservation
- Zero waste discharge facility
- The sand recovered (from the wet processing of C&D waste) will also reduce sand mining from the river banks
- Reduced level of PM 2.5 and PM 10 particulate matters
- A long term sustainable solution

For the sustainability of the project, it is very important to maintain a balance between economic, social and environmental issue. Sustainability is at the nexus of socio cultural, environmental, and economic factors.

CONCLUSION

Construction waste is bulky, heavy and is mostly unsuitable for disposal by incineration or composting. The growing population in the country and requirement of land for other uses has reduced the availability of land for waste disposal. Re-utilization or recycling is an important strategy for management of such waste. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/ re-use technology in order to be able to conserve the conventional natural aggregate for other important works. Apart from mounting problems of waste management, other reasons which support adoption of reuse/ recycling strategy are reduced extraction of raw materials, reduced transportation cost, reduced capital investment on raw materials, improved profits and reduced environmental impact. It is therefore necessary to install C&D recycling facilities in each city/area where such waste is being generated.

MINIMISATION AND MITIGATION OF CONSTRUCTION WASTE : A CONSTRUCTION MANAGEMENT APPROACH

LT. COL. HARSH RAGHUVANSHI* AND DR. K.N. JHA**

Abstract

Construction Industry is a potent indicator of a nation's progress. Research indicates that in the past half a century the construction alone has accounted for about 40 percent of development investment. However, construction industry is also responsible for generation of a large amount of construction related waste.

Present paper discusses the waste control, mitigation and minimisation techniques and methods using construction management philosophies, tools and techniques.

INTRODUCTION

Construction Industry is a major stakeholder of a nation's journey to development. Other than contributing to the economic growth to a nation, this is the single industry whose efforts are seen on the ground and remain testimony to the human civilisation. While the construction industry is responsible for creation of all kinds of infrastructure, the processes involved produce a quantifiable waste product whose disposal becomes a necessity. With the increase in construction activities to ensure the development saga of India, it becomes even more necessary to carry out the waste mitigation audit of construction industry. There have been a lot of talks in the recent past on development of environmental friendly and waste reducing technologies. However, success of any technology is a direct function of effective implementation and utilisation of the same by the professionals involved. In other words, technology management is as important as the technology itself. Present paper looks at the construction management approaches for effective mitigation and minimisation of construction wastes.

INDIAN CONSTRUCTION INDUSTRY LANDSCAPE

As per National Skills Development Corporation (NSDC) report on Building, Construction and Real Estate Services Sector 2022 (Fig 1), Indian construction sector can be broadly classified into 2 sub-segments:-

- Real estate (residential, commercial/corporate, industrial and special economic zones (SEZs)).
- Infrastructure (transportation, urban development, utilities)

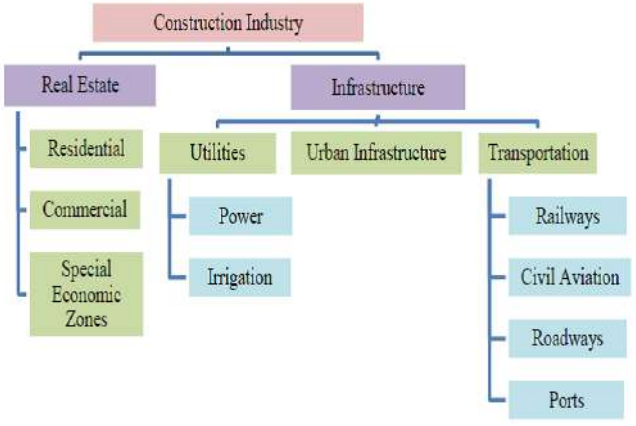


Fig. 1: Indian Construction Industry Landscape

(Source: ICRA Management Consulting Services Limited (IMaCS) analysis, hired by NSDC)

Obviously, construction industry of India is an important indicator of India's growth potential.

** So1 (Design), HQ Chief Engineer Shillong Zone (MES), Shillong ** Associate Professor, Department of Civil Engineering, Indian Institute of Technology, Hauz Khas, New Delhi*

A record analysis of last half a century shows that construction alone has accounted for about 40 percent of the development investment. The Indian construction industry comprises of about 200 firms in the corporate sector. In addition to these firms, there are about 120,000 class 'A' contractors registered with various government construction bodies. There are several thousands of small contractors, which compete for small jobs or work as sub-contractors of prime contractors.

As per a report by Centre for Science and Environment (CSE) construction Industry in India is already at about 10 per cent of the GDP and it has been growing at an annual rate of 10 per cent over the last 10 years as against the world average of 5.5 per cent per annum. Almost 70 per cent of the building stock in India is yet to come up. The built-up area is expected to swell almost five times from 21 billion sqft in 2005 to approximately 104 billion sqft by 2030.

CLASSIFICATION OF CONSTRUCTION WASTES

Construction processes leave two kinds of wastes; (1) Tangible wastes, (2) Intangible wastes. Tangible Wastes are the ones who are immediately noticed like scrap, site waste, unused material, debris from demolition, wasted shuttering and formwork items, undisposed earth etc. Intangible wastes include those wastes whose effects are not directly seen with naked eyes but whose effects are manifested over the overall efficiency of the construction processes. This may include wastage of menpower, wastage of employee potential, wastage of inventory, wastage of machinery, wastage of natural resources, waste due to unnecessary processes, waste of capital and time over runs. For the purpose of discussion we will restrict the scope of this paper mainly to tangible wastes and only waste of natural resources out of intangible wastes.

CONSTRUCTION MANAGEMENT APPROACHES TO DEAL WITH WASTE

Recent decades have seen considerable growth in intellectual knowledge bank of construction industry. Certain recent thinking has resulted in the emergence of new philosophies of 'Lean Construction'and 'Green Building Concept'.

Lauri Koskela did his path breaking work on Lean Construction in 1992. He suggested that construction management is not founded on sound theoretical foundation and that ideas from general management have been adopted in the field of construction management without actually identifying their correct applicability to the later. He suggested that the existing system of time- cost- quality tradeoff was inadequate to address all the needs of a complex construction management process. Inspired by Lean developments in other industries, Koskela came out with a theory of production management and applied it successfully to the field of construction, treating construction as a temporary production system. This theoretical foundation for construction management was termed as Lean Construction (Koskela 1992,2000). One of the major focus of Lean Construction is to reduce, mitigate or eliminate construction wastes.

Green Building on the other hand is a derivative of sustainable development approach which calls for "meeting the needs of present generations without compromising the ability of future generations to meet their needs", as defined in Brundtland report (1987). Therefore Green Building refers to a structure and using processes that are environmentally responsible and resource- efficient throughout a building's life-cycle(Yan Ji and Stellios Plainiotis, 2006). Green Building Approach focuses on reducing, mitigating or eliminating all sorts of construction wastes responsible for earth's environment degradation.In addition Green is a part of policy framework in a number of countries and hence almost mandatory to adhere to during construction.

Subsequent paragraphs will discuss the tools and philosophies associated with both these construction management systems.

LEAN CONSTRUCTION TOOLS FOR CONSTRUCTION WASTE MANAGEMENT

Lean Construction employs a number of tools and techniques to unearth, identify and mitigate the wastes of construction industry. However, since the focus of this paper is only on the tangible wastes described earlier, we will talk about only those tools and methods which directly deal with the tangible wastes.

Value Stream Mapping

Value Stream Mapping is a primary tool used in Lean Construction. Its job is to map the entire process leading to a particular activity till its completion. It could be say foundation work of a building. Value Stream Mapping will record all the steps in the process and divide them into following category:-

- Value adding and necessary
- Non- value adding but necessary
- Non- value adding and not necessary

The third category is the one which is of interest here, since it will lead to defects and inconsistencies in the processes which will ultimately lead to repairs and re- works and thus generating material waste.

The 5S Tool

5S is an important tool of Lean Construction. The 5S refers to the following:-

- Seiri (sort, classify,clear what is needed)
- Seiton (straighten, simplify, set in order, configure)
- Seiso (shine,improve and check the process)
- Seiketsu (standardize and stabilize the process)
- Shitsuke (sustain the improvements)

Evidently 5S (Fig.2) gives the complete way of 'How to Start' to 'How to Efficiently Finish' a process. It seeks to standardise the tested processes and practice them so that defects do not re-occur.

Fig. 2: 5S Technique

(Image source : <https://upload.wikimedia.org/wikipedia/commons/e/e5/5S_methodology.png>)

Jidoka

Jidoka refers to 'Build in Quality' in the processes so that the end product does not have to go through repairs or change. It has two primary components:-

- Building in quality at the process.
- Enabling separation of men from machine in work environments.

Lean construction aspires for processes that are capable of making intelligent decisions and shutting down automatically at the first sign of anabnormal condition such as a defect, or any other problem. The goal is not to run continuously but to stop running automatically when trouble arises.The 'automatic stop function' helps in achieving the following:-

- It helps in stopping defects from escaping downstream.
- It prevents injury.
- It limits machine damage.
- It enables a better look at the current condition whenever there is a problem.

Inventory Management

Inventory Management is an important aspect of Lean Construction. Lean Philosophy believes in maintaining the minimum possible inventory. It helps in two ways :-

- It mitigates the possibility of construction material becoming unserviceable in the storage due to the constraints of shelf life, weather effects like rains and environmental effects like dampness, rusting, setting of cement in storage etc.
- It unearths inconsistencies in the processes, otherwise there is a tendency to quickly repair the defect with extra available inventory thereby reducing chances of root cause analysis of defects

Reducing/ Eliminating Rework

Rework accounts for a considerable chunk of Construction Site Wastes. If work is done correct the very first time, it will negate the possibility of re- doing

it. This can be achieved by the following:-

- Value stream mapping
- Use of 5S tool
- Use of Jidoka

Managing/ Reducing Variability

Lean Construction aims at reducing the variability in construction processes and thereby ensuring that defective construction does not take place. In construction works, at site conditions, standardisation is difficult and hence aim is to reduce and manage the variabilty at the minimum possible level.

Reducing Movement of Man/ Machines

Excessive movement causes confusion, inconsistencies in the construction processes, increased chances of accidents, wastage of materials due to multiple handling and chances of breakages. Lean Construction aims to minimise the movement by proper planning and layout.

Work Space Optimisation

Work Space Optimisation aims at achieving efficiency in layout of materials , machines and construction space. There are many systems and algorithms for Work Space Optimisation which forms a separate specialisation and hence detailed discussion on this is kept out of the scope of this paper. Work Space Optimisation reduces wastes at construction sites and paves way for better disposal of construction wastes, thereby keeping clean and uncluttered Work Space.

Last Planar System of Lean Construction

Last Planar System (Fig.3) was developed by Dr Glen Ballard to increase plan reliabilty in construction processes. Ballard achived the plan reliability of more than 80% by use of this method which implies that more than 80% of the planned work was completed in a typical construction process. Last Planner System is a holistic approach for increasing productivity, managing variabilty, standardising processes in construction and avoiding wastes of materials.

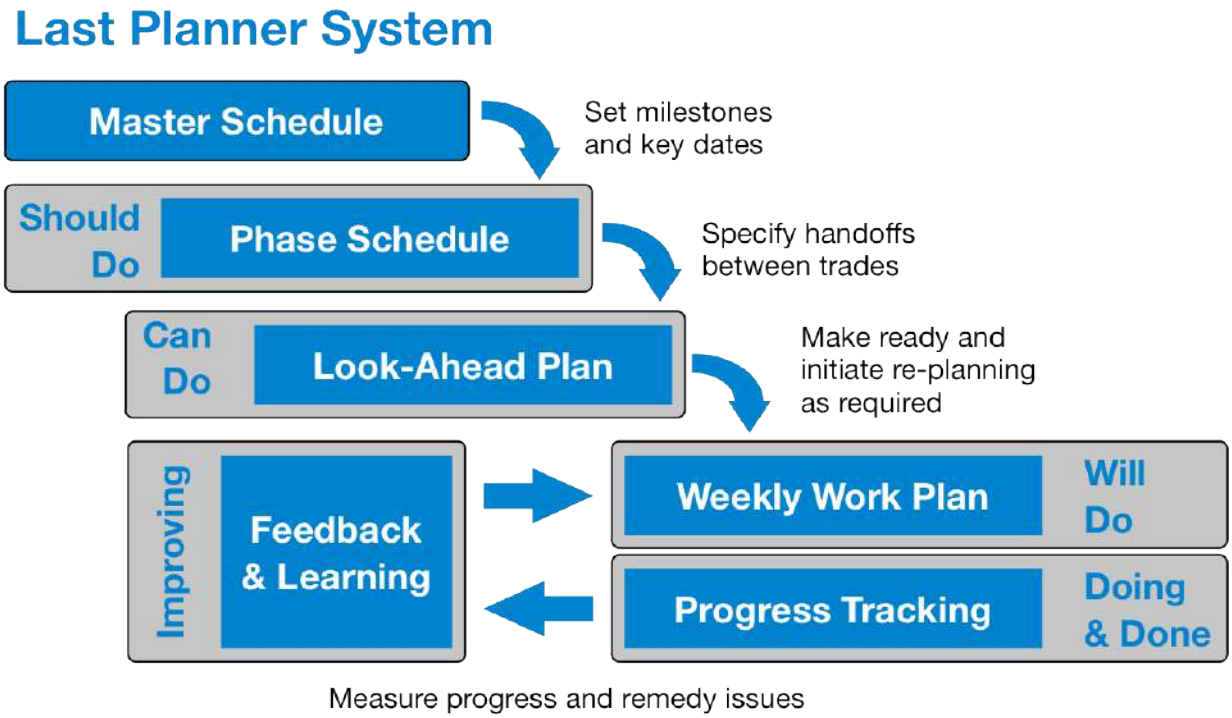


Fig. 3: Last Planar System

(Image source : <http://ennova.com.au/assets/posts/last_planner.png>)

GREEN BUILDING TOOLS FOR CONSTRUCTION WASTE MANAGEMENT

Green Building concept aims at reducing environmental wates from construction processes. Over the time a lot of work has been done to refine the concept of Green Building. A number of countries have their own norms to achieve environmental friendly construction processes and materials. India has her own GRIHA norms to promote civil construction in harmony of nature. We shall discuss in brief the more relevant tools and methods for Green Building here. From construction management perspective following methodologies are suggested to achieve environmental friendly construction :-

Environmental Impact Assessment

The purpose of environmental impact assessment (EIA) is to "protect the environment and quality of life of the people of the province; and facilitate the wise management of the natural resources of the province". It requires anyone who plans a project that could have a significant effect on the natural, social or economic environment to present the project for examination.

The environmental assessment process (Fig.4) ensures that projects proceed in an environmentally acceptable manner. When the potential environmental effects of projects are of concern, the process generates real benefits by: (i) providing for comprehensive project planning and design, (ii) maximizing environmental protection, (iii) enhancing government coordination, accountability and information exchange, and (iv) facilitating permitting and regulatory approval of projects.

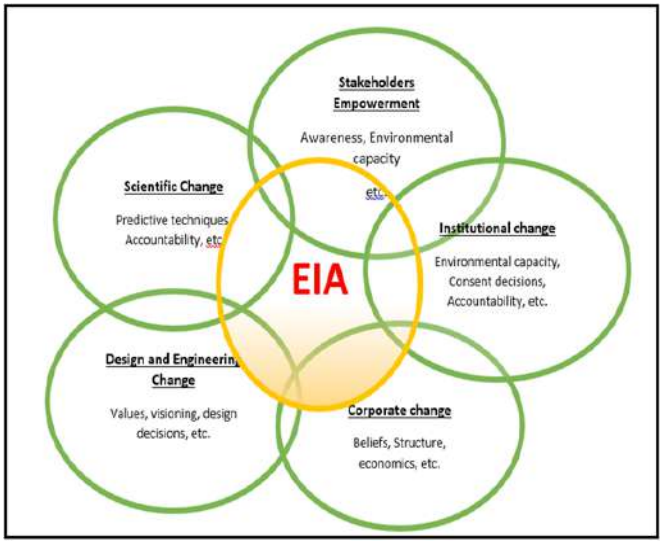


Fig. 4: Environmental Assessment System

(Image source : < http://www.civilserviceindia.com/subject/General-Studies/notes/images/Environmental-Impact-Assessment.png>)

The Ministry of Environment, Forests and Climate Change (MoEFCC) of India lays down laws, regulatory framework and guidelines for Environmental Impact Assessment in India.The main laws concerning civil construction are the Water Act(1974), the Air (Prevention and Control of Pollution) Act (1981), Environment (Protection) Act (1986), and the Biological Diversity Act(2002). The responsible body for this is the Central Pollution Control Board.

Environmental Impact Assessment (EIA) studies need a significant amount of primary and secondary environmental data. Primary data are those collected in the field to define the status of the environment (like air quality data, water quality data etc.). Secondary data are those collected over the years that can be used to understand the existing environmental scenario of the study area.

The Environmental Information Centre (EIC) has been set up to serve as a professionally managed clearing house of environmental information that can be used by MoEF, project proponents, consultants, NGOs and other stakeholders involved in the process of environmental impact assessment in India. EIC caters to the need of creating and disseminating of organized environmental data for various developmental initiatives all over the country.

EIC stores data in GIS format and makes it available to all environmental impact assessment studies and to EIA stakeholders in a cost effective and timely manner. So that we can manage that in different proportions such as remedial measures etc.

Environmental Management System

Environmental Management System (EMS), has been described in the specification prepared by the International Organization for Standardization (ISO 14001), within construction organizations, and for

each project, during construction, facility operation and even during decommissioning (Fig.5).

Fig. 5: Environment Management System

(Image source : < http://www.civilserviceindia.com/subject/General-Studies/notes/images/Environmental-Impact-Assessment.png>)

The goals of EMS are to increase compliance and reduce waste, according to which:-

- Compliance is the act of reaching and maintaining minimal legal standards. By not being compliant, companies may face fines, government intervention or may not be able to operate.
- Waste reduction goes beyond compliance to reduce environmental impact. The EMS helps to develop, implement, manage, coordinate and monitor environmental policies. Waste reduction begins at the design phase through pollution prevention and waste minimization. At the end of the life cycle, waste is reduced by recycling.

ENVIRONMENTALLY EFFICIENT AND WASTE REDUCING TECHNOLOGIES

Research in construction field has come out with a number of construction waste reducing technologies. A good management always tries the successful new technologies to cut out construction waste, improve environmental compliance and increased profitability in the long run. Some of these technologies have been briefly discussed here.

Steel Concrete Composite Structures

Steel Concrete Composite Structure systems do away with a separate requirement of shuttering/ scaffolding. Here concrete filled tubes (CFTs) provide as integral part of the columns and beams system. Slabs are casted as steel- concrete sandwich panel. As a result, there are hardly any site wastes as all the construction material used forms a part of the structural system. Walls are made of non- load bearing claddings. As a result construction is very fast, shuutering material is not required and there are savings in the cost. Eurocode 4 and ACI 318-5 are some of the codes laying down construction procedures of these structures.

Myvan Technology

MYVAN Technology uses pre-designed aluminium alloy formwork system which can be used repeatedly over 100s of times thus avoiding the waste occuring due to conventional shuttering options. As a result the construction is very fast, work space is well organised and un –cluttered as well as there are overall savings in cost. MYVAN technology converts the construction work space into a temporary production system and hence supporting the tenets of Lean Construction Philosophy

Pre cast Construction Technology

Pre- cast construction technology allows the concrete structural members to be prepared in the controlled environments at factory setting and later assembling them at the site of construction. As is apparent, this technology also allows avoidance of waste produced due to conventional shuttering material. In addition the work space is better organised and uncluttered. In this method too the construction work space is converted into a temporary production system and hence it also supports the Lean Construction Philosophy.

PEBs

Pre Engineered Buildings use steel structural members and hence avoiding any need of formwork. Members are pre designed and assembled at site

using welding/ rivetting techniques. As a result the work space is better organised and uncluttered. Here also the work site is typically organised as per temporary production system and hence this system too supports Lean Construction Philosophy.

CONCLUSIONS

Construction waste pose a great challenge for construction professionals. It not only cuts on profits, but also presents challenges for finding suitable dumping areas, facing compliance related issues and getting negative public attention. While there have been considerable work in the area of suggesting waste reducing technologies, the main challenge remains to tackle the construction waste at the management level and come out with practices, training procedures and company managemnt policies to effectively implement the waste reduction techniques. Present paper gives an overview of contemporary construction management philosophies, methods and tools to specifically tackle the construction wastes. If we implement the suggested philosophies, tools and methodologies, it is likely to positively increase the waste reduction capability of a construction organisation as well as help them in achieving various govt compliances, better public and customer satisfaction and increased profitability in the long run.

REFERENCES

1. Ballard, H.G. (2000). "The Last Planar System of Production Control". Ph.D. Dissertation, School of Civil Engineering, Faculty of Engineering, University of Birmingham.
2. Brzev, S., Guevara-Perez, T., "Precast Concrete Construction", <http://www.world-housing.net/wp-content/uploads/2011/08/Type_Precast.pdf> Accessed 12 Aug 2016, 10:45 AM.
3. Environmental Management System- Wikipedia, the free encyclopedia <https://en.wikipedia.org/wiki/Environmental_management_system>,accessed 11 Aug 2016, 11:10 PM.
4. Environmental Impact Assessment- Wikipedia, the free encyclopedia <https://en.wikipedia.org/wiki/Environmental_impact_assessment>, accessed 11 Aug 2016, 9:56 PM.
5. Environment Assessment, Department of Environment and Conservation, Newfoundland, Labrador, Canada<http://www.env.gov.nl.ca/env/env_assessment/>accessed 11 Aug 2016, 9:36 PM.
6. Ghosh Shibani, "Demystifying the Environmental Clearance Process in India", NUJS LAW REVIEW, January 2, 2015.
7. Koskela, L. (2000). "An Exploration towards a Production Theory and its Application to Construction" Ph.D. dissertation. Finland: VTT Technical Research Centre of Finland.
8. Lean Construction- Wikipedia, the free encyclopedia <http://en.wikipedia.org/wiki/Lean_construction >, accessed 27/08/2014, 10:58 AM.
9. Lean Manufacturing Tools- what-is-5s-seiri-seiton-seiso-seiketsu-shitsuke <http://leanmanufacturingtools.org/192/what-is-5s-seiri-seiton-seiso-seiketsu-shitsuke> Accessed 11 Aug 2016, 9:25 PM.
10. MIVAN_An Aluminum Formwork Construction Technique<http://www.slideshare.net/sandeepnj7/mivan-an-aluminum-formwork-construction-technique>, accessed, 12 Aug 2016, 10:38 AM.
11. Pre Engineered Buildings - Wikipedia, the free encyclopedia<https://en.wikipedia.org/wiki/Pre-engineered_building>,accessed 12 Aug 2016,10:55 AM.
12. Sroufe, Robert. (2003) "Effects of Environmental Management Systems on Environmental Management Practices and Operations." Production and Operations Management. 12-3 (2003): 416-431.
13. Sayre, D. (1996). Inside ISO 14001: the competitive advantage of environmental management. St. Lucie Press, Delray,Beach, FL.

WASTE-TO-ENERGY FROM VEGETABLE MARKET WASTE – A REVIEW

J. VENGADESAN* AND AKHILESH KUMAR SINGH**

Abstract

Urban cities in India generates around 3,00,000 MT of waste per day. Major cosmopolitan cities such as Mumbai generates about 9000MT of waste per day, Delhi generates about 8360MT, other large cities like Chennai and Kolkata generate waste in the range between 3000 – 5000MT per day. It is also evident that all large to medium sized cities in India have large vegetable/ meat markets which generate a huge amount of organic waste every day. Decentralized treatment of this waste will help cities reduce the burden on their landfill sites and also contribute to energy generation.

One of feasible way to convert the organic waste into energy is installation of Biomethanation plants. One of Biomethanation plant has been installed in one of India's largest wholesale vegetable market at Koyambedu, Chennai. Detailed investigation was made regarding the methods of practices associated with sources, quantity generated, collection, storage, and process. The concerning data was obtained through questionnaire, individual field visit, interacting with people and authentic record of Chennai Metropolitan Development Authority.

INTRODUCTION

Chennai, the capital city of Tamil Nadu is the fourth largest metropolitan city in India and is a prominent industrial and commercial centre in South India. As per the Census of India (2011), the current population of Chennai city is close to 46 Lakh, however the city has a much larger urban agglomeration. The Chennai Metropolitan Area (CMA) comprises the city of Chennai, 16 Municipalities, 20 Town Panchayats and 214 Village Panchayats in 10 Panchayat Unions, and is spread over an area of 1189 sq km. The population of the Chennai Metropolitan Area is above 86 Lakh.

Structure of City Governance

The Corporation of Chennai (CoC) is the civic body that governs the city of Chennai. The governing body includes the Mayor and over 200 councilors each of whom represents one of the 200 wards of the city. The executive wing is headed by the Commissioner. There are Deputy Commissioners and heads of departments who are in charge of various municipal services and infrastructure provision. The CoC has a decentralized structure of governance in line with the 74th Amendment Act. There are 15 Zonal Officers each responsible for administering one of the 15 zones in the city. In addition to CoC, there are several other state-level statutory bodies involved in planning, development and management functions in the Chennai Metropolitan Area, the chief being the Chennai Metropolitan Development Authority (CMDA).

CMDA was constituted as an ad-hoc body in 1972 and became a statutory body in 1974 vide the Tamil Nadu Town and Country Planning Act of 1971. The primary function of CMDA is to prepare the land use plan for the Chennai Metropolitan Planning Area and provide infrastructure and services. Some key projects in Chennai undertaken by the CMDA include the construction of the Chennai Mofussil bus

**Engineering Manager, Larsen & Toubro Construction Limited, Chennai* ***Asst Engg Manager (Mechanical) Larsen & Toubro Construction Limited, Chennai

terminus, a wholesale vegetable market at Koyambedu and Chennai Mass Rapid Transit System.

The Koyambedu wholesale market complex was conceived and implemented by the Chennai Metropolitan Development Authority (CMDA) to decongest the central business district of Chennai city and to facilitate trading of perishable items like vegetables, fruits and flowers. The market is spread over nearly 290 acres, and has about 3,200 shops. The Koyambedu Wholesale Market Complex is maintained by the Market Management Committee (MMC) constituted as per the Tamil Nadu Specified Commodities (Regulation of location) Act 1996 so as to give necessary legal protection to the administration of Koyambedu Wholesale Market Complex.

The Market Management Committee is an autonomous functioning body that oversees the functions of the Market. The main functions of MMC include administration, management, and maintenance, security of the market complex as well as operation and maintenance of the biomethanation plant. The Market Management Committee has a total of 18 members with the Member Secretary of CMDA as the Committee Chairman. Non official members on the Committee include trader representatives.

Management of waste generation at Koyambedu Wholesale Market

The market complex is visited by about one lakh people daily and receives 700 trucks every day. The market generates annual revenue of Rs.4 Crore through collection of entry fee. This market complex being one of the largest in Asia generates large quantity of organic wastes. About 150 MT of waste is generated every day. Prior to the installation of the biomethanation plant, the waste was collected and transported by a private agency and transferred to a transfer station within the market complex. From there, it was transported to the Perungudi dumpsite by the Corporation of Chennai.

However such large amounts of perishable organic waste dumped at the dumpsite emitted obnoxious odours and gases like methane and carbon dioxide. This posed a potential threat to the environment and to the health of the people living around the dumpsite. The MMC and CMDA actively considered installing a decentralized waste processing plant at the market to manage the organic waste more efficiently and sustainably.

Implementation of the biomethanation plant at the market

In 2005, the CMDA approached the Ministry of Non-conventional Energy Sources, (now Ministry of New and Renewable Energy (MNRE)), Government of India to support a biomethanation plant at the Koyambedu Market under the Ministry's waste-to-energy program. The MNRE agreed to support 75% of the cost of the plant under the United Nations Development Program (UNDP)- Global Environmental Fund (GEF) Program. The MNES appointed the Central Leather Research Institute, (CLRI) as the technical agency to identify the technology most suitable for implementing a viable biomethanation plant for generating energy and manure from vegetable wastes at the site. A biomethanation plant with a capacity of 30 MT per day was proposed under the Waste-to-Energy program at Koyambedu. The plant was designed based on a unique technology patented by CLRI in which the Biogas Induced Mixing Arrangement digester has a unique mixing part which does not require mechanical moving parts and has the ability to control scum/sediments while handling high solids concentration. A financial support of Rs. 5.5 crore was provided to CMDA by UNDP/GEF through MNRE to implement the pilot project. Prime objectives of the project were-

- To evaluate the feasibility of biomethanation of vegetable, fruit and flower waste for energy generation and manure production.

Biomethanation plant at Koyambedu market

- Strengthening institutional capabilities in developing indigenous technology.
- Absorption of process technology for improvisation, scale-up and widening the scope for implementation of biomethanation technology for management of same or similar type of solid wastes.
- Capacity building in development of technology package, transfer of technology, project management & implementation.

The biomethanation plant was established in 2006 in the Koyambedu Wholesale Market as a unique national level demonstration project in order to utilize the organic waste generated from the market for power generation. The waste generated from the market was characterized to reveal that that the major components of waste included vegetable wastes (21%), fruit wastes (15%), flower wastes (10%), banana stem and related materials (38%) and packing materials (hay, straw, paper, etc. 16%).

Non-organic waste such as stones, plastics, wood etc. was limited to less than 1% of the waste quantity. There were also seasonal variations in the quantity and nature of waste generated daily from the market. The total solids and volatile solids content were 25% and 73.7% respectively. The moisture content was 75%.

View of Koyambedu Market

Logistics and operation Requirements

The vegetable and fruit waste is disposed by the shopkeepers in the open ground near their shops. A private contractor collects all the waste from the market complex. About 30 MT is separated and transferred to the receiving platform at the biomethanation unit. The remaining waste is transported to the landfill site by the contractor.

The waste is lifted by grab from the receiving platform and transferred into the hopper provided in the belt conveyor and is carried through the conveyor to the shredder to reduce the size of the waste to about 15-20 mm. The shredded waste is blended with water in a collection tank. The mixed waste is macerated and pumped into the digester by means of screw pump. Biogas Induced Mixing Arrangement digester has a unique mixing part which does not require mechanical moving parts and has the ability to control scum/ sediments while handling high solids concentration. The biogas generated, as a result of stabilization of the waste, leaves the digester to a dry type gas holder (530 m3) made of a synthetic membrane (polyester). An in-situ biological desulphurization unit has been installed in the digester to reduce the H2S concentration in the biogas below 500 ppm. A group of facultative bacteria which adhere to the walls of digester separating the upper and main chamber are utilized for biological desulphurization. The biogas, after removal of H2S, is used as fuel in the engine to produce electricity. The gas is drawn from gas holder by gas blowers and fed into the gas engine and alternator is connected to the engine to produce electricity.

The net power generated after in-house consumption is exported to Tamil Nadu Electricity Board grid. In the case of maintenance of gas engine and when gas generation exceeds beyond the storage capacity of the gas holder, the biogas is burnt in the flare. The dewatered cake is discharged at the other end of the press. The cake from screw press is converted in to manure by composting.

Notable Outcomes:

- The average biogas production from the Biomethanation plant at Koyambedu is 2500 m3 per day in which methane content is 65%.
- The power generation of plant is on an average 2600 KWH/ day which translates to about 500 units per day. The units are sold to the grid by CMDA. The revenue generated takes care of the operational expenses of the plant.
- This plant has reduced Green House Gas emission. The reduction accounts to be 8308

tons of CO2 equivalents per annum. The current price of emission reduction credits in existing markets is in the range of US $ 5 to 15 per ton of CO2 equivalents. Hence in the present project considering the minimum value of US $ 5 per t of CO2 equivalents, the revenue generated apart from energy generation accounts to be Rs 16,61,600/- per annum (considering 1 US $ = Rs 60/-) with considerable significance in Green House Gas (GHG) emission reduction.

- Of the 4500 MT municipal waste disposed at open dumping site everyday, 30 MT is diverted and used for producing energy.

Scope for Improvement:

The plant was inaugurated in 2006 and was operated by the MMC till 2008. The plant remained dysfunctional some time in between due to lack of easy availability of the machine parts. The parts were finally procured and the plant became operational till October 2011, but was again closed for the second time because of equipment malfunction. The plant started its operations again in May 2014. The Koyambedu plant was established at a huge cost using sophisticated and expensive technology but remained closed for some part since it was installed, and hence could not achieve the desired outcomes in terms of emission reduction. Proper operations and maintenance of such plants is critical for their success. Preparing and adopting standard operating procedures for the day-to-day operations and routine maintenance of the plant can help prevent the frequent malfunctioning of the equipment. All staff should be trained in operating the plant. In the long-term, development of local technology for biomethanation should be promoted and use of imported equipment should be limited. Make in india programme may help us to manufacture the required part and technology for us and thus will help us to run the plant and to maintain the plant as well.

The CMDA also faced challenges in managing contracts for transportation of waste from the market to the plant. The private contractor earlier responsible for transporting all the waste to the landfill was asked to divert 30MT to the processing plant. Since the contractor was being paid to transport the waste to the dump site on a per ton basis, it was not in his interest to divert part of the waste to the plant. It is important that such contractual agreements are worked out and finalized before implementing the project to avoid such situations.

Establishing a routine operations and maintenance procedure is critical to the long term sustainability of the plant. The operation of the plant is currently outsourced to a private contractor who has revamped the facility. The selling price of the electricity produced is Rs.5 per unit. This cost is sufficient to cover the operational cost of the plant if it runs efficiently. CLRI has submitted a proposal to MNRE to upgrade the plant and increase the capacity from 30 MT to 60 MT.

Conclusion:

Keeping the nation's vision of make in india programme and with the details available with us we can take it forward on implementing such plants in all medium to large sized cities in India which have large vegetable/meat markets which generate a huge amount of organic waste every day. we may plan for decentralized treatment of this waste which help the cities to reduce the burden on their landfill sites and also contribute to energy generation. Though the biomethanation of organic waste is a little expensive option for bio-energy generation in India, MNRE provides a capital subsidy to institutions interested in establishing such urban and waste-to-energy projects. A biomethanation plant was also piloted in Pune at the Gultekdi market where 1 MT waste was converted to biogas every day which was supplied to restaurants in the vicinity. The plant was later scaled to 10 MT per day.

References:

1. Census of India 2011.
2. Urban solid waste management in Indian cities by UMC
3. www.chennaicorporation.gov.in/departments/solid-waste
4. www.kmcgov.in/KMCPortal/jsp/SolidWaste
5. www.delhi.gov.in/EnvironmentalIssues/WasteManagement
6. www.mcgm.gov.in

PLANNING AND MANAGEMENT OF SOLID WASTE IN SMART HABITAT

Dr. Indrasen Singh*

Abstract

Any non liquid material that is thrown or discarded as useless and unwanted is considered to be solid waste. Solid waste is always generated in cities, towns and villages. At first glance, the disposal of solid waste may appear to be a simple and mundane problem. In this age of lasers, microcomputers, and space flight, it hardly seems possible that garbage disposal should present any great challenge. But many factors make solid waste disposal a complex problem of huge proportions for a modern smart habitat.

In smart habitat, it is best solved by adequately informing the public and involving them in decision making before final plans and designs are completed. Clearly, problems related to solid waste go beyond merely their proper disposal. In addition to many technical and environmental difficulties, administrative, economic and political problems must be solved. The effort to address all these problems is usually referred to as the practice of solid waste management. In this context, management encompasses the planning, design, financing, construction and operation of facilities for the collecting, transporting, processing, recycling and final disposal of the residual solid waste material. In smart habitat the disposal of solid waste should be part of an integrated waste management plan.

INTRODUCTION

The first municipal refuse incinerator was built in England around 1875. In the United States, several cities started incinerating solid wastes at the beginning the 20thcentury. Most of the largest cities though were still dumping solid waste on land or in water at that time.

Early incinerations caused noticeable air pollution. The sanitary landfill was developed as a relatively inexpensive alternative to refuse incineration, especially for cities or towns with ample land areas. It was an improvement over the city dump, but it soon became clear that unlined land-fills were not economically safe in the long run. Today, air pollution control devices are required on all incinerators, and for smart habitat sanitary landfills must be lined and have other environmental safe guards.

THERMAL ENERGY

Today, the disposal of solid waste should be part of an integrated waste management plan. This means that the methods of collection, processing, resources recovery, and final disposal should mesh with one another to achieve a common objective (Fig.1). Disposal of sewage sludge with refuse, for example could be one part of an integrated waste management plan.

Recycling (resource recovery and refuse) is playing an ever- increasing role in these plans, and recycling technology has evolved considerably since the 1970 and now, almost every smart habitat should have solid waste management plan and at least some recycling component. Despite these advances, there is still (and probably always will be) a need to dispose of some solid waste in the ground.

Solid waste comprises two types of materials! Refuse and trash. Refuse includes garbage and rubbish. Garbage contains putrescible or highly decomposable food waste, such as vegetable and meat scraps. Rubbish contains mostly dry non putrescible

**Senior Professor and Dean, National Institute of Construction Management and Research (NICMAR), Goa*

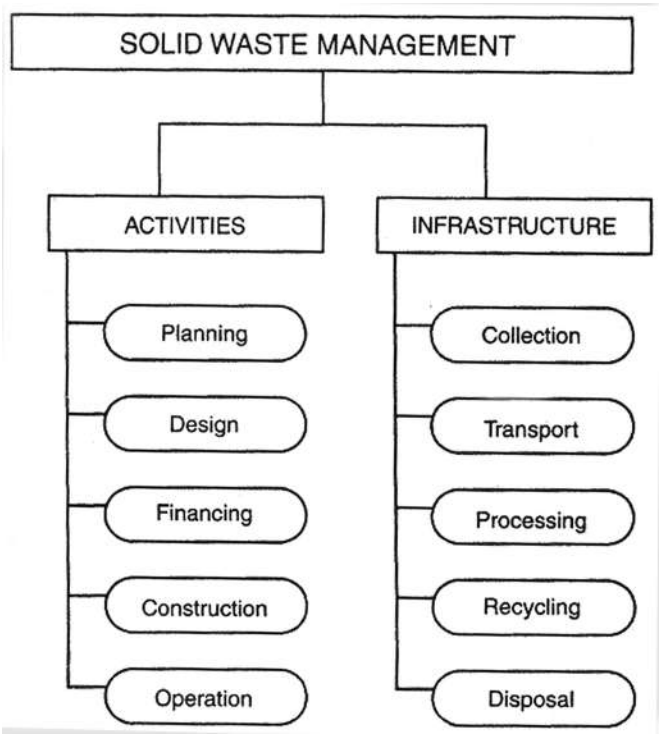


Fig. 1: Solid Waste Management Plan

material, such as glass, rubber, metal cans, and slowly decomposable or combustible material, such as paper, textiles, or wood objects. Actually, only about 10 percent of refuge is garbage, most of it is rubbish. Trash includes bulky waste materials that generally requires special handle and is therefore not collected on a routine basis.

QUANTITIES AND COMPONENTS

Information regarding the weight, volume, and composition of solid waste is necessary for the proper planning, design and operation of collection and disposal facilities. Although average data are available, it is usually necessary to make measurements and evaluate a community's solid waste in detail before preparing specific plans or final facility designs.

Solid waste management strategy U. S. Environmental protection agency (EPA) integrated waste management strategy includes three main components, listed in order of preference:

- Sources reduction
- Recycling
- Disposal

Sources reduction (waste prevention) includes reuse of products on site, designing products or packing to reduce their quantity or make them easy to reuse, lengthening the useful lives of products, as well as on site composting of yard trimmings.

Recycling, the offsite recovery and processing for reuse of various solid waste components, including off-site compositing. Final disposal includes incineration (preferably with energy recovery) and land disposal.

SOLID WASTE COLLECTIONS

Solid waste collection may be a local municipal responsibility, whereby public employees and equipment are assigned to the task. Sometimes it is more economical to have private collection companies do the work under contract to the municipality. In some communities, private collection companies do the work under contract to the municipality. In some communities, private collectors are paid for the service by the individual home owners. Whatever the actual administrative arrangement, proper planning, operation, and regulation of the collection activity are necessary for smart habitat.

Combined collection of garbage and rubbish is generally more economical than separate collection of these types of refuse. In many communities however, certain materials are recycled. Home owners practice source separation; that is, they separate glass, metal, paper, and plastic from the remainder of their refuse. The recyclable materials are then picked up in a separate collection truck to prevent the refuse from contaminating the recyclable component and lowering its resale value. One of the most effective ways to minimize waste collection costs is to optimize the collection route. An optimum route is one that results in the most efficient use of labour and equipment.

Selected characteristics of an optimum route include the following:

- Collection vehicles should not travel twice down the same street, that is collection paths should not overlap
- Refuse collection on crawled streets and roads should not occur during morning or afternoon rush hours

- Collection should occur in the downhill direction as much as possible to conserve fuel
- The starting point should be close to the collection vehicle garage and the last collection point should be as close as possible to the destination of a filled vehicle (that is, transfer station, incinerator, processing plant, or sanitary landfill).

These characteristics may seem to be simplistic examples of what is only common sense. Actually they place significant constraints or limits on the collection routes, especially for large and densely populated urban areas as well as for smart habitats. In fact systems analysis or operations research is needed to solve this complex problem. Computers are routinely used to conduct the analysis, providing engineers and managers with collection routes that can be modified periodically to accommodate changes in community growth or development.

TRANSFER STATIONS

A transfer station is a facility at which solid wastes from individual collection trucks are consolidated into larger vehicles such as tractor-trailer units. It is more economical for a few of these larger vehicles to transport the consolidated solid waste over the long-haul distance to the processing or disposal location, rather than have each collection truck make the trip. A one-way haul distance of about 20 km may be a typical upper limit for an individual waste collection truck, but thorough engineering and cost-benefit comparison studies are generally conducted to determine the need for and advantages of a transfer station.

SOLID WASTE PROCESSING

Solid waste may be treated or processed prior to final disposal. Solid waste processing provides several advantages. It can serve to reduce the total volume and weight of waste material that requires final disposal. Volume reduction helps conserve land resources because the land is the ultimate sink or repository for most waste material. It also reduces the total cost of transporting the waste to its final disposal site.

In addition to volume and weight reduction, waste processing changes its form and improves its handling characteristics. Processing can also serve to recover natural resources and energy in the waste material for reuse or recycling. The most widely used solid waste treatment processes are;

- Incineration
- Shredding
- Pulverizing
- Baling and
- Composting

Although incineration (burning) greatly reduces the waste volume, it is a processing rather than a disposal operation; land burial is still required for final disposal of the ashes and other unburned residence that remains behind.

INCINERATION

One of the most effective methods of reducing the volume and weight of solid waste is to burn it in a properly designed furnace under suitable temperature and operating conditions. This process is called incineration. It is expensive, primarily because extensive air pollution control equipment is required. An incinerator also requires high level technical supervision and skilled employees for proper operation and maintenance. The advantages of incineration, however, often outweigh these disadvantages. According to EPA estimates, roughly 15 percent of the total MSW stream in the United States was incinerated in 2003. In contrast, Japan burns about 75 percent of its MSW.

INCINERATOR RESIDUES AND EMISSIONS

Incineration does not completely destroy the solid waste. Bottom ash, the solid residue remaining in the furnace after combustion, includes glass, metal, fine mineral particles, and other unburned substances. The volume of solid waste bottom ash is about 5 percent of the original solid waste volume. Another type of incinerator ash, called fly ash, is carried along in the combustion airstream (or flue gas.) Fly ash consists of finely divided particulate matter, including cinders, mineral dust, and soot. Most of solid waste incinerator ash (about 80 percent by weight) is bottom ash; the remainder is fly ash.

DESIGN AND OPERATION

Most large, modern municipal incinerators are designed for continuous-feed operation, as opposed to the less desirable intermittent or batch-feed mode of operation. A continuous feed of refuse allows for uniform furnace temperature; this provides more efficient combustion and reduces potential shock damage to the incinerator components.

A typical incinerator includes a below-grade refuse storage pit or tipping area, which provides volume for at least 1 day of refuse storage. Sufficient storage volume is necessary to allow for continuous operation of the facility. Refuse is lifted from the pit by a crane with a grab bucket and deposited into a charging hopper and chute. Then it is released from the chute onto a charging grate or stoker. Various types of mechanical traveling or rocking grates are available to agitate and move the burring material through the furnace in a manner that allows for a proper draft or flow of air.

Municipal incinerators are built in a variety of configurations, including the rectangular furnace and the rotary kiln furnace and the rotary kiln furnace. In the rectangular type or more moving are arranged in tiers; in a rotary kiln furnace, a drying grate precedes the rotating drum (kiln) where burning is complete. A rotary kiln furnace is shown schematically in Fig. 2.

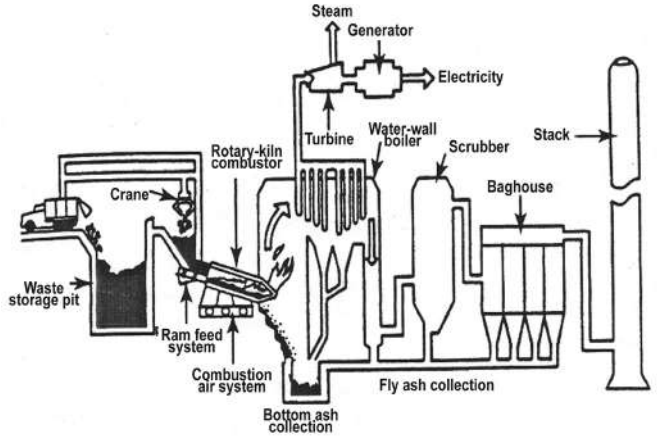


Fig. 2: Schematic of a Rotary Kiln Waste-to-Energy Furnace

ENERGY RECOVERIES

Recovery of the heat given off by burnings refuse in an incinerator can be accomplished using a refractory-lined furnace followed by a boiler. The boiler converts the heat from combustion into steam or hot water. In this way, the energy content of the refuse can be recycled and put to beneficial use.

Another type of energy recovery system makes use of a water-tube wall furnace. A water-tube wall furnace is lined with closely spaced welded steel tubes that are arranged vertically to form continuous walls. Insulation on the outside of the walls reduces heat loss. Heat is absorbed by the water that circulates through the tubes, and the heated water is used to produce steam. An advantage of this type of system is that the water also serves to control furnace temperature, eliminating the need for excess air. Smaller volumes of airflow result in lower air pollution control costs compared to the costs for a refractory-lined furnace.

PYROLYSIS

Pyrolysis is a high-temperature thermal process that can provide an alternative to incineration; it takes place in a low-oxygen or oxygen-free environment and produces by-products that can be used as fuels. Natural gas is burned to start the process. Instead of oxidation, a complex series of decomposition and other chemical reactions takes place. Air pollution with Pyrolysis is less of a problem than with incineration due to the reduced volume of waste gases. Pyrolysis can be used for the processing of discarded rubber tires; rubber tires can also be shredded and added to asphalt paving material for road construction).

SHREDDING AND PULVERIZING

Size reduction of solid waste accomplished by the physical processes of shredding or pulverizing. Shredding refers to the actions of cutting and tearing, whereas pulverizing refers to the actions of crushing and grinding. These two terms are frequently used synonymously with regard to solid waste management. Note that the size reduction obtained by shredding or pulverizing refers to the size of individual components or pieces of the solid waste material. However, shredding and pulverizing also reduce the overall volume of the original or raw waste material, sometimes by as much as 40 percent. There are many reasons for size reduction of solid waste. The production of refuse-derived fuel (RDF), requires processing of the raw solid waste; this typically includes shredding and pulverizing.

HAMMER MILLS

One of the most common types of equipment used for processing into a uniform or homogeneous mass is the hammer mill. A hammer mill is a mechanical impact device in which the raw solid waste material is hit with a force sufficient to crush or tears individual pieces of the waste. Impact is provided by several hammers that rotate at high speeds (up to 1500 rev/min) around a center horizontal or vertical shaft. A vertical mill is shown in Fig. 3.

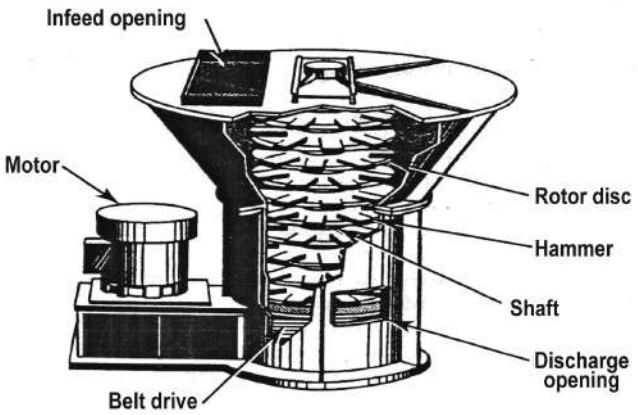


Fig. 3: Vertical Hammer Mill

BALING

Compacting solid waste into the form of rectangular blocks or bales is called baling. Bales are typically about 1.5.m3 in size and weigh roughly 1 KN (or 1 ton). Semi automatic horizontal presses can bale up to 36 KN (or 4 tons) per hour of solid waste. Volume reduction can be as much as 90 percent of the original waste volume.

The basic advantages of a solid waste baling process include the significant decrease in waste volume, the ease of handling the compacted refuse, and the reduction of litter and nuisance potential. Additionally, the compacted waste can be hauled to a landfill by conventional vehicles, and the service life of the landfill can be greatly increased (by as much as 60 percent) because of the smaller volume of waste requiring burial. At the landfill, the bales can be neatly stacked in place without a problem of windblown debris, the likelihood of animal or insect infestation is decreased, soil cover requirements are reduced, and the need for on-site compaction is eliminated.

COMPOSTING

Composting is a process in which the organic portion of solid waste is allowed to decompose under carefully controlled conditions. It is a biological rather than a chemical or mechanical process. Decomposition and transformation of the waste material are accomplished by the action of bacteria, fungi, and other microorganisms. Composting, where it is applied must be part of a comprehensive solid waste management system that handles other components of the solid waste stream and the organic portion.

RECYCLING

Residential, commercial, industrial, and institutional activity will always result in the generation of solid waste. But the public view of what constitutes waste, that is, useless and unwanted material, is changing. As people become more aware of ecological or environmental imperatives and as the space available to landfill waste in certain regions of the country shrinks, the need for recovering and reading much of what was previously thrown away or dumped is becoming more evident. Also the cost of disposing of solid waste material in an environmentally sound manner makes it more necessary to consider alternative waste management techniques.

The ideal approach to solid waste management is to first reduce waste at the sources and then to recover reusable materials from the waste stream prior to disposal. This is accomplished by recycling, that is, by separating out and reusing these components of the waste stream that may have some economic value. Recycling returns various materials to the production cycle and saves natural resources along the way.

CONCLUSION

Solid waste comprising garbage, rubbish, and trash from homes, businesses, and institutions, must be properly disposed off protect environmental quality and public health. Three key components of an integrated waste management strategy are source reduction (waste prevention), recycling (recovery and reuse), and disposal (incineration and landfill).

About two thirds of the total cost for solid waste management is needed for waste collection, including

transfer to a collection vehicle and transport to a processing facility or disposal site. Compaction in a collection vehicle can temporarily reduce the waste volume quite considerably. In many communities, source separation is practiced so recyclable material can be collected separately from garbage and non recyclable rubbish. Transfer stations are used if it is not economical for individual collection trucks to haul the waste to processing disposal site. In some place, innovative pneumatic collection systems pull the waste by vacuum to a central processing plant.

Ultimately, a portion of the solid waste stream is disposed off in a sanitary landfill, which is a carefully planned and engineered facility. The key characteristics that distinguish landfills from old-fashioned "dumps" are waste is placed in a suitably selected and prepared site in a carefully prescribed manner. Waste material is spread out in layers and compacted with appropriate heavy machinery, and waste is covered each day with a layer of compacted soil. In addition, all landfills are designed to prevent groundwater pollution by the leachate (polluted liquid) seeping out from the bottom of the landfill. Landfill is generally the most economical alternative for solid waste disposal, although it has become increasingly difficult to find suitable sites for new landfills. Also, in the long run, some environmental damage may occur no matter how well the site is designed, built, and operated. (Nonetheless, it is not possible to recycle and reclaim all solid waste materials).

The most important factors in landfill site selection are volume capacity, accessibility, and hydrogeologic conditions. Generally, about 1 ha-m (8 ac-ft) of volume is needed to serve a population of 10,000 persons. Accessibility refers to the ease with which collection or transport vehicles can reach the disposal area without causing a public nuisance or hazard. Local geology and hydrology (hydrogeology) have a direct influence on the possibility of water pollution. At no time should the waste be in contact with surface water or groundwater. Modern landfills are also called containment landfills because they are constructed with bottom liners. The liners confine the leachate and prevent it from mixing with groundwater. They are generally a combination of a layer of clay covered with a flexible plastic material called a geomembrance. Methane gas that is generated in solid waste landfills must be properly vented or collected for use as a fuel. Placing final capping soil and drilling groundwater-monitoring wells is necessary to close completed landfills.

REFERENCES

1. Davis, M.L and corn well D.A (1991)," Introduction to Environmental Engineering" 2nd edition, McGraw Hill Inc, New York
2. Gupta, Rams; (1997), "Environmental Engineering and Science", An introduction, Government Institutes, Rockville, MD.
3. Leshin C (1997), "Internet Investigations in Environmental Technology" prentice Hall Ine Englewood Cliffs, N.J
4. Manahan, Stanley E; (1993), "Environmental science and Technology, Lewis publishers, Boea Raton, F.L
5. Salvato J.A (1992), "Environmental Engineering and Sanitation, 4th edition John Wiley& sons, Ine, New York.

EFFECTIVE SEWERAGE AND DRAINAGE IN URBAN AREAS –CASE STUDY KOLKATA

Dr. Biswajit Mukherjee* and Bhaskar Ghosh**

Abstract

For adopting Smart Sanitation System, the waste water should be treated as a 'resource' and not as 'refuse'. Smart city should reuse it so efficiently that use of fresh water gets reduced to a large extent. Sewage from about 50 cities of 5 states is discharging into the Ganga. National Urban Sanitation Policy has decided that by 2020, no sewage should be disposed in Ganga. Ganga Action Plan was taken up to save Ganga in several phases. Based on the Greater Calcutta Master Drainage Plan recommendations, topography wise, east and west banks of river Ganga has been divided into several drainage basins. Calcutta, having combined sewerage system, was topographically divided into four drainage basins. Details of drainage networks and pumping stations are given in the write-up. However, building of new sewerage or drainage or any type of new pollution management infrastructure alone will not build a smart city. Several sewage treatment plants are lying inactive because of financial constraints. Sewage network of Municipalities carry only a fraction of sewage as house connections have not been laid.

Success of adopting Smart Sanitation system will depends on sustainability of investments in modern infrastructure, adopting innovative models and financing them.

INTRODUCTION

Public Health engineers are often faced a very common question from the local people that they have laid the sewer pipeline, but water logging problem in the area has not been removed. There is a difference between drainage pipelines and sewer line, we all know. The drainage pipeline or surface drains are carrying the storm water in a locality and discharge it to nearby water body or any canal or river directly. But in case of sewer line it carries the sewage to a treatment plant and after treatment the treated effluent is discharged into the nearby water bodies. The drainage system in an area is designed considering the rainfall intensity in that area and the diameter of pipeline in case of storm water drains are rather large in comparison to sewer line which is basically designed in the line of population basis in that area.

In urban areas and cities the road width is used for laying different public utilities like water supply, gas, telephone, etc, hence combined sewer system was adopted which carries both storm water and dry weather flow simultaneously. In Kolkata different areas have combined sewerage system but in case of Municipalities near Kolkata, separate sanitary sewerage are now being constructed. The effective drainage is capable of flowing with self-cleansing velocity to ensure that the wastewater passes freely through the system to the main sewer. Velocity is determined by a combination of gradient and pipe diameter. Drains operate most efficiently when the ratio of the liquid to air in the pipe is 65:35. This ensures adequate ventilation through the system and allows drains to flow at a rate to allow them to self-clean.

The Indus Valley Civilization in Asia (1900 BC) shows early evidence of sanitation system. The urban areas of Indus Valley Civilization included public and private baths. Sewage was disposed through underground drains and in the drainage system drains from houses were connected to wider public drains.

**Suptdg. Engineer, KMWSA. ***Suptdg. Engineer, PWD, Kolkata*

In prehistoric age the people preferred to settle near any water body like river or ocean which they used as disposing area of sewage which would be satisfactorily diluted and dissipated.

In prehistoric days or at the time of Indus Valley Civilization the population outburst was not so acute in comparison to problems now a day.

Presently due to huge population growth and rapid urbanization, industrialization aggravated the problem of drainage and sanitation. A recent study showed that the sewerage system typically reduced the water borne diseases by about 30 % or perhaps enhance as much as 60% when there is combination of water supply system. The presence of efficient drainage and sewerage system is a major factor in prevention of water borne diseases.

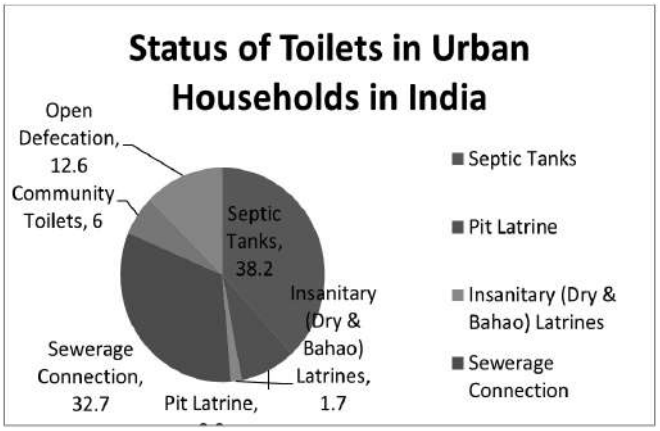


Fig. 1: Status of Toilets in Urban households in India

As per census 2011, in India the population in urban area has increased from 28% in 2001 to 31.2% in 2011 and no. of towns has increased upto 8000 in 2013 and among the urban population only 32.7% of urban households are connected with sewer system whereas 38.2% have septic tanks for disposal of their waste and 8.8% households are having pit or pour flush latrine and 1.7% households are having other type of latrines like connection of their latrines to open drains or manual scavengers are used for removing the night soil. About 18.6% of urban households still do not have latrines whereas about 6% use public latrine and 12.6% are practicing open defecation. In Karnataka only half of 52 towns were served by sewerage system while in West Bengal out of 60 nos. of towns 2350 MLD sewage is generated out of which only 500 MLD sewage is treated (source CPCB Report, 2007). In 1875 by the British rulers, underground sanitation network in eastern India was built, at the time, matched only by the systems in London and Hamburg, Germany. In Kolkata, the sewerage system exist in majority of the areas. Mostly they are combined sewers, but in some municipal areas have no sanitary sewer system and they dispose the sewage either by septic tank or some areas by cesspool system. However recently under an environmental improvement programme, sewerage facilities are being build up in municipal areas. In this program development of storm water drainage system including pumping stations, where necessary are being also constructed.

NATIONAL URBAN SANITATION PROGRAMME

In 2008 the National Urban sanitation Policy has laid down a framework for addressing the challenges of city sanitation. The overall goal of this policy is to transform urban India into community driven, open defecation free and leading to totally sanitized and healthy cities and towns. The urban areas on the bank of river Ganga in the five states in India are discharging their municipal sewage mostly into the river Ganga so a drive was taken by the Govt. of India so that no waste water be disposed to river Ganga by the year 2020. For implementation of that mission, National Ganga River Basin Authority (NGRBA) was formed and a drive was taken in West Bengal for installation of sewer system in the 43 Municipalities on the bank of river Ganga. Under this program the work of laying of sanitary sewer system at Bhatpara, Kalyani, Gayeshpur, Barrackpore, Halisahar and Budge Budge (6 nos) have been started. In those Municipal areas the house to house connections will be established and the sewage will be treated by STP (Sewage Treatment Plant) and after that the treated effluent will be discharged to nearby water body or river.

In case of smart sanitation system the waste water should be treated as a "resource" rather than consider as "refuse". The waste water in the smart city should be reused efficiently so that the use of fresh water could be reduced to a great extent. The waste water after treatment, in some cases upto tertiary

treatment may be adopted, so that the reclaimed sewage or sullage could be used in gardening, park beautification, road-side plantation, etc and reusing the waste water returning nutrients and organic matter to nearby agricultural field and may be the source renewable energy, e.g. production of bio gas or fuel. The storm water may be stored up partially for using it in cleaning roads, washing purposes and watering to the plants, etc.

GANGA ACTION PLAN

To save the river Ganga from pollution by the drains and sewage of the locality from 50 major cities each having more than 50,000 populations, GoI has launched Ganga Action Plan (GAP) in 1985. In this program the sewage directly discharged into the river through drains and nullah, etc are being intercepted before flowing into the river and diverted into the sewage treatment plant (STP) with pumping stations and ultimately the treated effluent is discharged into the river or nearby water bodies and thereby reducing the pollution load. Ganga Action Plan, Ph-I was declared closed on 2000 and Ganga Action Plan Phase-II was approved in the year 1993 for abatement of pollution of river Ganga. In December, 1996 GAP Ph-II was merged with NRCP. NRCP covered 35 stretches of polluted rivers in 164 towns spread over 20 states for abatement of pollution of these rivers like Ganga, Yamuna, Damodar and Gumoti. In the GAP works, the river water quality has improved i.e. dissolve Oxygen has been increased, BOD level has decreased but the Fecal Coliform (FC) value is not within the bathing standard. In West Bengal the value of FC is 11250 MPN/100 ml as minimum and 283333 MPN/100 ml as maximum in the year 2010, whereas the FC value should be below 1000 MPN/100 ml as standard fixed by NGRBA. In India about 46,000 MLD of sewage is produced per day in which 12,000 MLD of sewage is being disposed with hardly treatment of 20% of it. In Ganga Action Plan, Phase I and II both a total 1016 MLD capacity of STP has been created.

Based on the recommendation of greater Calcutta Master Drainage Plan the present topography and land use pattern and outfall system of the catchment area has been divided into 25 nos. of drainage basin. The east bank of river Ganga has 18 nos. drainage basins and west bank consists of 7 nos. drainage basin. In the Kolkata Municipal Corporation the drainage system is mostly combined sewerage system. The system composes mainly the following drainage basin:

- Manicktala-Ultadanga Basin
- Tollygaunge-Panchannagram Basin
- Bagijola basin covering Cossipore Chitpur area
- Tolly's Nullah Basin

The general elevation of Kolkata is between 19 to 22 ft KODS (Kidderpore old dock sill). The average slope is from west to east i.e. from East Bank of Hooghly river to Salt Lakes. Netaji Subhas road near Hooghly river is (+) 22 KODS where Salt Lake City is (+) 18.5 KODS. The trunk sewers are laid in east to west direction and carry the waste water and the storm water both to the different pumping station like Palmer Bridge pumping stations, Ballygaunge drainage pumping station and Dhappa lock pumping station and Chingrighata pumping station where water is pumped to the dry weather flow (DWF) channel and storm water flow channel (SWF) for disposal into Kulti river which is 36 km away from the city. The major part of the sewer network carries combined flow whereas in few areas partially separate drainage systems are present.

In the town system the average invert level of the trunk sewer near Hooghly river is about 13.5 KODS, whereas the level near pumping stations is 3.61 KODS, producing about 10 ft fall. The sewer network of town system is constituted of the following trunk sewer.

- Baghbazar street trunk sewer.
- Shobabazar street – Grey street sewer.
- Nimtala ghat street – Beadon street sewer.
- Kolutala street – Mirzapore street sewer.
- Lenin Sarani sewer.
- APC Road sewer.
- AJC Bose Road sewer.

In the suburban area of about 26 sq.km bounded by AJC Bose Road and Convent Road at north, eastern railway line on the south and east and the dock area in the west. Three trunk sewers are

running from west to east and finally disposed to Ballygaunge drainage pumping station (BDPS). The three trunk sewers are:

- Rash Behari Avenue trunk sewer.
- Hazra Road trunk sewer.
- Padmapukur Road trunk sewer.

Two other trunk sewers, namely CIT Road trunk sewer and Tiljala Road trunk sewer from north to south carrying the combined sewage and discharged into BDPS. Another trunk sewer is carrying storm water to BDPS is Park street trunk sewer. All the sewers are circular in section. A part from Ballygaunge drainage pumping station (BDPS) 6 nos. more pumping stations are there to dispose of the storm water, those are:

- Chetla lock pumping station.
- Dhapa lock pumping station.
- Mominpur pumping station.
- Jodhpur Park pumping station.
- Nimak Mahal pumping station.
- Kalighat pumping station.

New Town, Kolkata is newly built up town adjacent to Salt Lake. It consists of three major action area I, II and III for habitation and business centre is also growing up there. New Town has separate sewer system. The total length of sewer lines in action area – I is about 80 Km and for action area – II and III is 99 Km and 59 Km respectively. The drainage line in action area-I, II and III is 113.5 Km, 116.5 Km and 81 Km respectively. All the above sewerage and drainage systems have been mostly completed. There are presently 17 nos. of drainage pumping stations in New Town which lift the storm water and discharged into Bagjola canal and Kestopur canal respectively. Sewage treatment plants are now in construction phase, one existing STP is in the "Digher Bheri" area. The main problem in New Town area is that the storm water from the Airport area (which is at higher elevation) is now accumulated in New Town area through Ghurnia canal and ultimately the outfall is at Bagjola canal.

In New town, Kolkata, the newly built up town has its own drainage and sewerage system in which Bagjola and Kestopur canal are being used for outfall for drainage system. But in case of sewer system the main outfall is Digher Bheri though Sewage Treatment Plant of about 70 mld capacity.

CONCLUSION

Building of new sewerage or drainage or any type of new pollution management infrastructure alone will not help Kolkata to build a smart city. Already there are several sewage treatment plants which are lying inactive because of financial constraints. The Urban Local Bodies (ULB) are unable to run those plants as they are not even in a financial position to pay the electricity bills. The sewage networks carry only a fraction of sewage load as because house to house connections have not been built up. So, most of the STPs are underfed. Past experience shows that the ULB or the regulatory bodies or development authorities should be strengthened with skills and resources to operate and maintain modern infrastructure. The sustainability of investments in building new and modern infrastructure will depend as much on adopting innovative models and to finance them as on efforts to build the capacities of ULB and development authorities managing these facilities. If these measures can be combined the cities could emerge as "Smart Cities".

USE OF RECYCLED CONCRETE AGGREGATE FOR SUSTAINABLE DEVELOPMENT

V. SRINIVASAN* AND S.K. SINGH**

Abstract

The concrete is the most consumed man made material in the world. Construction sector today has become one of the largest consumers of natural resources and energy in various forms which has become serious concern for sustainable development. Recognising the widening gap between demand and supply of traditional materials and promotion of energy efficient, environment friendly building technologies which could be produced by recycling and reuse of waste materials. The 3Rs (Reduce, Reuse and Recycling) are the key concepts in conservation of resources and sustainability of environment.

The main concerns which demand attention of mankind in the field of construction are rapid depletion of quality aggregates for concrete and construction debris and demolition wastes in the land fill. The above factors demand recycling of the construction and demolition waste and its fruitful utilization rather than disposal. However, many research studies indicated the inferiority in quality of recycled aggregates, which has resulted in limited use or negligible use of recycled aggregates in buildings and other structures. This paper is an attempt to address these issues and possible suggestions to mitigate the detrimental effect of use of recycled aggregate in concrete.

INTRODUCTION

Due to rapid urbanization, explosion of population, liberalization of economy and rapid growth in infrastructure, the numbers of old structures being demolished are increasing day by day. Construction Industry is an important activity in the economy of any nation and it creates impact on the environment due to the amount of waste generated and the consumption of natural resources. The major contribution to waste generation is from the demolition of buildings. 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. A glimpse of Construction and Demolition Waste generation in different developed and developing countries is presented in Table 1. Generation of such a huge quantity of waste is posing a major problem in its disposal and also resulting in conversion of useful land into landfills and dump yards.

In recent years, considerable research work has been carried out in different countries like Japan, UK, Germany, USA, China, Hong Kong, Denmark, Netherland etc. and it is observed that the recycled materials performed well in several engineering applications. Of the 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 (RA) in the US produced by natural aggregate producers, contractors and debris recycling centers, 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

** Senior Scientist, CSIR-Structural Engineering Research Centre, Chennai ** Principal Scientist, CSIR-Central Building Research Institute, Roorkee-247 667*

in road construction, 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. But in India, not much progress in research on the reuse and recycling of the construction and demolition waste has been made. This may be due to lack of awareness and standards on recycle and reuse of recycled aggregates in the construction industry. Hence, there is an urgent need to carry out a systematic study of recycling the construction and demolition waste (CDW).

Table 1: Construction and Demolition Waste generated annually in various countries

Country	Amount per year (Million Tonnes)	Year
Germany	223	2003
Australia	19	2008-09
China	200	2005
France	24	-
Japan	85	2000
South Korea	61.7	2013
Ireland	11	2004
Norway	1.5	2003
India	14.7	2001

Source: Guidelines on Recycling, use and management of C & D Wastes, ICI Bulletin 01

Advantages of using recycled aggregates are:

- The exploitation of natural resources for need of aggregates can be reduced.
- The quantity of useful material getting into waste can be minimized.
- The transportation costs of aggregates from quarries to site can be curtailed.
- Proportion of CDW to be dumped in land fill can be minimized, and thus the precious land can be saved from becoming a dumping yard.
- As waste material is used as a part of concrete, use of recycled aggregate makes the concrete production economical.

In spite of the above advantages, 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 three basic parameters for which the concrete is proportioned. The composition of the wastes depends upon 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 and it is shown in table 2. CPCB 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. Table 2 indicate the proportion of concrete wastes to vary from 23 to 35 percent. The proportion of soil between 32 to 43 percent. Based on TIFAC study, quantum of waste generated during construction is around 35 kg/m2 of construction activity, while during demolition waste generated is about 350 kg/m2of demolition. According to the findings of survey of TIFAC (Technology, Information, Forecasting and Assessment Council), the most dominant reason for not adopting recycling of waste from construction industry is 'lack of awareness of the recycling techniques'.It is presumed that the cited data in table basically relate to building demolition wastes. However, significant quantities of waste are disposed at unauthorized and designated public locations. With development in data collection more precise estimates of the composition of C & D wastes will also be available.

Table 2: Estimation of C & D wastes composition in India

C & D Waste composition, %	TIFAC study	MCD Survey 2004	IL & FS Survey 2005
Soil/Sand, Gravel	36.0	43.0	31.5
Bitumen	2.0	-	-
Metals	5.0	-	0.4
Masonry / Bricks	31.0	35.0	-

Concrete	23.0	35.0	-
Wood	2.0	-	1.5
Others	1.0	7.0	7.6

Source: Guidelines on Recycling, use and management of C & D Wastes, ICI Bulletin 01

The comparative study of C & D waste for India and USA for the year 2000 is shown in Table 3. The data for USA were collected from CIB TG 39 reports.

Table 3: Comparative study of C & D Waste

Description	India	USA
C & D waste generation		
a) New Construction	50 Kg/m2	41 Kg/m2
b) Renovation / Repair	45 Kg/m2	118 Kg/m2
c) Demolition	425 Kg/m2	515 Kg/m2

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. Apart from steel rebars and aluminium window frames, inert materials are removed through different methods like hand picking, water flotation, air classifier, etc. Use of specialized equipment is vital in recycling process. There are many manufactures producing a variety of equipment such as jaw crushers, magnetic separators, two cone crushers, sieves/ screens, washing equipment, etc. Construction and Demolition wastes flow chart is illustrated in Fig.1.

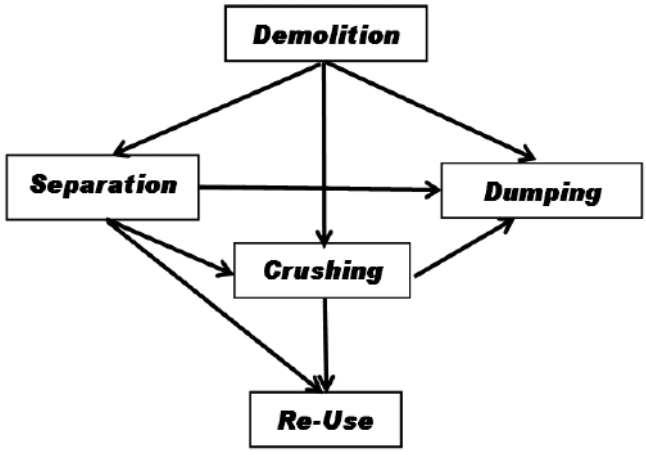


Fig.1 C&D Flow Chart

The recycled concrete aggregates exhibit inferior mechanical properties than the natural aggregates, which was employed in 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

The result of sieve analysis carried out as per IS 2386 for different types of crushed recycled concrete aggregate and natural aggregates. It is found 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 were in the order of 5-20% depending upon the original grade of demolished concrete. The best quality natural aggregate can obtained by primary, secondary and tertiary crushing whereas the same can be obtained after primary and 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 ranges from 3.05% to 7.40%, which is relatively higher than that of the natural aggregates. The Table 4 gives the details of properties of RCA and natural aggregates.

Bulk Density

The rodded and 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% and 50% respectively. The crushing and impact values of recycled aggregate satisfy the BIS specifications.

Table 4: Comparison of Recycled Aggregates and Natural Aggregates

Properties	Natural Aggregates	Recycled Aggregates
Shape of aggregate	Angular	Angular
Surface texture	Rough	Rough and porous
Fineness modulus(<20mm)	6.98	6.96
Water absorption	0.4%	4.5%
Specific gravity	2.66	2.55%
Crushing value (20mm-12.5mm)	18.73%	30.25%
Impact value(20mm-12.5mm)	16.53%	25.54%

ISSUES IN USE OF RAIN CONCRETE

Despite the inferior properties of the recycled concrete aggregates, worldwide efforts are on to use them in concrete construction by partly or fully replacing the natural aggregates with the recycled concrete aggregates. Various studies by different researchers showed that the performance of recycled aggregate concrete is inferior to the concrete made natural aggregates and this is primarily due to presence of adhered mortar. These limitations have to be taken into consideration when recycled aggregate is used in any concrete. The associated problems can be minimized at the design stage itself. Some of the difficulties associated with the use of recycled aggregates in structural concrete and the possible remedial measures to overcome the same are discussed below:

Slump

The slump of recycled aggregate concrete decreases with increase in percentage of recycled aggregates. With every 20% increase in recycled aggregates the slump decreases by 1.5 - 5.5%. It has been suggested to a) use super plasticizers, b) use recycled aggregates in SSD condition or c) use mineral admixtures, in order to overcome the slump loss.

Slump Test for OPC and RA

Compressive Strength

Compressive strength of recycled aggregate concrete decreases with increase in percentage replacement of recycled aggregate above a certain minimum replacement. The compressive strength of recycled aggregate concrete was lower by up to 30% than that of natural aggregate concrete. Researcher reported that there was no detrimental effect on

the compressive strength of standard 100mm concrete cube when coarse recycled concrete aggregate replaced the natural aggregate by up to 30%. The decrease in compressive strength can be compensated by a) reducing the water cement ratio, b) using supplementary cementitious materials, and c) adopting two stage mixing.

Tensile Strength

The behaviour of recycled aggregate concrete under tension varied with change in aggregate source and hence no proper trend was observed in variation of tensile strength. The split tensile strength decreased with an increase in percentage of replacement of natural aggregate with recycled aggregate. However, there was only a negligible difference between normal aggregate concrete and recycled aggregate concrete with respect to flexural behaviour. This decrease in strength due to use of recycled aggregate can be minimized by use of a) Mineral admixtures like fly ash, silica fume etc., b) reduced water cement ratio and c) using saturated surface dry aggregates.

Shear Strength

Shear crack pattern in recycled aggregate concrete was similar to that in natural aggregate concrete. The shear resistance of the recycled aggregate concrete slabs was on average 6.13% lower than the resistance calculated as per codal provisions.

Modulus of Elasticity

A decreasing trend in modulus of elasticity was observed, when the percentage of recycled aggregate was increased. Measures such as a reduction in water cement ratio of the mix b) use of mineral admixtures like fly ash, silica fume etc, and/ or c) increase of the curing period can be adopted to achieve a higher elastic modulus of concrete when the recycled concrete aggregate were used.

Durability

Concrete made with recycled concrete aggregate was reported to exhibit a) an increase in water absorption with increase in percentage of recycled aggregate, b) higher vulnerability to chloride ingress, c) higher permeability to water, d) greater depth of carbonation. The possibility of occurrence of alkali aggregate reaction in concrete depends purely on the source of aggregate.

All these durability related problems in recycled aggregates are mainly due to the increased porosity of recycled aggregate due to presence of adhered mortar. The detrimental effects can be mitigated by a) Increasing the cement content, b) Increasing the curing period and c) adding mineral admixtures to the concrete mix.

EXPERIMENTAL STUDY ON RECYCLED AGGREGATE

Compressive Strength

The average compressive strengths cubes cast are determined as per IS 516 using natural aggregate and RCA at the age 3, 7, 28 days and reported in Table 5 and Fig.2-3. As expected, the compressive strength of RAC is lower than 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.

Table 5: Trial Mix for (OPC with Natural Aggregate and OPC with Recycled Aggregate)

		OPC with Natural Aggregate		OPC and Recycled Aggregate	
w/c ratio		0.40	0.42	0.42	0.45
Superplasticizer		0.4%	0.5%	0.5%	0.5%
Slump		10 mm	30mm	zero	zero
Compressive Strength (MPa)	3 days	27.85	32.18	25.52	30.56
	7 days	33.75	35.29	32.46	40.38
	28 days	52.88	53.49	39.19	41.63

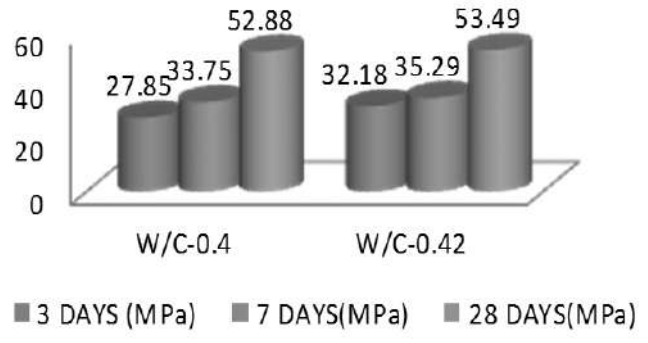


Fig. 2: OPC with Natural Aggregate

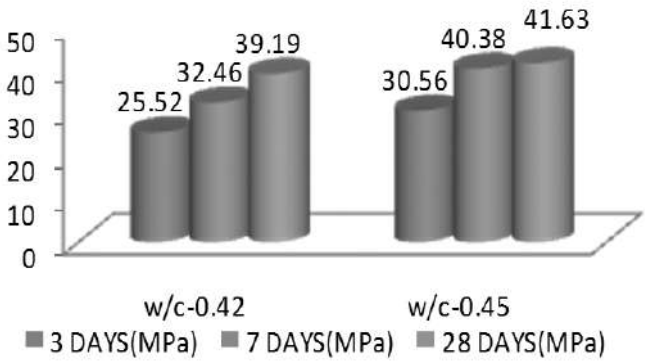


Fig. 3: OPC with Recycled Aggregate

APPLICATIONS OF RECYCLED AGGREGATES IN BUILDINGS

The instances of use of recycled aggregate in structural concrete have been limited till now. In general, applications of concrete demolition wastes without any / due processing such as i) General bulk filling, ii) Bank protection, iii) Base or fill for drain structures, iv) Road construction, v) Embankments etc. Thoroughly processed recycled aggregate can also be used in concrete with partial or full replacement of natural coarse aggregate. The following are some of the examples where the recycled concrete aggregate was used in real time buildings:i) Vilbeler Weg office building, Darmstadt, Germany, 1997/1998 – 480 m3 of recycled aggregate concrete was used, ii) Waldspirale residential building in Darmstadt, Germany, 1998 – 12000 m3 of recycled aggregate concrete was used. iii) Reuse of waste and creation of zero waste were among the mottos of Olympics and Paralympic Games, London 2012. Accordingly, recycled concrete aggregates from various parts of the British Union were used in the construction of the Olympic village. In general, after proper processing demolition wastes can be used as i) structural grade concrete, ii) new concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters., iii) soil cement pavement bases iv) lean concrete bases

CONCLUSION

Indian construction industry consumes the largest 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 tons 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 and economical respect. Recycled aggregate posses relatively lower bulk density, crushing and 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. However, more research and initiation of pilot project for application of RCA is needed for modifying our design codes, specifications and procedure for use of recycled aggregate concrete. 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 subject of use of RCA in construction works in India should be given impetus, because of sustainable infrastructural projects are being planned like smart cities.

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. Butler L., West J.S., Tighe S.L., (2011), "Quantification of Recycled Concrete Aggregate (RCA) Properties for Usage in Bridges and Pavements: An Ontario Case Study", Innovative

Developments in Sustainable Pavements Session of the 2011 Annual Conference of the Transportation Association of Canada, Edmonton, Alberta.

3. Buchner, S. and Scholten, L.J. (1992). "Demolition and Construction Debris Recycling in Europe", European Demolition Association (EDA).
4. Casuccio M., Torrijos M.C., G. Giaccio G., and Zerbino R., "Failure mechanism of recycled aggregate concrete", Construction and Building Materials, Elsevier, 22, Issue – 7, pp 1500 – 1506.
5. Chakradhararao, M., Bhatta charya S.K., Barai, S.V (2011) "Behaviour of recycled aggregate concrete under drop weight impact load", Constr. Build. Mater. 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. Deshpande. Neela, Kulkarni S.S, Patil. Nikhil, (2011), "Effectiveness of using Coarse Recycled Concrete Aggregate in Concrete", International Journal of Earth Sciences and Engineering ISSN 0974-5904, 04, No 06 SPL, pp 913-919.
8. Deyu Kong, Ting Lei, Jianjun Zheng, Chengchang 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.
9. 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.
10. Indian Concrete Institute (2015), Guideline for recycling, use and management of C & D wastes, ICI report of Technical Committee
11. Kiyoshi Eguchi, Kohji Teranishi, Akira Nakagome, Hitoshi Kishimoto, KimihikoShino zaki,MasafumiNarikawa, (2007)., "Application of recycled coarse aggregate by mixture to concrete construction", Constr. Build. Mater., 21(7), 1542–1551.
12. 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.
13. 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.
14. Meyer, C. (2009). "The greening of the concrete industry." Cement. Concrete. Comp., 31(8), 601–605.
15. Molenaar A.A.A., (2013). "Durable and Sustainable Road Constructions for Developing Countries", the 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, Proceedia. Eeng. 54, 69-81.
16. Mullick, A K. (2015), "Recycled concrete aggregate from C & D Wastes", The Master Builder, August, pp 56-65.
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. Olorunsogo F.T., Padayachee N., "Performance of recycled aggregate concrete monitored by durability indexes", Cement and Concrete Research, Elsevier, 32, pp 179 – 185.
19. Rahal, K. (2007) " Mechnical Properties of Concrete with Recycled Coarse Aggregate", Building and Environment, Vol. 42, pp 407-415.
20. Salomon M.Levy, Paulo Helene., (2004). "Durability of recycled aggregates concrete a safe way to sustainable development", Cement. Concrete. Res. 34(11), 1975–1980.
21. Schubert S. and Hoffmann C,(2004), "Structural Behavior of Concrete with Recycled Aggregates", EMPA Materials Science and Technology , 342, Issue 2004.
22. Singh, S. K. and P. C. Sharma (1998)"Recycling and Reuse of Building Waste in Constructions-

A Review", All India Seminar on Concrete for Infrastructural Development, Roorkee, pp 317-329.

23. Soberon. Jose M.V. Go´mez, (2002), "Porosity of Recycled Concrete with Substitution of Recycled Concrete Aggregate -An Experimental Study", Cement and Concrete Research, Elsevier, 32, pp 1301–1311.
24. 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.
25. Tam, Vivian W.Y., Tam, C.M., Le, K.N, (2007)."Removal of cement mortar remains from recycled aggregate using pre-soaking approaches", Resour. Conserv. Recy. 50(1), 82–101.
26. 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.
27. 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.

INNOVATIVE TECHNOLOGY FOR PRODUCTION OF FLY-ASH LIGHTWEIGHT AGGREGATE

G. B. Singh*

Abstract

The paper advocates use of lightweight aggregate in preference to normal stone aggregate in structural concrete. It describes different ways of sourcing lightweight aggregates and mentions, merits, demerits and major beneficial applications.

The paper strongly advocates conversion of fly-ash into aggregate, as the preferred method, for it makes productive use of an industrial waste product. This is especially important for India, currently producing 165 million tonnes of fly ash per year. This ash is not only polluting the environment, but has buried 100,000 acres of land. Leaching from these ash dumps caries arsenic and other toxins into rivers, lakes, ponds, which can cause cancer, respiratory, lung, diseases to those consuming such water. Imagine the gravity of situation, when fly-ash output goes up to 900 million tonnes/ year by 2031-32.

The paper describes the internationally known processes of producing fly-ash aggregate by sintering, steam curing and compares the properties of their outputs with his recently patented innovative technology, performed under ambient conditions, which is being claimed to be far more economical.

INTRODUCTION

The use of lightweight aggregate concrete (LWAC) for building, bridge, ship and other constructions has intrinsic and documented benefits, that contribute to the sustainability of our built environment. The traditional benefits associated with 25% to 35% reduction in density and up to a 50% reduction in heat conductivity, as compared to normal weight concrete, are well known and must be noted[1]. What is less well known, is the multitude of other uses, that have become important and have been described in this paper.

HISTORY OF LWAC DEVELOPMENT

The use of LWAC can be traced to as early as 3,000 BC, when famous towns of Mohenjo-Daro and Harappa were built, during the Indus Valley civilization.In Europe, the use of LWCA occurred nearly 2,000 years ago, when the Romans built Pantheon(Fig.1), the aqua ducts, and the Colosseum (Fig.2) in Rome.[2].

Fig. 1: Roman Pantheon

Fig. 2: Colosseum- Rome

* *Chief Consultant, System Building Technologists, New Delhi*

The fact that some of the structures are still in good condition speaks about LWA concrete's durability.

TYPES OF LIGHTWEIGHT AGGREGATES (LWA):

LWA can be divided into different categories like : -

- Occurring naturally or produced by pyro-processing of natural raw materials.
- Obtained as by-product of industrial processes performed at elevated temperature.
- Produced from industrial waste product like pulverized fly-ash, sludge etc.

LIGHT WEIGHT AGGREGATES FROM NATURAL RAW MATERIALS

- **Naturally Occurring Lightweight Aggregate**

- Pumice (Fig. 3). It is formed, when very light and porous SiO2 rich molten lava from explosive eruptions of a volcano cools and solidifies rapidly. It is called "super-cooled liquid". The word pumice is derived from the Latin word "pumex", meaning foam. The low density is because of presence of gas bubbles. It has a density of around 0.25g/cm3. It was the stone used by the romans and is still being used in countries like Germany, Italy and Japan.

Fig. 3 Pumice Stone

- Tuff (from the Italian "tufo") (Fig .4). is a type of rock made of volcanic-ash ejected from a vent during a volcanic eruption. Following ejection and deposition, the ash is compacted into a solid rock in a process called consolidation. It is formed into aggregate by crushing and sieving.

Fig. 4 Tuff Stone

- **LWA Obtained by Thermal Processing of Natural Raw Materials**

  Techniques have been developed to produce LWA by thermal treatment to natural raw materials like perlite, vermiculite, clay, shale, slate etc. in factories.

In one such heating process the expansion of basic rock material is very high and is applicable for production of lightweight Perlite and Vermiculite (Fig.5), mostly used for non-structural applications. However, both these raw materials come from different kinds of rocks.

* Perlite is a glassy volcanic rock, gray and with a pearly shine on the rock's surface. Perlite is not a trade name, but a generic term for naturally occurring siliceous rock. The distinguishing feature, which sets perlite apart, from other volcanic glasses, is that when heated to a suitable point in its softening range, it expands from four to twenty times its original volume. It consists mostly of silica and has water molecules trapped within it. Crude perlite rock, when quickly heated to above 870 °C, the rock pops in a manner similar to popcorn. The expansion is due to presence of 2% -6% combined water in the crude perlite rock. The combined water vaporizes and creates countless tiny bubbles, which account for the amazing light

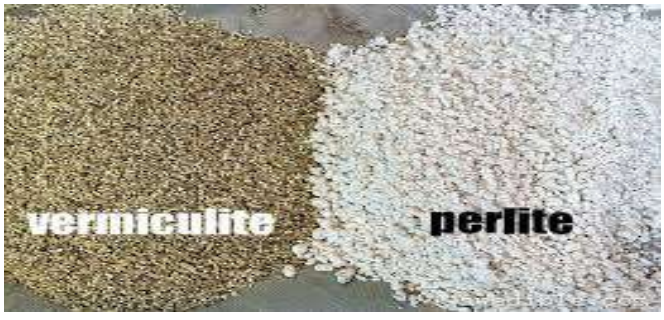


Fig. 5: LW Perlite and Vermiculite

weight and other exceptional physical properties of expanded perlite. This expansion process also creates one of Perlite's most distinguishing characteristics: its white color. While the crude rock may range from transparent light gray to glossy black, the color of expanded perlite ranges from snowy white to grayish white. Expanded Perlite can be manufactured to weigh as little as 32kg/m3, making it adaptable for numerous applications.

* Vermiculite comes from 19 varieties of micaceous minerals and the ores contain silica, alumina, iron oxides and magnesium oxide. Vermiculite ore, when heated to temperatures between 800-1100 °C, expands 8 to 20 times its original volume. The expansion is called exfoliation and is thought to be due to the sudden escape of water in the shape of steam. The expanding properties of vermiculite, upon heating, were first observed by Thomas Webb in 1824, who heated ore over a candle and watched it turn into elongate forms, that resembled worms. He named it vermiculite from the Italian word for worm, "vermiculus".

Pyro-processing of Natural Materials[3],[4].

This process is being applied for production of most of structural grade LWA from natural raw material such as clay, shale, or slate. In this process the, the raw material is expanded to about twice the original volume. The expanded material has properties similar to the natural aggregate, but is less dense and therefore yields a lighter concrete product.

The quarried, crushed and sized material is fed into a rotary kiln (or travelling grates), which is fired with coal/ coke/ natural gas, or fuel oil, to temperatures of 1,150-1,300 C. As the material is heated, it liquefies and carbonaceous compounds, in the material. form gas bubbles, which expand the material. In the process, volatile organic compounds (VOC) are released.

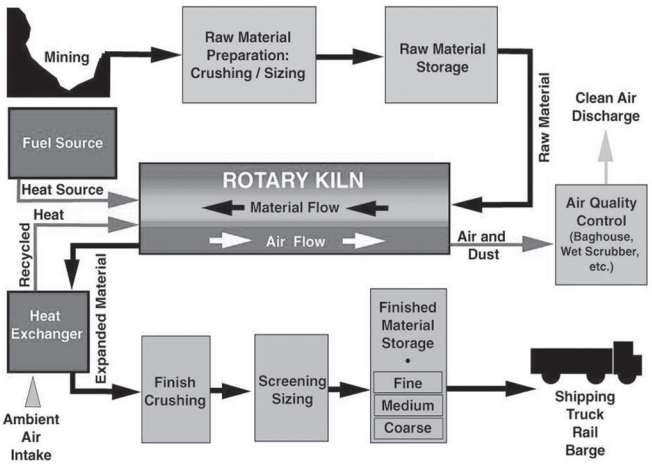


Fig. 6 Manufacturing of Expanded Shale, Clay and Slate

The expanded product (clinker) from the kiln is transferred by conveyor into the clinker cooler, where it is air cooled, forming a porous material. After cooling, the lightweight aggregate is screened for size, crushed if necessary, stockpiled, and shipped. The flow diagram of manufacturing expanded shale, clay and slate is shown in (Fig. 6).

Un-fortunately some undesirable emissions are produced in this process of manufacturing lightweight aggregate. These consist primarily of particulate matter (PM), which is emitted by the rotary kilns, clinker coolers, and crushing, screening, and during the material transfer operations. Pollutants emitted as a result of combustion in the rotary kilns include sulfur oxides (SO2), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO2), and VOCs. Chromium, lead, and chlorides also are emitted from the kilns. In addition, other metals including aluminum, copper, manganese, vanadium, and zinc are emitted in trace amounts by the kilns. Attempts are made to contain the pollutants.

LWA AS BY-PRODUCT OF INDUSTRIAL PROCESSES

These include foamed and granulated slag, organic cinder, coal cinder etc. obtained as by-products of industrial processed performed at elevated temperatures which after cooling are crushed and screened in different sizes for sale as alternative aggregate.

PROCESSING FLY ASH INTO LIGHTWEIGHT AGGREGATE

There is high importance of these technologies for India. Fly Ash is a nuisance by-product of thermal power plants, which now supply 69% of India's power needs. These plants are currently producing around 165 million tons (MT) of such ash per year. The government of the day is quite alive to the problem and has initiated steps in gainfully utilizing this product in cement making, mine filing, agriculture, brick making and road-embankments etc. It has also initiated steps to give increased stress to alternative, environment friendly power generation sources, like solar, atomic, hydraulic etc.

However, despite all this, nearly 100,000 acres of land is currently buried under fly ash dumps.

This ash is a very fine material, which pollutes the environment, while coming out of power plant chimneys and by blowing off with wind from storage sites. Moreover, leaching from the coal ash dumps carries toxins with it, which poisons the water bodies, like lakes, rivers, ponds, wells, tube wells, water pumps in the vicinity. Environment pollution control agencies[5] have established, that those consuming water from any of the sources. in the surroundings of these fly ash impoundments, are prone to cancer, lung, stomach, respiratory and other diseases, due to poisoning from arsenic and other toxic metals present in fly ash.

As per Planning Commission estimate[6], our fly ash output is likely to increase to 300 MT per year in 2017 and 900 MT per year by 2031-32. We can ill afford to subject our people to the tremendous derogatory health impact and waste precious land resource for stocking of this detrimental waste product, especially because we are an over populated country with growing population, where agriculture is the major occupation.

Many other countries, especially in the developed world like UK, USA, Europe, Japan, who are also facing similar problem with fly ash output, have made and continue to make, efforts in this direction. They have introduced different patented processes for the manufacture of structural grade lightweight aggregate, from this pulverized fuel ash. We, therefore need to critically review all these techniques for possible promotion in our country to assist in saving the environment, land and health of our people.

Sintering Process.

One such process, originally developed in UK, with other patented versions in USA, Japan etc. deploys a process of Sintering. Green pellets are formed from a mix offly-ash, pulverized coal and water in a pan type pelletizer and fed into a sinter strand, heated to around 1,200*C. The indurated pellets, emerging after sintering, are air cooled and dropped on to vibrating screens to form separate stock piles of 5-10mm and 10-15 mm aggregate for delivery to market. Fig.7 depicts a simplified process flow chart of this technology.

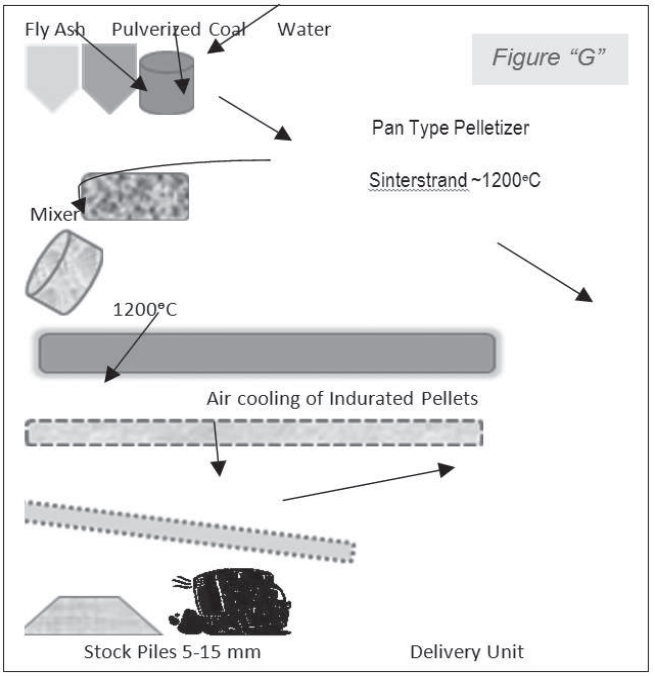


Fig. 7: Flow Chart of Sintering Process

Aardelite Technology.

Fig. 8 Flow Chart of Aardelite Process

A Dutch company[7] has developed another technology of processing fly ash pellets with quick lime and water, which are then cured with steam at around 85*C in a special plant. They are marketing their product by the trade name of "Aardelite". They seem to also have set-up plants in California and India. They claim their process to be simpler and cheaper than sintering. Fig 8 showl be schematic process flow chart of this technology.

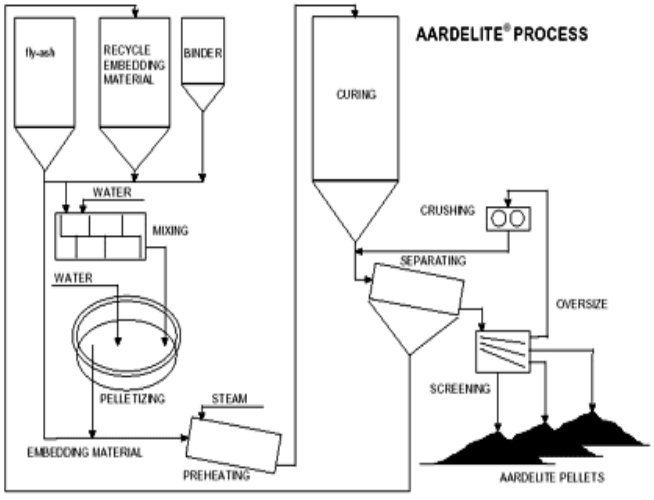


Fig. 8 Flow Chart of Aardelite Process

Fly Ash Aggregate Production under Ambient Conditions

Almost all the hitherto known technologies for production of fly ash aggregate, warrant heavy capital investment and need substantial energy in-put. This writer has, however,recently obtained a patent[8], of a very simple process of producing similar kind of LWA. The uniqueness of this process, is that it is performed under ambient conditions, makes use of simple basic equipment, has low investment. minimal power consumption, warrants no critical control at any stage of production and can be performed by unskilled manpower.

The process enables production of wide variety of particle sizes, as also a varied range of different controlled densities to suit diverse applications. Fig 9 is a picture of the different sized aggregate traduced using this simple process mention above.

Fig. 9: Sample Aggregate Produced Using Innovative Technology

The typical properties of fly ash aggregate produced by the two processes mentioned above and the test reports of samples produced using writer's new innovative technology, have been compared with the corresponding properties of normal crushed stone aggregate in Table-1 here-under:

It would be observed, that the artificial aggregate, produced as per this innovative process has similar primary physical characteristics, as obtained from the established processes. The merits of this alternative process are: -

- The process is performed under ambient conditions and even the produced aggregate is water mist/ spray cured, so energy consumption is minimal.
- The investment in this technology is far lower than the other alternatives. A sintering plant, apart from requiring high power consumption, would need an investment in the range of Rs. 100 Crores, while a plant using this innovative process could be set-up as a small scale unit, with investment under Rs. 10 crores and avail additional concessions available to this sector.
- This process also offers flexibility of producing different sized aggregate and in varied densities.
- Fly ash content of the input material can be over 80%, with the flexibility of also using other low cost waste fine materials like quarry dust etc.
- It can, therefore, easily be inferred, that the production cost of such an end product, would not only be cheaper than products of other processes, but also cheaper than natural crushed stone aggregate.
- It is expected, that even this technology, shall prove to be very popular and beneficial to the construction industry, just like the "site produced fly ash based cellular lightweight concrete technology", introduced by the author in India in 1995.

Table 1: Comparison of different types of Fly Ash Aggregates with Normal Stone Aggregate

ITEM	SINTERED FLY ASH AGGREGATE	AARDELITE PROCESS	INNOVATIVE PROCESS[9]	CRUSHED STONE AGGREGATE
Specific Gravity	1.3-1.6	1.7	1,23-1.44	2.75-2.95
Shape	Round	Round	Round	Angular
Bulk Density - kg/m3	750 - 900	1050	800 – 980	1,450 – 1,750
Particle Size –mm	5 – 15	Per Requirement	6 - 50	5 - 40 & greater
Water Absorption-%	14 – 18	18	20 - 20.3	0.5 – 1.5

MERITS AND DEMERITS

Merits

Lower dead weight, purity of man-made aggregate, Better physical properties because of lower modulus, lower coefficient of thermal expansion, easier drilling, Improved durability because of superior bond between aggregate and matrix, which penetrates inside the aggregate, Reduced shrinkage, Lower permeability, improved freeze-thaw resistance, savings in transport and labour costs and easier demolition etc.

Demerits

Reduced resistance to locally concentrated loads, more brittle, Greater care required in controlling water content, mixing, and supervision and need special measures for pumping concrete.

USAGE OF LIGHTWEIGHT AGGREGATE

As An Insulation Medium

Aggregates like perlite, vermiculite etc. have outstanding insulating characteristics and light weight, and are widely used as a loose-fill insulation in cavity walls and hollow block masonry constructions. In addition to providing thermal insulation, these enhance fire ratings, reduces noise transmission and are also rot, vermin and termite resistant.

When used as an aggregate in concrete, a lightweight, fire resistant, insulating concrete is produced, that is ideal for roof decks, under-floor insulation and other applications. Perlite can also be used as an aggregate in Portland cement and gypsum plasters for exterior applications and for the fire protection of beams and columns. Other construction applications include under-floor insulation, chimney linings, paint texturing, gypsum boards, ceiling tiles and roof insulation boards.

Production of Lightweight Aggregate Concrete

The use of LWAC has been a feature in the construction industry for centuries. The production of lightweight aggregate concrete has been expanding, and now includes all types – from no fines concrete of low density, mainly for block production for walling masonry work (Fig.10), to structural concrete with densities from 1000 to 1,800 kg/m3 and compressive strength up to 80MPa.

Fig. 10: LWA Blocks for Masonry

LWAC has been successfully used for construction of large span stadiums (Fig.11), Tall buildings (Fig.12), Bridges (Fig. 13), Shipbuilding (Fig.14), and in marine applications (Fig. 15).

Fig.11: Wellington Stadium, New Zealand

Fig. 12: Hearst Towers, Charlotte,NC (USA)

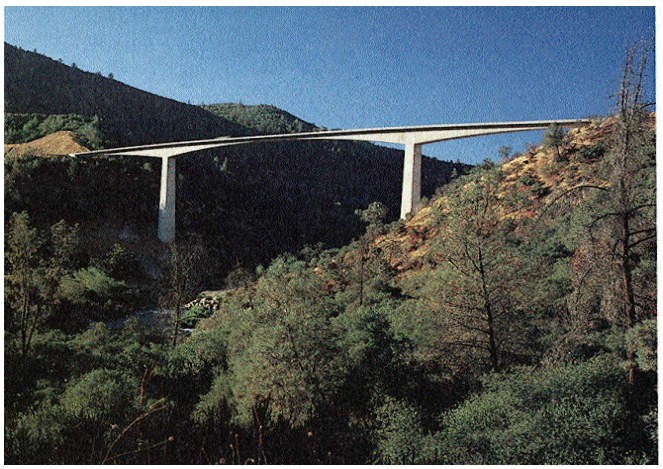


Fig. 13: LWA in Bridges

As per 1984 estimates, that there were over 400 LWC bridges in the world, especially in USA and Canada. Now many more have been and are being constructed in other counties like USSR, Holland, Japan etc.

At the time, when it was constructed, the 195m center span of California's Parrotts Ferry Bridge was the longest span built by the cantilever method in the U.S.A.The use of structural lightweight concrete reduced dead weight by 20 percent and construction cost by 10 percent. A recently constructed Benicia-Martinez bridge in California, has spans varying from 127m to 201m in its total length of 2.3 Km.

LWAC has been a successfully used for marine applications and in shipbuilding for almost centuries. LWC ships were produced in the USA during the 1914-1918 war, and their success even led to the production of a war ship-"USS Selma".

Fig. 14: LWA in Ship Building

The offshore drilling unit shown in Fig. 15 was towed from where it was built in Japan, to the Beaufort Sea, north of Alaska. The midsection of the structure (called the BRICK) was made of structural lightweight concrete. To withstand sea and ice loads, this lightweight concrete was also high strength and air entrained.

Use as Waste Water Filter Beds[10].

In the treatment of municipal waste, filter beds are used where a bacterial film anchors and develops on aggregate surfaces. The surface of lightweight aggregates provides an ideal medium for the development of this bacterial growth and is particularly effective in lowering the phosphates content. The texture of vesicular aggregate provides

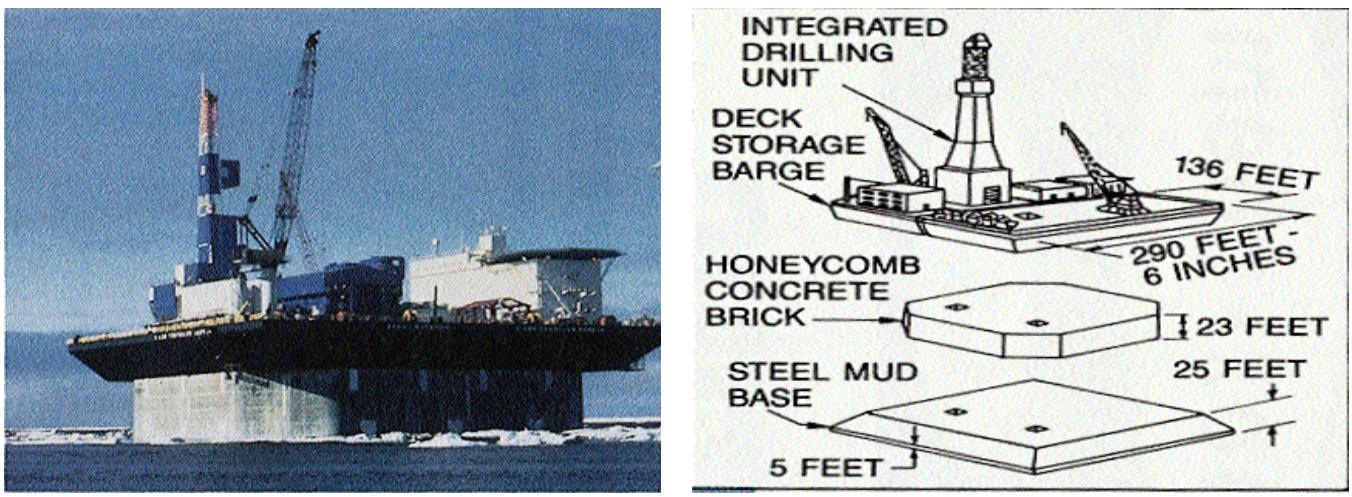


Fig. 15: LWA in Marine Applications

an effective attraction for the beneficial organisms to form, as compared to normal weight aggregates. The same beneficial result occurs when drainage from urban areas flow through lightweight aggregates, or through soils containing lightweight aggregates.

Horticultural Applications

Lightweight Aggregates like perlite, vermiculite, Leca and similar other low density products are a sought after product for application in horticulture. As a horticultural application, it is not only 30% lighter as a growing medium, but the vesicules within the aggregate, become reservoirs of irrigation water and fertilizer because of higher water absorption capacity, thereby reducing operation and maintenance costs. Also being clean, these are used as common growing medium for planters in households and offices.

In the quest to reduce the "heat island" generated by cities, the most sensible approach is to replace impermeable non-reflective surfaces, such as tar and gravel roofs with vegetation. This presents an increased structural load which can easily be reduced by employing lightweight aggregates, as the growing media for green roofs, which reduces the heat island effect in urban areas.

Germany is the leader in terms of numbers of green roofs, where they make extensive use of Leca® and Liapor® expanded clay aggregates, as ingredients for the growing medium and also for the drainage layer.

In the past several years a large number of roof top gardens (Fig. 16) have made good use of the expanded lightweight aggregates even in the USA.

Fig. 16: Roof Garden

CONCLUSION

"Production of Fly-Ash Lightweight Aggregate" is very important pertaining to utilization of an industrial waste product for producing artificial aggregate for construction industry. The innovative process of the author is superior to several of the existing international technologies, which require heavy investments and very high energy input. Such an alternative aggregate not only has 80%-85% fly ash content, but would also save degradation of nature through mining and crushing of natural stone at quarries, for production of normal concrete. The structural applications of such lightweight aggregate, instead of normal stone aggregate in concrete, also saves on cost and time of construction, as brought out in the paper. LWAC has been successfully used for construction of large span stadiums, tall buildings, bridges, shipbuilding and in marine applications.

REFERENCES

[1] T.W. Bremer, J.P. Ries and W.H. Wolfe; Achieving Sustainability with Lightweight Aggregate.

[2] Lightweight Aggregate Concrete, Japan

[3] Lightweight Aggregate manufacture; PCA- USA

[4] Expanded Shale, Clay &State Institute, Saltlake, Utah -USA; Chapter 2; Manufacturing of ESCS lightweight Aggregate.

[5] PMI Ash Technologies LLC, 6300-170, Greenmoor Road # 372, Raleigh, NC - 27612 (USA)

[6] Physicians for Social Responsibility, US affiliates of International Physicians for Prevention of Nuclear War; Coal Ash Hazards to Human Health

[7] R K. Joshi, Department of Science and Technology; Fly Ash Scenario in India. pp3

[8] Indian Patent No: "228364" entitled "An Apparatus & Process foe Production of Synthetic Lightweight Aggregate; Patentee "Gurbaksh Singh".

[9] Results of test reports of 3 - samples of LWA produced per Innovative Process Conducted by "Bureau Veritas (India) Private Ltd." F-4, Sector-3, Noida-201203 on June 15, 2015 & August 10, 2015.

[10] Clean Soil, Air, Water article June 02, 2014 on Performance evaluation of LWA…

TECHNICAL SESSION - IV

ENERGY MANAGEMENT

NET ZERO ENERGY BUILDINGS: CASE STUDIES

Rajendra Kumar*

Abstract

Net Zero Energy Building (NZEB) concept is an attempt of reduction of energy consumption in building through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. In the present era of rapid technological advancement, we need to think new ways of using energy and try to maximize the advantage of renewable energy sources in our buildings. NZEB is regarded as an integrated solution to address problems of energy-saving, environmental protection, and CO2 emission reduction in the building section. A building approaching zero energy is called "near-zero energy building" or "ultra low energy building". It is believed that most NZEBs are very "green"; however, very few green buildings use zero energy. NZEB and green building have many similarities since both aim to reduce energy bills and greenhouse gas emission to achieve high-performance energy efficient buildings. The goal of green building is to use resources more efficiently and reduce building's negative impact on the environment. NZEB may or may not be considered "green" in all areas, such as reducing waste, using recycled building materials, etc. Also, ZEB does not consider the embodied energy of the structure, energy for construction of the building and energy for transport or commuting.

Paper discusses few case studies of contemporary buildings and projects in different continents, which are using natural and renewable energy by means of innovations in architectural design and incorporation of latest technology.

INTRODUCTION

Net Zero Energy buildings represent a new paradigm in building design, providing super-efficient structures that generate as much energy as they consume over the course of a year. This approach to design has the potential to make massive inroads into the total amount of greenhouse gas (GHG) emissions associated with building energy use supplied by nonrenewable, carbon-based sources of power. Heightened concerns about the GHG issue are driving and transforming the leaders within the building industry to target this new level of building performance. As the case studies illustrate, architects and engineers generally have the skills and experience to design Net Zero buildings provided that this objective is consistently embraced in the early part of the process and involves integrated disciplines with each early decision-making step.

As the "zero energy" and "net zero energy" concepts are relatively new, there are not yet definitive, widely accepted zero-energy metrics. There are several definitions for "net zero energy", and they encourage building designers, owners, and operators to select the metric that best fits their project. It suggests four ways in which net zero energy may be defined:

- Net Zero Site Energy
- Net Zero Source Energy
- Net Zero Energy Costs
- Net Zero Energy Emissions

Site Energy refers to the energy consumed and generated at a site (e.g. a building), regardless of where or how that energy originated. In a net zero site energy building, for every unit of energy the building consumes over a year, it must generate a unit of energy.

Source Energy refers to primary energy needed to

**Architect & Associate Professor at Ansal University, Gurgaon.*

extract and deliver energy to a site, including the energy that may be lost or wasted in the process of generation, transmission and distribution. For example, a coal-burning power plant may generate 1 Joule of electricity for every 3 Joules of energy in the coal consumed. If natural gas is used at a site, for every 20 Joules consumed, 1 Joule may be needed to extract and distribute the gas to the site. Metrics for net zero source energy buildings account for these factors, though exact metrics can vary depending on site and utility factors.

Net Zero Energy Cost is perhaps the simplest metric to use: it means that the building has an energy utility bill of Zero over the course of a year. In some cases, building owners or operators may take advantage of selling renewable energy credits from on-site renewable generation. Many conventional energy sources result in emissions of carbon dioxide, nitrogen oxides, sulfur dioxide, etc.

Net Zero Energy Emissions building either uses no energy which results in emissions or offsets the emissions by exporting emissions-free energy (typically from on-site renewable energy systems).

GRID CONNECTION AND NET ZERO

Most Net Zero Energy buildings are still connected to the electric grid, allowing for the electricity produced from traditional energy sources (natural gas, electric, etc.) to be used when renewable energy generation cannot meet the building's energy load. When, conversely, on-site energy generation exceeds the building energy requirements, the surplus energy should be exported back to the utility grid, where allowed by law. The excess energy production offsets later periods of excess demand, resulting in a net energy consumption of zero. Due to current technology and cost limitations associated with energy storage, grid connection is usually necessary to enable the Net Zero Energy balance. Differences in how utilities and jurisdictions address payment for energy that is exported from the building into the grid can impact project economics and should be carefully evaluated.

ENERGY EFFICIENCY

Regardless of the definition or metric used for a Net Zero Energy Building, minimizing the energy use through efficient building design should be a fundamental design criterion and the highest priority of all NZEB projects. Energy efficiency is generally the most cost-effective strategy with the highest return on investment, and maximizing efficiency opportunities before developing renewable energy plans will minimize the cost of the renewable energy projects needed. Using advanced energy, design teams can optimize efficient designs and technologies.

Energy efficiency measures include design strategies and features that reduce the demand-side loads such as high-performance envelopes, air barrier systems, day lighting, sun control and shading devices, careful selection of windows and glazing, passive solar heating, natural ventilation, and water conservation.

Once building loads are reduced, the loads should be met with efficient equipment and systems. This may include energy efficient lighting, electric lighting controls, high-performance HVAC, and geothermal. Energy conversion devices such as systems, fuel, and micro turbines do not generate renewable energy. Instead, they convert fossils fuel energy into heat and electricity and are can be considered energy efficiency strategies.

RENEWABLE ENERGY

On-Site Renewable Energy

Once efficiency measures have been incorporated, the remaining energy needs can be met using renewable. Common on-site electricity generation strategies include photovoltaic (PV), solar water heating, and wind turbines.

Renewable, on-site thermal energy can sometimes be provided by effective use of biomass. Wood, wood pellets, agricultural waste, and similar products can be burned on-site to provide space heating, service water heating, etc. Biofuels, such as biodiesel, may also be used in conjunction with conventional fossil fuels to meet thermal loads. Priority should be given to renewable approaches that are readily-available, replicable, and most cost-effective. System maintenance must also be given consideration. Life-cycle cost analysis should be used to evaluate the economic merits of various systems over their usable lifetimes.

Off-Site Renewable Energy

Depending on the NZEB metric and guidelines used, buildings may be permitted to use energy generated off-site to offset energy used in a building. If space is limited, a facility owner may install dedicated wind turbines, solar collectors, etc. at a separate location. Most often, however, credit for off-site renewable generation is gained by purchasing renewable energy credits (RECs). RECs are available from many renewable energy technologies. Large, utility-scale wind farms, solar plants, geothermal plants, and hydropower facilities generate electricity without using fossil fuels or primary energy. The costs of constructing and operating these generation facilities are often paid for by selling the "credit" for generating energy renewably (as well as selling the energy itself). The structure and market for RECs is evolving and it varies regionally.

Here's a simple "order of operations" for better NZEB.

- Reduce energy loads
- Optimize design for passive strategies
- Optimize design of active systems
- Recover energy\
- Generate energy on-site
- Buy energy/carbon offsets

CASE STUDIES

Bahrain World Trade Center

Fig.1: Bahrain World Trade Centre

The Bahrain World Trade Center (BWTC) is the world's first building to integrate large-scale wind turbines; and together with numerous energy reducing and recovery systems. This development shows an unequivocal commitment to raising global awareness for sustainable design. This building is pioneering a new direction for designers and owners acting as a technological precedent. The BWTC (Fig.1) has shown that commercial developments can be created with a strong environmental agenda and addresses the needs of our future generations. The BWTC encapsulates the essence of a sustainable philosophy engaging all of the social, economic and environmental impacts of the project. As well as making significant strides in environmentally balanced architecture, the building is now considered a source of national pride for Bahrain residents, and is attributed with generating economic prosperity within the capital of Manama.

The BWTC forms the focal point of a master plan to rejuvenate the 30-year-old existing hotel and shopping mall on the site. The planning of the site became constrained by the existing buildings and the road network around the site. By extending the main axis of the existing shopping mall towards the sea and creating a secondary axis from the Hotel, "Retail Streets" were established. The twin towers' natural location was therefore positioned on the main axis, facing the Arabian Gulf and creating the entrance for the development.

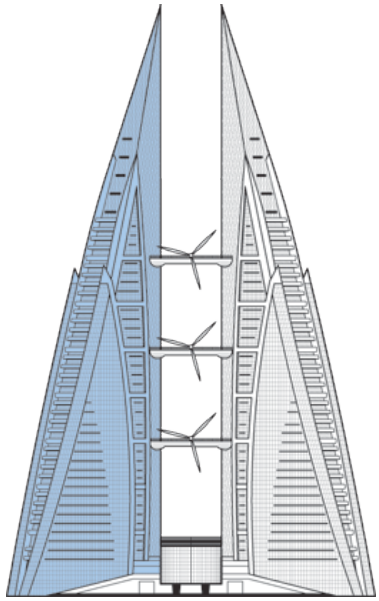


Fig. 2: Location of Wind Turbines

The inspiration for the 42-story twin towers (Fig.2) originated from regional "Wind Towers" and their ability to funnel wind, and the vast sails of the traditional Arabian Dhow as they harness the breeze in driving them forward. After careful computational fluid dynamics (CFD) modeling and extensive wind tunnel testing, the towers' shape was literally carved out by the wind to create optimum airflow around the buildings. The elliptical plan forms act as aerofoil, funneling the onshore breeze between them, creating a negative pressure behind, thus accelerating wind velocity between the two towers. Vertically, the sculpting of the towers is also a function of airflow dynamics.

Fig. 3: Wind Turbines

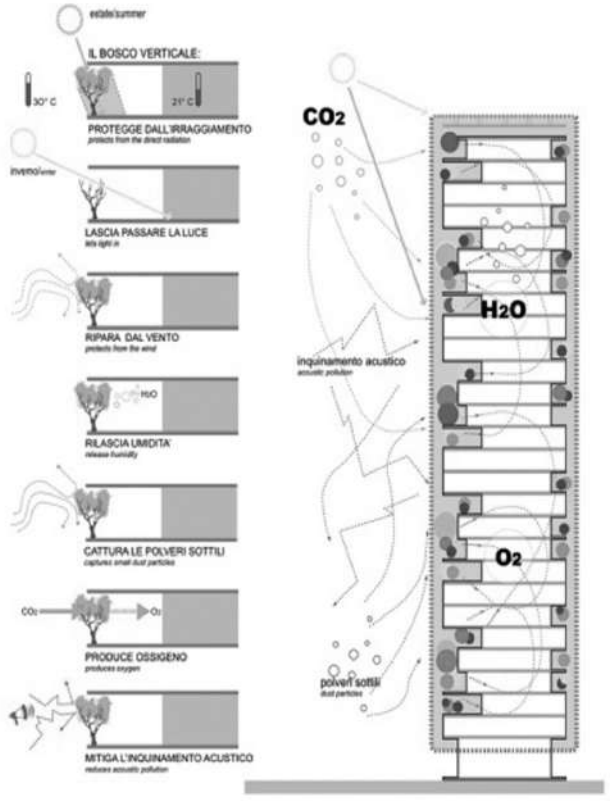
As they taper skywards, the aerofoil sections reduce. This effect, combined with the increasing onshore wind velocity at higher altitudes creates a near equal regime of wind speed on each of the three turbines, irrespective of height, allowing them to rotate at the same speed and generate the same energy levels. The three 29-meter (95-foot)-diameter, 11 ton wind turbines are supported on 31.5-meter (103-foot), 70 ton bridges between the towers. Each turbine generates 225kW. The buildings have been sculpted to funnel the uninterrupted on-shore breeze onto the turbines and create a perpendicular slip stream that corrects the wind direction to take advantage of 70% of Bahrain's wind energy. The premium on this project for including the wind turbines was less than 3% of project value. Based on the energy savings and the increased value of the building having wind turbines, the payback period is extremely favorable. The initial energy yields during the design phase was approximately 15%, therefore 1300MWh per year; however, from early commissioning results the turbines (Fig.3) are estimated to generate substantially more energy due to the reduced occupancy profile of the building and the wider operational period of the turbines.

Bosco Verticale, Milan, Italy.

"Bosco Verticale" building,(Fig.4) The Vertical Forest is an architectural concept which replaces traditional materials on urban surfaces using the changing polychromy of leaves for its walls. The biological architect relies on a screen of vegetation, needing to create a suitable microclimate and filter sunlight, and rejecting the narrow technological and mechanical approach to environmental sustainability. The Vertical Forest increases biodiversity. It promotes

Fig. 4: Bosco Verticale Building

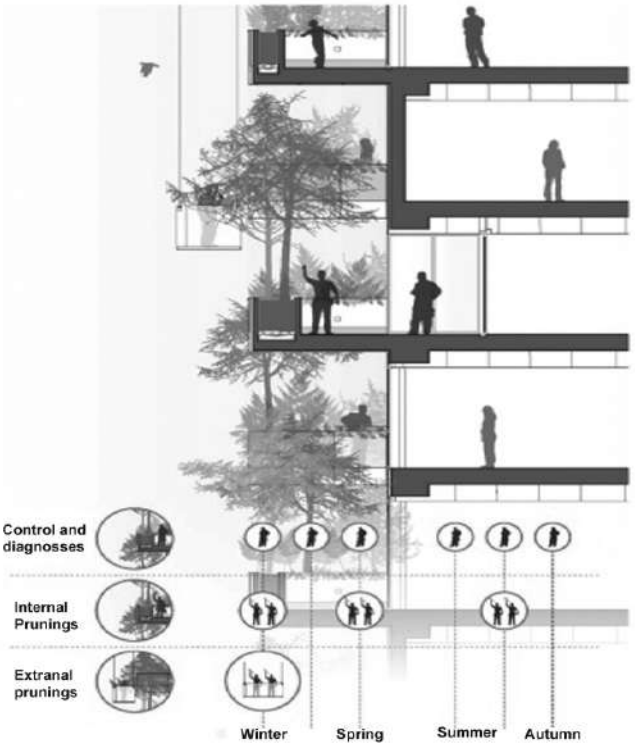
the formation of an urban ecosystem where various plant types create a separate vertical environment, but which works within the existing network, able to be inhabited by birds and insects (with an initial estimate of 1,600 specimens of birds and butterflies). In this way, it constitutes a spontaneous factor for repopulating the city's flora and fauna.



Mitigation

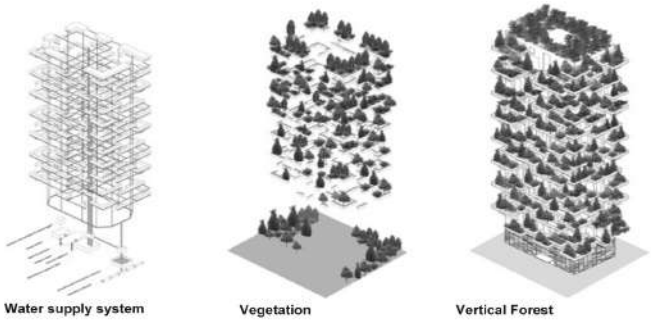
The Vertical Forest helps to build a microclimate and to filter fine particles contained in the urban environment. The diversity of plants helps to develop the microclimate which produces humidity, absorbs CO2 and particles, produces oxygen, and protects against radiation and noise pollution.

The Vertical Forest is an anti-sprawl method which helps to control and reduce urban expansion. In terms of urban density, each tower constitutes the equivalent of a peripheral area of single family houses and buildings of around 50,000 sqm.



Trees

The choice of species and their distribution according to the orientation and height of façades is the result of three years of studies carried out alongside a group of botanists and ethnologists. The plants which are used on the building were pre-cultivated in a nursery in order for them to become accustomed to similar conditions to those which they will find on the balconies.



Anti-sprawl

Changing façades

The Vertical Forest is an ever-evolving landmark of the city, whose colors change depending on the season and the different natures of the plants used.

Hydration and irrigation system

Following micro-meteorological studies, the calculation of irrigation requirements was carried out by examining climatic characteristics and is designed depending on the exposure of each façade and the distribution of vegetation on each floor.

India's Net Zero Energy Building: Indira Paryavaran Bhavan, New Delhi

Fig. 5: Indira Paryavaran Bhavan

Indira Paryavaran Bhavan, New Delhi is India's first net zero energy building that has been constructed with adoption of solar passive design and energy-efficient building materials.

The Indira Paryavaran Bhavan is one of the first buildings in India to have deployed energy efficiency and renewable energy technologies at a large scale. It is one of the exemplary projects to be rated under Green Rating for Integrated Habitat Assessment (GRIHA) and has set standards that can be emulated by upcoming buildings in the region.

The building boasts an earthquake-resistant structure with a total plinth area of 31,488 sq. m. It covers only 30 per cent of the total area, while more than 50 per cent area outside the building is a soft area with plantation and grass. The building has a robotic parking system in the basement that can accommodate 330 cars. Thin-client networking system has been provided instead of conventional desktop computers to minimize energy consumption.

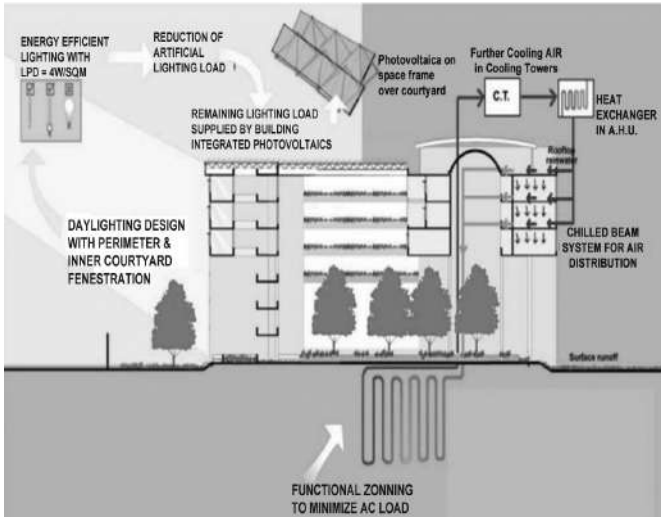


Fig. 6: Green Building Strategies

Buildings have an enormous impact on environment, human health and economy. The energy used to heat and power our buildings leads to consumption of large amounts of energy, mainly from burning of fossil fuels, oil, natural gases and coal, which generate significant amounts of carbon dioxide, the most widespread greenhouse gas. The successful adoption of green building strategies can maximize both the economic and environmental performances of buildings.

Fig. 7: Natural Daylight

The design allows for 75 per cent of natural daylight to be utilized to reduce energy consumption. The entire building has an access friendly design for differently-able persons. With an installed capacity of 930 kW peak power, the building has the largest rooftop solar system among multi-storied buildings in India. The building is fully compliant with requirements of the Energy Conservation Building Code of (ECBC) India. Total energy savings of about 40 per cent have been achieved through the adoption of energy efficient chilled beam system of air-conditioning. As per this, air-conditioning is done by convection currents rather than airflow through air handling units, and chilled water is circulated right up to the diffuser points unlike the conventional systems. Green materials like fly ash bricks, regional building materials, materials with high recyclable content, high reflectance terrace tiles and rock wool insulation of outer walls have been used. For doorframes and shutters renewable bamboo jute composite materials are used. UPVC windows with hermetically sealed double glass are installed. Pavements and roads are of calcium silicate ceiling tiles with high recyclable content and grass paver blocks.

Reduction in water consumption has been achieved by use of low-discharge water fixtures, recycling of waste water through sewage treatment plant, use of plants with low water demand in landscaping, use of geothermal cooling for HVAC system, rainwater harvesting and use of curing compounds during construction.

CONCLUSION

A good NZEB design should first encourage energy efficiency, and then use renewable energy sources available on site. A building that buys all its energy from a wind farm or other central location has little incentive to reduce building loads, which is why we refer to this as an off-site NZEB. Efficiency measures or energy conversion devices such as day lighting or combined heat and power devices cannot be considered on-site production in the NZEB context. Fuel cells and micro turbines do not generate energy; rather they typically transform purchased fossil fuels into heat and electricity. Passive solar heating and delighting are demand-side technologies and are considered efficiency measures. Energy efficiency is usually available for the life of the building; however, efficiency measures must have good persistence and should be "checked" to make sure they continue to save energy. It is almost always easier to save energy than to produce energy. The key to designing net zero energy buildings is first reducing energy demand as much as possible, and then choosing good energy sources.

BIBLIOGRAPHY

1. https://www.wbdg.org/resources/netzeroenergybuildings.php
2. http://www.thehindu.com/news/cities/Delhi/indias-first-net-zero-energy-building/article6589478.ece
3. https://energydesignresources.com/media/19864463/zne_case_study_buildings-11.pdf?tracked=true
4. http://global.ctbuh.org/resources/papers/download/2099-a-new-urban-forest-rises-in-milan.pdf
5. http://www.archdaily.com/777493/hans-and-delphine-atelier-vens-vanbelle/564e5e02e58ece4d73000386-hans-and-delphine-atelier-vens-vanbelle-image?ad_medium=widget&ad_name=navigation-next
6. http://www.ctbuh.org/TallBuildings/FeaturedTallBuildings/Archive2008/BahrainWorldTradeCenterManama/tabid/4371/language/en-GB/Default.aspx

ROLE OF ENERGY EFFICIENCY IN SMART AND SUSTAINABLE DEVELOPMENT

USHA BATRA*

Abstract

Smart and sustainable habitat design has direct impact on energy and resource consumption. To achieve energy efficiency in India, energy consumption needs to be reduced through conservation, adoption of energy efficiency measures and exploration of renewable energy generation resources. Maximum consumption being in building sector, it will require mandate of energy efficient and net zero buildings using renewable energy and adopting green building concept. The other two main sectors being transportation and transmission and distribution, followed by agriculture are required to be addressed simultaneously.

The country has great potential of renewable energy which is also environment friendly, clean and safe, especially solar energy, which has maximum potential followed by wind, biomass and hydro. Country has already started use of solar coaches and solar aircraft. Slowly and steadily, increasing the share of renewable energy and ultimately a complete shift to renewable energy is the solution to smart and sustainable habitat.

INTRODUCTION

India is at the threshold of a major shift in the way human habitation is perceived. By the end of 2030, 250 million new urbanites are expected to join Indian cities. This significant transformation needs sustainable solution to extend a decent quality of life to every citizen in the country. The electrical energy demand will reach about 500GW by 2030 with an installed capacity requirement of 800 -900GW. Present power plants particularly thermal plants are the source of CO2 emissions. On an average global CO2 emission is growing at 1.3% per year. CO2 emissions expected to increase from 71% in 2006 to 76% in 2030 and thus there is an urgent need to switch over to other non polluting sources of electricity generation. Simultaneously, there is a need to evolve energy efficient design of habitat which is smart and comfortable to our requirements and climatic conditions.

There is no doubt that human habitat needs energy and resources to survive and sustain its living standard. It is known that proper habitat design has a direct impact on energy and resource consumption. In the past we have planned and designed many habitats, including the newly developed urban habitats like Noida, Gurgaon, and Raipur and so on struggling with various issues arising from poorly conceived habitat design, based on Western thoughts, while ignoring the ethos of Indian habitat design. It is also evident that optimization of energy consumption and maintenance of environmental balance is a pre requisite for achieving the goal of sustainable habitat design, which requires emphasis on smart - architecture and built form, urban planning and design, physical infrastructure, social infrastructure, water and sanitation, transportation, economy, energy and environment, governance, and smart housing resilient to natural disasters.

For energy security of any nation, it is very important to reduce the dependency on imported energy sources. However, out of all these options, the simplest and the most easily attainable are to reduce the demand through persistent energy conservation/efficiency efforts. Energy conservation and energy efficiency are related concepts aiming at saving energy, often used interchangeably, but are different. Energy conservation is a behavioural change where as energy efficiency aims in using energy more effectively. Energy conservation often

**Additional Director General, CPWD, Mumbai*

involves sacrifices to comfort and safety whereas energy efficiency delivers the same output with less input. Thus, there is a need to curtail dependency of energy produced from non renewable resources. Energy efficient buildings are to be planned and constructed for comfortable working environment simultaneously reducing the demand of energy to conserve the fast depleting natural resources. It was estimated that in case standard energy efficiency measures are implemented in new construction and major retrofits, India alone could save 2988 MW of generation capacity from 2010 to 2030. It can further be complemented by constructing net zero buildings and making best use of renewable resources like sun and wind.

Besides above, renewable energy has the following additional socio-economic impact to the society;

- Local employment
- Capacity building and skill up gradation
- Export potential
- Industrial growth
- Health improvement

ENERGY EFFICIENCY MEASURES FOR BUILDINGS

Energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. Some of the measures are given below:

Reducing Heating Demand

Heating demand can be reduced by limiting the exposed surface area of the building, improving the insulation of the building's fabric, reducing ventilation losses by selecting efficient heating systems with effective controls.

Reducing Cooling Demand

Energy use in typical air-conditioned office buildings is approximately twice of naturally ventilated office buildings. The need for air-conditioning or the size of the systems installed can be reduced by controlling solar gains through glazing, reducing internal heat gains, setting AC thermostat at 25-26°C instead of 23-24°C, making use of thermal mass and night ventilation to reduce peak temperatures, providing effective natural ventilation, reducing lighting loads and installing effective lighting controls.

Reducing the Energy Requirements for Ventilation

The main use of energy for both mechanical cooling and for air conditioning is the fans needed to circulate the air. Fan energy use for mechanical ventilation can be reduced by designing the system to reduce pressure drops, selecting efficient fans, utilizing variable speed fans to respond to varying load requirements, avoiding excessive air supply volumes, etc.

Reducing Energy Use for Lighting

This can be accomplished through making maximum use of daylight while avoiding excessive solar heat gain, using task lighting to avoid excessive background luminance level, installing energy-efficient luminaries' with a high light output to energy ratio, selecting lamps with a high luminous efficacy, providing effective controls like occupancy sensors, smart light control for street lights that prevent lights being left on unnecessarily.

Reducing Energy Demand for Heating Water

This can be achieved by installing time controls, and setting them to correctly reflect the hours of hot water requirement, replacing any damaged or missing insulation from all hot water pipe work and cylinders, except where the pipes are providing useful heat into the space and identifying a suitable hot water system. The most significant reduction in energy use for hot water can be achieved by providing solar water heating.

Some examples of energy savings in LEED rated green buildings in India are given in Table 1.

MEASURES FOR GREEN RATINGS OF BUILDINGS

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) formed in the year 2001 provides green Building rating system, focusing on five major areas e.g., sustainable site development, energy efficiency, water efficiency, building materials and wastage, indoor environment

Table 1: Energy Savings in LEED-Rated Green Buildings in India

Building	Built-in Area (m^2)	Energy consumption (kWh)		Rating achieved	EPI(kWh/m^2)
		conventional	LEED Designed % reduction		
CII-Godrej GBC, Hyderabad	1,858	350,000	130,000 (63%)	Platinum (56 points)	70
ITC Green Centre, Gurgaon	15,794	3,500,000	2,00,000 (45%)	Platinum (52 points)	127
Wipro,Gurgaon	16,258	4,800,000	3,100,000 (40%)	Platinum (57 points)	191

EPI: Energy Performance Index

quality and innovation in designs.

GRIHA attempts to minimize resource consumption and wastage thereby reducing the environmental impact during the entire lifecycle of a building from construction to operation and then demolition consuming various resources like energy, water, materials, etc., besides emitting wastes, through enhanced assessment tools.

ECBC 2007 provides design norms for building envelope, including thermal performance requirements for walls, roofs, and windows, Lighting system, including day lighting, HVAC system, including energy performance of chillers and air distribution systems and Electrical system.

During the development of ECBC, analysis conducted through energy simulation indicated that ECBC-compliant buildings use 40 to 60% less energy than conventional buildings being designed and constructed at that time.

Government of India (BEE, Ministry of Power) introduced the Standards and Labelling Program in May 2006. Under this program the manufacturers are required to place a label showing how much electricity the appliance will consume under certain conditions. BEE star rating of office buildings conducts energy audit to analyze energy efficiency and track improvements in comparison to other buildings. The star can vary from 1 to 5, where 5 being the best rating.

Perform Achieve and Trade (PAT) scheme designed and implemented by the Bureau of Energy Efficiency (BEE), under the Ministry of Power, Govt. of India, is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy intensive large industries and facilities, through certification on energy savings that could be traded.

Indian Railways launched a portal, RAILSAVER (https://www.railsaver.gov.in/), in April 2014 with an aim to improve energy efficiency in Indian Railways. This initiative will facilitate railways in saving energy up to 15% by the year 2020, through improved energy efficiency measures.

ENERGY CONSUMPTION AND SAVING POTENTIAL

Distribution of total energy consumption and sector wise consumption in India during 2012 is as given below in Figure1 & 2 respectively;

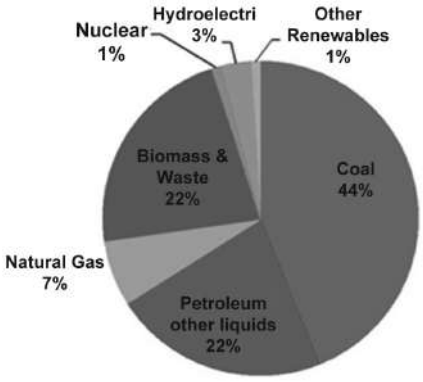


Fig. 1: Distribution of total energy consumption in India during 2012

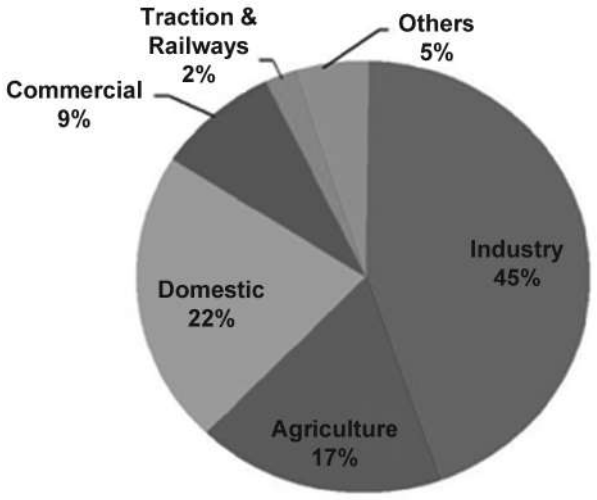


Fig. 2: Distribution of sectorwise consumption in electricity during 2012

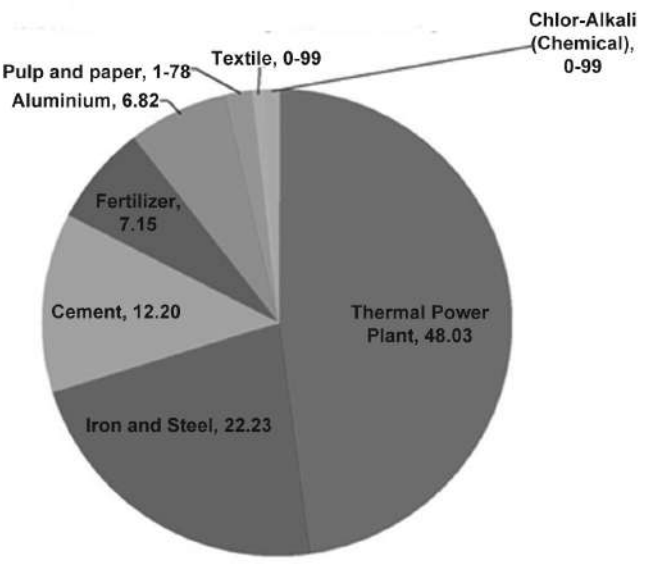


Fig. 3: % Saving Targets Envisaged under PAT

Energy Consumption and Saving Opportunities in Industries

It is seen above that maximum consumption is in Industrial sector. BEE has identified savings of 66.86 lakh toe from industrial sector through PAT, maximum from thermal power plants followed by other industries.

Thermal power plants form 50% share in PAT, with the rest 50% formed by iron and steel, cement, fertilizer, aluminium, pulp and paper, textile and chlor-alkali. Thermal power plant efficiency varies from 16.7% to 48.5%; the lowest being for coal based one. A total of more than 5.2crore tones of coal can be saved just by improving the power plant efficiency from 30to35%(30% being the average coal based power plant efficiency in India)and the corresponding saving in monitory terms would be about Rs. 8,440 crore per annum. At the same time generating units of power plants older than 30 years having very low efficiency needs to be replaced gradually with energy efficient ones. Similarly total saving per annum worth Rs. 16,200 crore is identified in Iron and Steel sector, Rs. 5,400 crore in cement sector, Rs.20,800 crore in chemical industry, Rs. 2,100 crore in aluminium sector, Rs. 3,750 crore in pulp and paper industry, and Rs. 13,940 crore in textile industry. Percentages saving targets envisaged under PAT are shown below in Fig.3.

Energy Consumption and Saving Opportunities in Building Sector

The next highest consumption sector is the building sector which includes residential and commercial buildings. This sector accounts for almost 29% of total electricity consumption. By incorporating the energy efficiency measures in new commercial buildings, there can be a potential saving up to50%. The major energy consuming equipments in the sector are the heating, ventilation and air conditioning(HVAC) systems, fans and lights. The energy saving opportunity in commercial buildings can be tackled more easily as compared to the residential buildings. In commercial buildings, consumption by lighting is 25% and by HVAC 55%. Possible reduction in lighting is 20-50%, HVAC is 20-60% and electronic and others is 20-70%. In residential, ceiling fans and lighting consume 62% energy. Use of CFLs and LEDs can bring approximately 40% reduction in consumption. Percentage consumption of various equipments in residential and commercial buildings is given below in Fig.4 & 5 respectively.

Energy Savings Opportunities in Sectors Other than Building Sector

It is estimated that up to 30% energy saving can be achieved by adopting smart street light controls alone. Considering 50% saving potential in street lights, 300crore units of electricity can be saved per

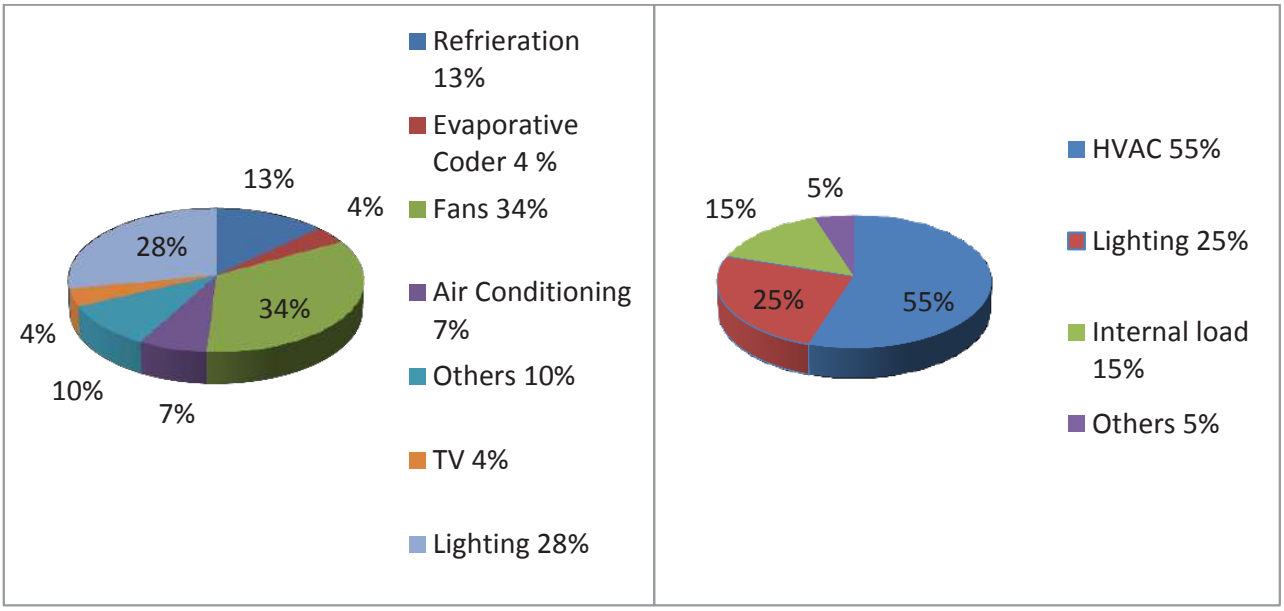


Fig. 4 Energy Consumption in resdl. Sector

Fig. 5 Energy Consumption in Commercial Sector

annum bringing saving worth Rs. 6,000 crore per annum.

Similarly in transportation sector, saving per annum worth Rs. 53,600 crore in agriculture pumps, saving worth Rs. 16,500crore, in ceramic industries, saving worth Rs. 714crore, in SME, saving worth Rs. 15,900crore in coal mining, saving worth Rs. 300crore, in power transmission and distribution, saving worth Rs. 35,000-40,000crore, and in sugar industry, saving worth Rs. 6,750 crore is envisaged. Net saving envisaged in Indian railway sector is 0.34 million toe and 2.07 billion kWh.

ENERGY EFFICIENCY INVESTMENT POTENTIAL

From the savings envisaged above, it is estimated that energy efficiency investment potential over a period of 5 years is highest i.e. Rs.2,70,000crore in transportation sector followed by transmission and distribution sector with Rs,2,00,000crore. Commercialand residential sectors together contribute to Rs. 1,11,000crore where residential sector contributes to the major share. Chemical sector including the petrochemical sector has an investment potential of about Rs 1,00,000 crore which is in line with the energy efficiency investment envisaged in agricultural water pumping. Thereafter, major potential exists in the SME sector amounting to around Rs.80,000crore.Coal based thermal power plants alone have an investment potential of about Rs. 42,200crore.Other sectors like textile, steel and iron, streetlight, coal, cement, aluminium, paper manufacturing industries etc. contribute to Rs.3,00,000crore.To achieve potential energy savings mentioned above, the following measures need to be taken on priority.

- Mandatory waste heat recovery system (WHRS) industries like steel and iron sector, thermal power plant, cement industry, sugar industry, and various SMEs.
- Use of energy efficient appliances/machinery in all the sectors.
- Adopting energy efficient lighting system in residential, commercial and industrial sectors. To begin with, all the public buildings and public places shall be equipped with efficient lighting systems and necessary awareness generation and promotional measures are required to be taken on priority for their use.
- Use of energy efficient and environmental friendly electrical/hybrid vehicles needs to be promoted through various financial incentives.
- Identify the energy saving potential and implement various energy efficiency measures, make energy audit mandatory in all the industrial,

commercial and other sectors.

- Carry out capacity building and training programmes regarding energy efficiency by making them mandatory in the annual training calendar of different corporate sectors/ industries.
- Promote greater awareness and ensure compliance with energy conservation and energy efficiency issues by including them in education curriculum, both at school and college levels.
- Ensure compliance of various energy efficiency policies and regulation through various national and state level certification agencies.

It is expected that with the proposed energy saving measures about 246 billion units of electricity, 88 million tonnes of coal and 12 billion litres of oil can be saved per annum. This will also help in reducing CO_2 emission.

The investment in residential sector is huge since it basically involves replacement of the old high energy consuming equipment with more efficient ones (high star rated). This basically involves tube lights, lamps, ACs, TVs, refrigerators, fans and air coolers. The potential is given below in Table 2. Further to make them smart, they need to be compatible to smart energy meters.

Table 2: Energy Efficiency Investment Potential in Commercial & Residential Sector

Sl.No.	Particular	Value (crore)
1	Investment in Residential Sector	1,06,300
2	Investment in Commercial sector	4,900
3	Total Investment	1,11,200

Many states are mandating / promoting use of ECBC and energy efficient building design in government buildings in new construction as well as for retrofitting , use of CFLs, T5 fittings, LEDs and other energy efficient lights in buildings, street lights, outdoor lighting, hoardings and advertisements, use of star labelled appliances, use of star labelled transformers for the distribution sector, use of solar water heaters, energy efficient chillers in HVAC system, use of solar panels and by following green energy concept and getting ratings of government buildings.

RENEWABLE ENERGY INSTALLED CAPACITY IN INDIA

Renewable energy is environment friendly, clean and safe energy resource. As per data available on renewable energy installed capacity 2014, India is on 5th number in wind and 11th in solar with 22.6 GW and 3.3GW capacity. Source wise renewable capacity is given in Table 3 below.

Table 3: Source Wise Renewable Capacity in India

Capacities in MW				
Source	**Installed capacity by end of 11th Plan (March 2013**	**Current installed Capacity (March 2015**	**Target as per 12th Plan (March 2017)**	**Revised Targets till 2022**
Solar Power	941	3383	10941	100000
Wind Power	17352	22645	32352	60000
Biomass power	3225	4183	6125	10000
Small Hydro	3395	4025	5495	5000
Total	24914	31351	54914	175000

RENEWABLE ENERGY POTENTIAL IN INDIA

Hydro power has the advantages like technology is mature and reliable, though less than 25 MW is in the "small hydro" designation. There is a potential of 15,000 MW, while installed is 1,520 MW. 4,096 potential sites have been identified.

Solar energy from an energy security perspective is the most secure of all sources since it is abundantly available. Theoretically, a small fraction of the total incident solar energy, if captured effectively, can meet the entire country's power requirements. Presently, 360 MW of solar rooftop projects have been sanctioned by MNRE and 49.677 MW have been commissioned. 13 States have come out with solar policy supporting grid connected rooftop systems. SERCs of 20 States/UTs have notified regulations for net metering/feed-in-tariff mechanism. Remaining states are being pursued to come out with their policies/regulations.

Potential of wind energy generation for grid interaction has been estimated at about 1,02,788 MW taking sites having wind power density greater than 200 W/sq. m at 80 m hub-height with 2% land availability in potential areas for setting up wind farms @ 9 MW/sq. km. It is one of the most environment friendly, clean and safe energy resources. It has the lowest gestation period as compared to conventional energy. Equipment erection and commissioning involve only few months. There is no fuel consumption, hence operating costs and maintenance costs are low.

In biomass energy, India is very rich. It has a potential of 19,500 MW (3,500 MW from bagasse based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW generation plants under construction. The facts reinforce the idea of a commitment by India to develop these resources of power production. Some states with most potential for biomass production are Andhra Pradesh (200 MW), Bihar (200 MW), Gujarat (200 MW), Karnataka (300 MW), Maharashtra (1,000 MW), Punjab (150 MW), Tamil Nadu (350 MW) and Uttar Pradesh (1,000 MW).

The country has already started use of solar panels on train, bus, truck and aircraft as shown Fig. 5.

Fig. 5: Solar Panels Being Used

SMART CITIES AND SMART HABITAT

To develop smart cities and smart habitat, energy is the basic requirement. India has high potential of clean energy and thus emphasis will have to be given on its generation through various sources as given above. This will also help in reduction of emission of CO2 and climate change. It is essential that integrated policies are adopted in generation, use and consumption of energy. Government of India has already announced various policies in this regard. Next phase will be Wi-Fi connectivity with the equipment and devices to be used in smart habitat and smart services to be developed in smart cities. This will require 24x7 electric supply and thus availability of clean energy will be the basic requirement. Excess energy when generated can be connected to smart grids to make it available in all parts of the country and even abroad.

CONCLUSION

Use of non-conventional renewable sources like wind, biomass, solar passive building technology to reduce energy consumption and improve comfort

level in the buildings, design of net zero buildings by use of renewable energy and mandating laws and regulations of energy efficiency prevalent in the country along with provision for single window clearance for energy efficiency projects can convert the dream of smart and sustainable smart habitat into reality.

Promoting awareness about energy conservation and energy efficiency, mandating use of BEE standard energy efficient pumps in agriculture sector, as well as shut down of power plants having very low efficiency and gradually replacing them with energy efficient ones is liable to contribute to good amount of energy savings.

Use of renewable energy potential to ultimately complete shift to renewable is a must for smart and sustainable habitat.

REFERENCES

1. Mnre.gov.in
2. Energy efficiency opportunities in India by Power Grid Corporation of India Limited.
3. http://www.geni.org/globalenergy/library/energytrends/currentusage/renewable/Renewable- Energy-Potential-for-India.pdf
4. http://www.geni.org/globalenergy/library/energytrends/currentusage/renewable/Renewable-Energy-Potential-for-India.pdf

DESIGN STRATEGIES FOR ENERGY EFFICIENT AND SMART BUILDINGS

A. K. JAIN*

Abstract

The consumption of fossil fuels for energy is resulting in to pollution, global warming, waste disposal problems, land degradation and depletion of natural resources.Energy efficiency and renewable energy are the twin pillars of sustainable energy. Energy efficiency in buildings, industrial processes and transportation could reduce the world energy needs in 2050 by one third and help control the emissions of greenhouse gases. The integration of energy efficiency and renewable energy offers a viable way to meet power and thermal needs with superior environmental performance.

The paper looks at the various issues and options involved in this task that leads to sustainable energy. While discussing policy, planning and design aspects, the paper cites a number of examples where sustainable energy systems have been successfully implemented.

INTRODUCTION

India's population of 1210 million lives in its 7936 cities and about 600,000 villages which pose huge demand of energy. To meet the exponential demand of energy, use of fossil fuels is increasing simultaneously. The environmental impacts of the consumption of fossil fuels for energy include pollution, global warming, waste disposal problems, land degradation and depletion of natural resources. Approximately 40 per cent of global energy demand and one-third of the carbon emission are related to buildings (IEA 2008) which can be substantially reduced by design.

Energy efficiency and renewable energy are the twin pillars of low energy building, which involve actions at various levels of planning and design:

- Site planning and building design
- Form and orientation
- Volume and building envelop
- Wall to window ratio,
- Building skin design
- Ventilation- wind tower, courtyard, verandahs, air scoop, earth air tunnel, etc.
- Resource recovery
- Landscape
- Indoor air quality
- Renewable/ solar energy and smart grids
- Energy-efficient controls, equipment and appliances

Site Planning and Building Design

Substantial energy can be saved by appropriately planned buildings keeping in view natural features and microclimate of the site. The formation of heat island and inversion effect can be avoided by layout planning. The concepts of the mixed land use, compact and smart development along the public transit corridors, using the materials having low embodied energy and conforming to energy performance standards of ECBC can make a city energy efficient and save the consumption of fossil fuels and emissions.

Form and Orientation

By building form and orientation the need for cooling, heating and lighting can be minimized,

* *Architect Planner, Ex Commissioner (Planning) DDA, Member of MOUD Committee on DD Act, Consultant UN Habitat*

reducing the demand for energy. By passive design of building with sun-shades, double-glazed windows, smart glazing, window overhangs, thermal storage wall/roof, roof painting, ventilation, evaporative cooling, day lighting, wind towers, earth air tunnel and low energy materials, the energy demand in building can be saved substantially.

Building Volumes and Envelop

The building volume and envelop are key determinants of the amount of heat gain and loss and wind that enters inside. The primary elements affecting the performance of a building envelope are:

- Materials and construction techniques
- Roof and walls
- Fenestration and shading
- Finishes, colour and surfaces

The roof receives significant solar radiation and plays an important role in heat gain/losses, day lighting, and ventilation. Appropriate thermal insulation and air cavities in roof and walls reduce heat transmission into the building. Lighter colour surfaces have higher emissivity and are ideal for energy saving in warm climate.

Wall to Window Ratio

WWR in a building in hot-dry climate should be generally between 40 to 60 per cent. A glazing area in excess of 60% of gross external wall area is not energy efficient. For South, East and West façades, Solar Heat Gain Coefficient should be minimized, whereas Visible Light Transmittance should be maximum.

Building Skin Design

To achieve energy efficiency building should have a skin which allows adequate daylight and reduces mechanical heating and air-conditioning. Simulation tools and techniques can help in designing the building orientation to minimize heat intake and maximize natural daylight. Lighting can be designed with efficient luminaries and using them in conjunction with fenestration/windows that reduces heat producing radiation.

Ventilation

Natural ventilation inside a building has direct influence on health, comfort and energy usage of building. The surrounding buildings and landscape also impact the wind flow and ventilation. Various form of natural ventilation can be considered according to micro-climatic conditions. These include wind tower, verandah, courtyards, air scoop, etc. The courtyards and verandahs have been an important part of Indian homes, which provide natural ventilated spaces for living, sleeping and cooking.

Evaporative cooling by desert coolers is another popular low-energy method, which lowers indoor air temperature by evaporating water. The wind catcher guides outside air over water-filled pots, inducing evaporation and causing a significant drop in temperature before the air enters the interior. These techniques have been refined at the Torrent Research Centre at Ahmedabad designed by architects Parul Zaveri and Nimish Patel. The Passive Energy Down-draft Evaporative Cooling (PDEC) system adopted by this building provides a pragmatic, low cost and low energy alternative to air-conditioning. Simulated design of inlet and outlet shafts circulates cooled air through a fine spray of water together with dust control.

Resource Recovery

The building materials, especially cement, steel, aluminium and other industrial products have a large amount of embodied energy. To reduce their energy contents, it is necessary to specify local materials and reuse of recycled materials. Over-designed structures result in the waste of energy and materials. Timbers should be used from sustainable forests and the use of toxic chemicals and hazardous materials should be avoided.

Indoor Air Quality

The building design should help in energy efficiency together with enhancement of indoor air quality for human health. Non-toxic paints, glues and recyclable building materials such as fly ash bricks, hollow bricks, stabilized mud blocks, etc. help in this.

Landscape

Proper landscaping reduces direct sun from

heating up building surfaces. It can also create airflow for ventilation, shading and cooling by water, fountains, etc. Green roofs, vertical gardens, climbing plants on walls, window boxes and balcony gardens, help in reducing heat intake of buildings, and thus energy efficiency.

Renewable Energy

Renewable energy sources offer a big scope for cutting energy generation from fossil fuels and carbon emissions. India has the advantage of long hours of sunshine, which can be a major source of solar energy for existing as well as new buildings. Photovoltaic systems can be integrated into the design of a building.

Solar roof can produce electricity in buildings for lighting, cooling, heating, water heating, cooking, etc. Solar streetlights, lanterns and garden lights featuring battery storage, photovoltaic and optimized CFL and LED are useful, both for remote areas and urban areas, which can save electricity bill. Solar lantern, CFL or LED based, has a built in mobile charger and also serves as an emergency light.

Power tower, Parabolic solar dish, Fresnel reflectors, and Parabolic solar bowl have been developed and are being used for cooking. These use no fuel, which means no smoke, no carbon emissions, no ashes or soot, no fire hazard, lesser fuel cost and reduced deforestation.

A hybrid solar oven can be equipped with a conventional electrical heating element for cloudy days or night time cooking. These are most suitable for hostels, hotels, railway canteens, religious establishments, etc., which regularly feed large number of people. Brahm Kumari Ashram at Mount Abu is using high tech solar cookers producing about 1200 meals per day which saves huge consumption of LPG. Tirumal Tirupati Devasthanam has solar steam cooking system for 30,000 meals per day, which saves 200 liters of diesel every day. Sai Baba Sansthan Temple at Shirdi uses solar cooking system for 7000 meals per day with enhanced capacity to cook 20,000 meals. The Akshardham temple in New Delhi has installed a solar concentrator for cooking 4,000 meals every day.

Renewable Energy Assisted Pump developed by BYPL and IIT-Delhi, has been installed in a number of government schools in East Delhi. It is an easy to install submersible pump connected to a water tank with a motor powered by a solar panel.

Following are several successful examples of energy efficient buildings in India:

- Eco housing Program (New Buildings and Retrofit), Municipal Corporation of Greater Mumbai,
- Thyagraj Sports Complex, New Delhi (Central PWD), with solar and gas turbine power generation, vapor absorption A.C.
- Paryavaran Bhavan, New Delhi (CPWD)
- Development Alternatives Building, New Delhi (Architect Ashok Lall)
- CII Godrej Building, Hyderabad
- IGP Office Complex, Gulbarga
- ITC Green Center, Gurgaon
- Wipro Technological Development Center, Gurgaon
- Vestas India, Chennai installed with a Wind Turbine, producing 950 kw
- CESE Building, Kanpur
- Torrent research Center, Ahmedabad (Architect Nimish Patel and Parul Zhaveri)
- Suzlon One Earth, Pune (Architect Christopher Benninger)
- Teri Building, Gwal Pahari, Gurgaon

While the energy efficiency systems are already available, these need to be institutionalized for wider adoption. This requires various actions, as given below:

- The Energy Conservation Building Code provides specifications for energy efficiency, building materials and systems, implementation strategies, energy performance, rating system, appliances standards and labelling for energy efficiency. This need to be enforced more widely and strictly.
- Energy efficiency audit of all buildings with loads

above 1mw and mandatory retrofit of existing buildings.

- Improved metering arrangements and tariff restructuring
- Compulsory solar energy cooking in large establishments,public advertising, lighting of open areas, parks and streets, traffic signals, hoardings, etc.
- Alternatives to diesel generators and inverters.
- Adoption of Smart load management techniques.
- Incentivizing energy savings and use of energy efficient gadgets.
- Public awareness, capacity building and training.

These efforts need legal, financial and capacity building supports. In this respect some lessons can be learnt from various other countries, as given below:

In China, Energy Performance Standards of the buildings have been strictly enforced since 1996, for both new and old buildings. High 100 per cent compliance of MEPS has resulted into energy saving level of 50 per cent to 65 per cent.

In Mexico, 'Green Mortgage 'and 'This is Your Home' programme encourage adoption of the energy efficiency by financial incentives viz. Este es Tu cess (This is Your Home) and Hootecs Verce (Green Mortgage). These offer loans and grants to purchase energy efficient equipment, appliance and technology. It is estimated that these programs saved on an average 40 per cent of electricity and gas in about half million homes. These also benefitted the construction industry, the electrical industry, as well as saved the Government investment in energy production and subsidy. Several energy efficiency demonstration program have shown that energy efficient building can be more cost effective than subsidizing energy distribution.

California has developed a Strategic Plan and Minimum Energy Performance Standards (MEPS). It provides financial incentives and has taken up motivational campaigns, such as 'Flex Your Power'. As a consequence, per capita electricity consumption has remained stable in California since the 1970s.

In Vermont, USA, Energy Efficiency Utility Program (EEUP) provides financial and technical assistance with regard to energy efficient appliances and buildings. EEUP is funded by energy efficiency charges, a special levy of a 4% on commercial energy bills.

Energy Guides, (energielotsen) in Hannover, Germany provide guidelines to architects, engineers and builders on ultra-low energy buildings which save about 90 % of electricity demand. The program also provides financial support to energy efficient new homes.

In Tunisia the Energy Efficient Package comprises MEPS and labelling program for new buildings and extensions to existing buildings. Obligatory energy audit, information campaign, financial incentives, capacity building and cooperation with architects, engineers and builders are the part of the packages. The National Energy Fund provides financial incentives for energy efficiency and renewable energy.

Denmark Energy Strategy-2050 aims to achieve energy supply free from fossil fuels by 2050. Ireland has introduced the Building Energy Rating which is mandatory for the building owners for its sale or renting out. This is also put on public online database.

CONCLUSION

The growing economy and new urban programs, such as Smart Cities Mission, Housing for All Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) have opened up the floodgates of building sector in India. It is estimated that 60 per cent of buildings which will exist in the year 2030 are yet to be built. This provides a unique opportunity to design energy efficient and smart buildings and develop strategies to promote renewable energy especially for space conditioning, cooling and cooking. This can save 30 to 40 per cent of energy aggregating to more than 10,000 MW of power.

REFERENCES

1. Adrian and Gordon Gill, 2011, Toward Zero Carbon, Image Pub., Australia

2. Bandyopadhyay, Bibek, Solar Water Heating IREDA News, Jan - March, 1998

3. BEE, (2009), Energy Conservation Building Code User Guide, Bureau of Energy Efficiency, New Delhi. http://www.emt-india.net/ECBC/ECBC-UserGuide/ECBC-UserGuide.pdf.

4. Benninger, Christopher, (2011) Letter to a Young Architect, CCBA Pvt. Ltd., Pune

5. Government of India (2009), National Mission on Sustainable Habitat, MOUD, New Delhi

6. GOI, (2006), Integrated Energy Policy, Expert Committee Report, Planning Commission, Government of India. http://planningcommission.nic.in/reports/genrep/rep_intengy.pdf.

7. Hardoy, I. E., Mitlin, D., Satterthwaite, D., 1992: Environmental Problems in Third World Cities. Earthscan Publications Ltd., London

8. ICLEI (2007), Preparing for Climate Change: A Guidebook for Local, Regional and State Government, Washington

9. IGBC, (2007), LEED - India, Green Building Rating System, abridged reference guide for new construction & major renovations (LEED-India NC), version 1.0, Indian Green Building Council, Hyderabad. http://www.igbc.in/site/mmbase/attachments/48344/LEED.Abrid_Ver.pdf

10. IPCC (2007), Climate Change, Impacts Adaptation and Vulnerability, IPCC, Cambridge and New York

11. Jain A.K (2013), Sustainable Urban Transport and System, Khanna Publishers, New Delhi

12. Jain A.K (2014), Revisiting Land Acquisition and Urban Process, Readworthy Publication, New Delhi

13. Jain, A.K., (2015), The Idea of Green Building, Khanna Publishers, New Delhi.

14. Jain, A. K., (2015), Smart Cities: Vision and Action, Discovery Publishers, New Delhi,

15. Jain, A. K., (2015), Conservation of Cultural Heritage, Discovery Publishers, New Delhi,

16. Jain, A. K., (2016), River Regeneration and Water Resources, Discovery Publishers, New Delhi

17. Jain, A. K., (2015), Towards Cleaner and Hygienic Cities and Villages, Discovery Publishers, New Delhi

18. Jain A.K., (2015) Transforming Delhi, Bookwell, New Delhi

19. Kachru, Upendra (1994), A Novel Method of Cooling & Heating of Buildings - Envelope Conditioning, Proceedings on Conference "Excellence in Housing", Feb. 24-25,1994, Dallas, Texas; Energy Efficient Building Association, Wasua, U.S.A

20. MNRE (2014), Report on New and Renewable Energy, Ministry of New and Renewable Energy, Government of India, New Delhi, http://www.grihaindia.org/index.php.

21. MNRE (2010), Green Rating for Integrated Habitat Assessment, Ministry of New and Renewable Energy, Government of India, New Delhi, http://www.grihaindia.org/index.php.

22. Satterthwaite, D. (2008). Cities' contribution to global warming: Notes on the allocation of greenhouse gas emissions. Environment and Urbanization, 20 (2).

23. UN-Habitat (2011),Cities and Climate Change, Global Report on Human Settlements, Earthscan, UK/USA/Nairobi.

ENERGY MANAGEMENT PLAN FOR SUSTAINABILITY – A STEP TOWARDS SMART CITY INITIATIVES

NEETI GARG*, DR. PARVEEN KUMAR**, ASHWANI KUMAR*** AND SATISH PIPRALIA**

Abstract

In fast developing economy of India and accelerating urbanization, 50 % of population will be living in cities by 2050. Most urban infrastructure and built fabric is aging and is not able to keep pace with growth of urbanization and population in flux; leading to a wide gap between demand and supply of physical infrastructure, particular in energy and causing serious environmental damages by way of pollution due to use of diesel set generators in absence of supply of electricity from grid. There lies a great opportunity and potential to look at new and existing buildings from energy efficiency perspective and retrofit them to improve energy performance index to reduce carbon footprint by 2030.

Smart city mission guidelines have underscored significance of retrofitting city infrastructure at different levels to meet energy demands and improving quality of life and improving environmental sustainability. The present paper addresses key aspects of energy management in city infrastructure at different levels i.e. city level, neighborhood level and building level for energy management.

INTRODUCTION

Typically urban life in cities is characterized ubiquitously by malaise of poor urban physical infrastructure. With Indian economy moving up the trajectory of growth, urbanization to the tune of 40 % people living in cities and contributing to 75% of India's Gross domestic product by 2030 and two third of built fabric is yet to be constructed by 2030 (GBPN,2014. HPEC, 2014), the economic growth momentum can be sustained with the structural transformation of existing economy by integrated approach to resource management. Cities and towns of India are visibly deficient in the quality of services they provide, even to the existing population (HPEC, 2014). Energy, communication networks and water supply form lifelines of any city (IBM, 2013). For meeting climate change targets of reducing green house gas emissions by 30% by 2030, energy management in cities holds key to run cities and helping in cleaner environment, less pollution and reduced carbon footprint strategy (ICLEI , 2009).

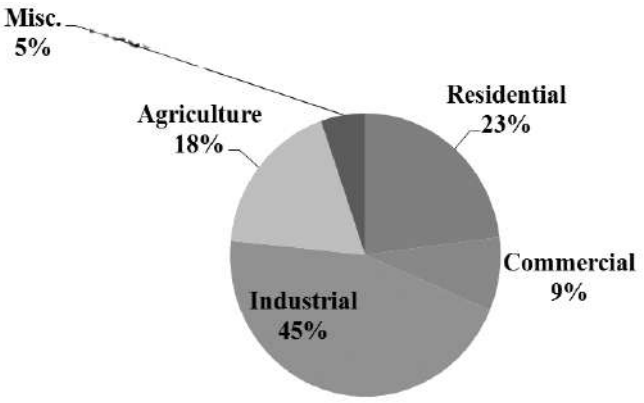
Despite energy crisis, climate change initiatives and commitments and deteriorating environmental conditions of cities, it has still not triggered the issue of energy management at urban planning level as integral part of city development plans in urban planning approach. Having underscored role of energy as major lifeline of city, it immediately calls for developing a sustainable energy plan for all cities across the nation. To reinforce the existing core infrastructure of cities , the ministry of urban development has launched mission guidelines for transforming nation by proposing 100 smart cities across the country and offering decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' solutions to the issues such as energy supply, waste management, and mobility (MoUd,2015).

EXISTING SCENARIO IN ENERGY CONSUMPTION

Cities are responsible for 75% of energy consumption worldwide and 80% of greenhouse

** Research Scholar, Malviya National Institute of Technology, Jaipur ** Associate Professors, Deenbandhu Chhotu Ram University of Science and Technology, Murthal Sonipat*** Assistant Professor, Malviya National Institute of Technology, Jaipur*

gas emissions and can act as avatar to new energy ecosystem of changed world by adopting digital technology, smart metering and real time information systems, integrating renewable energy and the buildings as producers than consumers. The buildings sector consumes nearly 30% of energy in cities can become as foothold for change, out of which almost 72% is consumed by the residential sector as seen in Fig. 1 ((IBM, 2013; CEA, 2014).With the higher affordability and more and more indoor living and higher thermal comfort expectations, there is an increased energy consumption in buildings (Paula, 2014; Kumar 2015). Also there is an increased demand in energy consumption owing to increased appliance ownership and use (Zia and Sharma, 2015). As per report of the Central Electricity Authority (2013), energy use in residential buildings has increased from 80 Twh in 2000 to 186 Twh in 2012.



Source: Central Electricity Authority, 2014

Fig. 1 Electricity Consumption in India (2012-13)

Global Buildings Performance Network GBPN (2014) in a study report titled "Residential Buildings in India: Energy Use Projections and Savings Potentials", has projected electricity consumption to rise from 650 kWh in 2012 to 2750 kWh by 2050 under the business-as usual scenario. In the absence of energy supply from the grid, use of diesel generator sets as an alternative means of power generation is causing serious environmental pollution (Kumar, 2015).

Using a very aggressive policy strategy, the increase in household electricity consumption could be cut to 1170 kWh per household in 2050 (GBPN, 2015). Thus there is a need to revamp the current structure of the energy use to frame market driven scenarios, energy codes for building and cities in the wake of future energy projections and availability of electricity, clean environment and climate change initiatives.

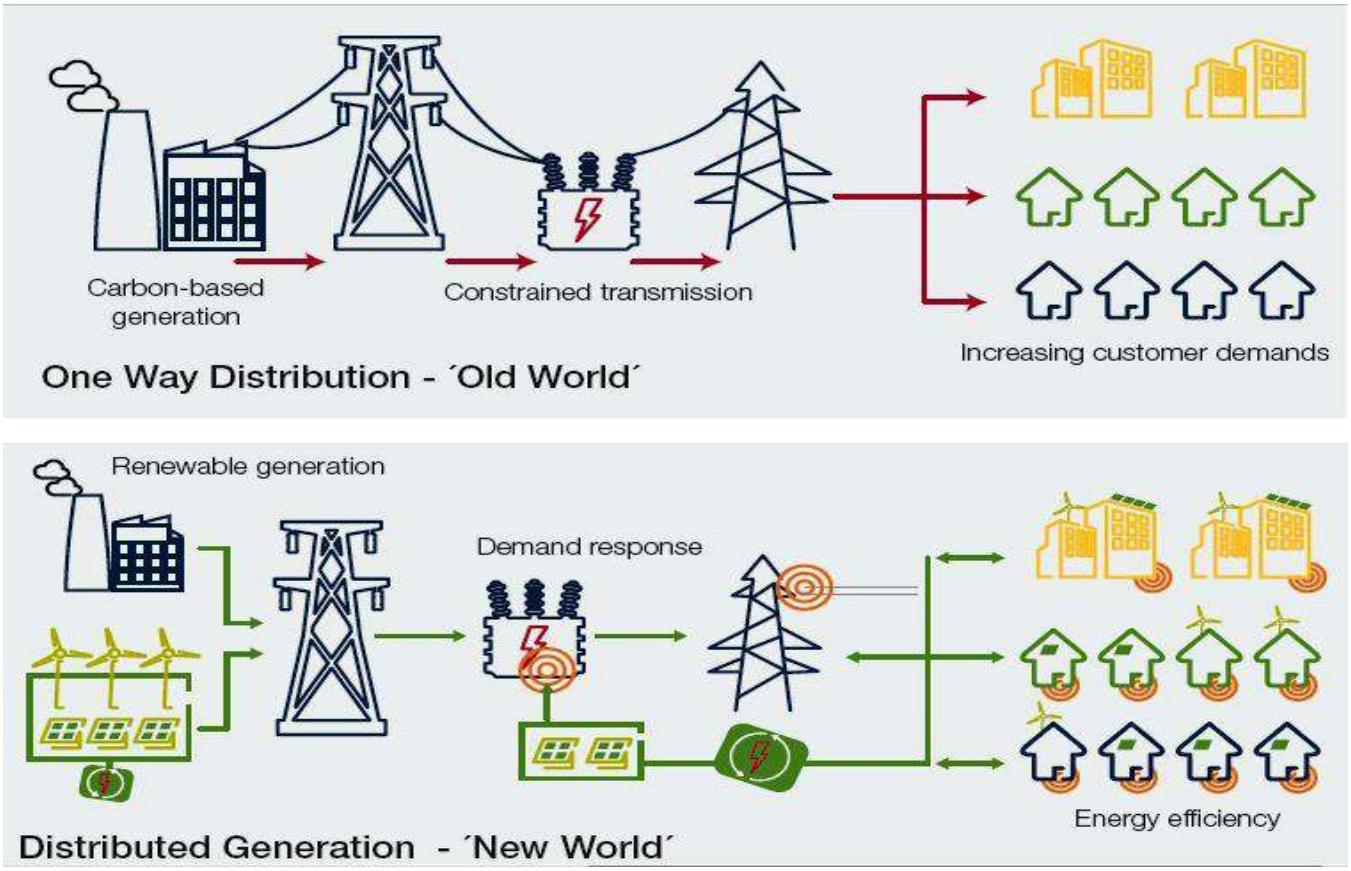
ROLE OF NATIONAL POLICIES

In order to achieve a sus¬tainable development path that simultaneously advances economic and environmental objectives, the National Action Plan for Climate Change (NAPCC, 2008), has advocated inclusive and sustainable devel¬opment strategy, sensitive to climate change, qualitative change in direction that enhances eco¬logical sustainability, efficient and cost-effective strategies for end use. NAPCC has strategically outlined eight National Missions for achieving key goals on climate change problem mitigation, energy efficiency and natural resource conservation.

National Solar Mission

The objective of National Solar mission is to harness the potential of application of solar energy and research and development in the field. Various initiatives like solar harvesting, integrated building photo voltaic systems, solar street lighting and new policies for net metering or smart grids have come up due to which the role of buildings is essentially and gradually changing from consumer to producer of electricity.

There is a huge untapped potential for solar applications as it permits decentralized distribution of energy empowering people at grassroots level. It has added new dimensions of supply of bi-directional energy chain from the current system of a one-directional supply. Added to the advantage due to net metering or smart metering, buildings can actively contribute in producing electricity and supply to the grid the surplus electricity. Fig. 2 illustrates schematic diagram of decentralized distribution in a bi directional energy chain. With the decline in cost of solar PV, more and more solar farms are being set up across the nation as cost effective means of generating electricity.



Source :IBM, 2013

Fig. 2: Bidirectional Energy Chain in Distributed Generation of Electricity showing Buildings and Grids as Active Participants in Energy Production.

The ambitious National Solar Mission anticipates covering 20 million sqm. by 2020 under solar thermal collectors. For grid power including rooftop and small plants, 20,000 MW is anticipated to be generated by 2020 through photovoltaic (Zia and Sharma, 2015).

National Mission for Enhanced Energy Efficiency

It provides a legal mandate through the Energy Conservation Act of 2001 through the institutional framework of the Bureau of Energy Efficiency (BEE) in the Central Government and designated state agencies in so as to make energy intensive large industries and facilities through certification of energy savings, creating more affordable energy efficient appliances and labelling them, developing fiscal instruments to promote energy efficiency.

National Mission on Sustainable Habitat

It aims to pro¬mote energy efficiency in the residential and com¬mercial sector, man-agement of solid waste and modal shift to public transport. Energy Conservation Building Code (ECBC) was formulated in 2007 to lay guidelines for conditioned buildings of 100 kW or 120 KVA and above and specifies performance standards using prescriptive as well as whole building simulation approach for compliance with the ECBC act. Many states have voluntarily adopted ECBC in their building codes so as to optimize their energy demand. It has emphasized in its draft policies that realizing the potential of energy saving requires an integrated design process involving all the stake¬holders, with full consideration of opportunities for passively reducing building energy demands.

National Building Code, 2005

Recently National building code has been revised to add part 11 'Approach to Sustainability as Amendment no: 1 to NBC 2005 (SP: 2007). It lays emphasis on energy efficient design and process, passive design strategies site planning and form, building envelope optimization and integration with renewable energy integration, building services optimization, embodied energy and construction technology and finally commissioning, operation, maintenance and building performance tracking. Subsequent to commissioning and handover stage of building to the owner, regular monitoring of the performance shall be carried out which will provide information whether set environmental performance and targets have been met or not. Thus it provides for monitoring of energy performance after occupancy, to ensure performance targets during operation of building by energy metering for end use energy consumption in lighting for both campus lighting and interior, air conditioning, domestic hot water, water pumping, elevators and plug loads separately by using Energy Management and Control systems (EMCS). It also emphasizes conducting occupant survey annually for first three years of building obtaining feedback from users for identifying possible areas of improvement and implementing rectifications accordingly.

Green Rating for Integrated Habitat Assessment (GRIHA)

GRIHA, designed as National Rating System and developed by the ministry of new and renewable energy and developed by TERI, The Energy & Resource Institute, New Delhi is in inception since 2007. It has undergone major revisions in 2015 to reflect the current scenario and development in green buildings and revised its benchmarks for meeting sustainability goals better. It integrates all relevant Indian codes and standards such as National Building Code 2005, the Energy conservation building code 2007, environmental policies of India (MoEF) and local bye-laws.

Retrofitting Existing Buildings

Although presently most new buildings are being designed as green buildings, but in absence of energy efficiency codes before 2005, existing buildings constructed continue to consume energy incessantly. As per the study report of the United Nations' Inter governmental Panel on Climate Change in its report on "Mitigation of Climate Change", largest energy and carbon savings potential in 2030 can be achieved by retrofitting and renovation of existing buildings (IPCC, 2013; Architecture 2030 , 2014). In wake of future energy projections due to urbanization and huge demand on existing infrastructure, there is a need to introspect existing built environment at various scales (building, neighborhood, and city-region) in view of climate change and resource constraints. Eames et al (2013) has envisaged 'Retrofit 2050 Vision' for three different kind of cities i.e. Smart-Networked City, The compact city and the Self reliant Green city; each one varying greatly in terms of indicators for energy , land use and urban density. Seven European countries collaborated in the project The ENPER-EXIST for energy performance standardization and regulation (Xavier et al. 2007). Keeping in mind the largest footprint of residential buildings coupled with their highest share in energy consumption, they can contribute potentially by retrofitting existing residential buildings from energy efficiency point of view. Most of the existing residential building stock is characterized by low thermal comfort, poor indoor air quality, poor lighting conditions, acoustical problems etc. The retrofitting of existing buildings can lead to significant improvement of the indoor environmental conditions as well as increase in productivity and larger economic saving due to enhanced productivity (Xavier et al. 2007). Retrofit of residential buildings usually involves multiple benefits such as reduction in consumption of energy and hence cutting energy and maintenance bills, improving safety, quality, indoor comfort and aesthetic properties.

ENERGY OPTIMIZATION BY URBAN PLANNING AT CITY LEVEL

Energy management can also be optimized by planners at land use planning level and controlling built fabric densities for efficient distribution of electricity. Using Geographic Information System and 3D Modeling of building blocks, modulating various element of urban form and bulk, and assessing solar radiations by devising suitable zoning regulations, exploring effect of mutual shading on buildings, daylight modeling in buildings, geometric orientation of streets can help in controlling overall solar heat gain to built fabric, urban heat island effect and as well can take advantage of direction of natural wind to promote natural ventilation for thermal comfort.

In an example by urban design scheme of Yuehai Eco-City in Yinchuan, China, simulations were carried in some of blocks to study effect of urban morphology various factors such as adjusting the building form slab block or point block, height, the orientation of buildings, and the community pattern were explored to assess energy use index (Shang et al, 2013). The results revealed that more compact building forms and horizontal and vertical random layouts of buildings can help to reduce the energy demand of buildings at urban scale. Moreover, moderate changes in the orientation of buildings only have a weak effect on the energy demand of buildings at urban scale. Lower wall-to-volume ratios avoid massive heat exchange, leading to better energy performance of buildings.

Effect of density and height has pronounced effect on building energy demand. Study report based on samples drawn of dominant residential building typologies identified for Paris, London, Berlin, and Istanbul concluded that compact and tall blocks building types are found to be more energy efficient urban form at the neighborhood scale as compared to detached housing (Rode et al, 2012). Pisello et al (2013) studied three residential neighborhoods of different densities and demonstrated that indoor operative temperature in buildings in very dense urban context and dense urban context is largely impacted by the presence of close buildings.

Design decisions in urban planning can be instrumental in reducing cooling or heating requirement by HVAC systems and energy use requirements and pollution as well. Also by promoting concepts such as mixed land use, walk to work culture and comprehensive mobility plan using public transport as a city basis, car free sectors by promoting non motorized transport such as bicycle tracks etc can also help in reducing the mammoth energy consumed in transportation in city significantly. A compact city plan by optimum utilization of land and having comprehensive mobility plan, transit oriented development and walk able neighborhoods with designed urban greens can enable efficiency in demand side management of energy and add to quality of life physically by cleaner air to breathe, promote social cohesion and security as well boost local economy.

ENERGY EFFICIENT DESIGN

Embodied Energy and Operational Energy

Energy management in buildings can be carried at multiple levels. Over life cycle of building, 20% of the energy is used as embodied energy and 80 % of the energy is used in operational energy for running air conditioning, lighting, processes and plug loads. Use of recycled materials such as flash bricks, AAC blocks and prefabrication technologies etc. can reduce embodied energy in environment friendly manner.

Building Performance Optimization

Building Performance optimization can be brought by either building envelope optimization or building services optimization. Passive solar design techniques such as shading, natural ventilation and orientation should be explored to reduce building envelope peak heat gain factor. ECBC has prescribed limiting values for thermal conductance (U values) for opaque elements, thermal mass, air tightness, surface reflectance (cool roofs) and SHGC factor for fenestrations along with wall to window ratio and shading. Various other innovative measures can be used for enhanced thermal comfort and reducing air conditioning load of buildings such as use of double skin facades , trombe wall systems, use of jallis, green roofs or green facades or automatic solar shades or blinds to cut sun or admit daylight.

Use of star rated equipments for individual packaged air terminals (window air conditioners or split air conditioners), ceiling fans, water heating, lighting or other electric appliances used in domestic buildings can also help achieving energy efficiency. For common areas services, use of smart building management systems, daylight sensors, and occupancy sensors in public buildings can also save energy significantly by reducing energy wastage. Use of regenerative lifts, gearless system of lifts with variable frequency drives (VFD) in lift motors and other water pumping motors use much less energy.

Energy Audits and Occupant Surveys

Post occupancy evaluation surveys to assess the building performance play pivotal role in defining benchmarks for thermal comfort and energy performance indices for a particular region. Occupant surveys carried out under normal daily life routine of subjects, with their entire psycho-

behavioural, environmental and social context, can serve as feedback and feed forward loop to continually evaluate and evolve relevant sustainability indicators (Kumar1 2014). Occupant surveys can reveal wider variations / diversity found in case of residential buildings in terms of occupant use, occupant age, built environment, psychological comfort and satisfaction and as well as wide variations in energy use, even within buildings of similar built up area and building geometry within the same location (Preiser 1995). Energy audits should be conducted by having real time metering and displaying of energy consumption by end use in a particular building complex or zone. Energy is so much invisible to people that people tend to take it granted leading to overuse or misuse of electricity. Thus both energy audits, occupant surveys and real time information systems of energy consumption by end use and finally energy mapping of different neighbourhoods and its display at community levels can foster competitiveness in reducing energy consumption or curbing energy wastage.

Renewable Energy Integration

Use of solar water heating systems has been already made mandatory in institutional, commercial and large residential complexes. Net zero buildings or nearly net zero energy buildings (NZEBs) have been target for new buildings as well retrofitting existing buildings by 2047 in net zero buildings all over the world. Buildings are seen as energy producers than consumers. Building facades can be used to integrated Photo voltaic panels in fenestrations or one can choose from array of systems such as stand-alone (off-grid) solar PV system with dedicated loads or grid-connected solar PV system with net metering or hybrid system (system with grid back-up power).

CONCLUSIONS

The paper has outlined various energy management techniques for cities at different levels. National level policies, smart city initiatives various building codes and benchmarks in GRIHA rating systems have been recently revised to incorporate energy management practices and set new key performance indicators for building performance evaluation. There is a need of concerted and synergic efforts to undertake energy consumption mapping and profiling at various levels and develop a sustainable energy plan for all cities by addressing key aspects of energy management in city infrastructure at different levels i.e. city level, neighborhood level and building level . Scalable models using digital technology are required to be implemented to bring systematic change in quality of life and approaching carbon neutrality by 2030 by taking initiatives at multiple levels right from incorporating sustainability and energy efficiency at development plan level, integrating national policies , developing prototypes in smart city mission cities and deploying cutting edge technologies including smart grids, automated building control systems and smart metering to track building performance in real time and information management systems.

REFERENCES

1. Ahluwalia, I. J., Munjee, N., Mor, N., Vijayanunni, M., Mankad, S., Lall, R., Sankaran,H., Ramanathan , Mathur, O.P. , Srivastava, P. K. (2014). Report on Indian Urban Infrastructure and Services, MoUD, Govt of India. Available at http://www.vision realization .com / Resources /Organizational/Benchmarking.pdf <accessed on 13.04.2016>
2. Architecture 2030. (2014). Roadmap To Zero Emissions, The Built Environment in a Global Transformation to Zero Emission. New Mexico ,USA. Available at http://architecture2030. org /files/roadmap_web.p df <accessed on 16.9.2015>
3. BEE. (2014). Design Guidelines For Energy-Efficient Multi-Storey Residential BuildingsComposite and Hot-Dry Climates. Bureau of Energy Efficiency. New Delhi.
4. Calvillo, C. F. , Miralles, A.S., Villar, J. , (2016) . Energy management and planning in smart cities , Renewable and Sustainable Energy Reviews. Vol. 55(2016) pp 273–287.
5. Central Electricity Authority. (2013). Growth of Electricity sector in India from 1947 to 2013. Ministry of Power, New Delhi.
6. Eames, M. , Dixon, T. , May ,T. and Hunt, M. (2013) "City futures: exploring urban retrofit and sustainable transitions". Building Research & Information, 41:5, 504-516,

Available at http://www.tandfonline.com/doi/pdf/10.1080/09613218.2013.805063 <accessed on 21.4.2016>

7. GBPN (2014). Residential Buildings in India: Energy Use Projections and Savings Potentials. Global building performance network. Available at www.gbpn.org. <accessed 12.2.2016>
8. GRIHA Version 2015 (2016) . GRIHA Council. New Delhi Available at http://www.grihaindia.org/index.php? option=com_content& view=article &id=78& t=library, <accessed 10.2.2016>
9. Hassanain, M.A.(2012). "Post-Occupancy Evaluation". Available at MA Hassanain opencourseware. kfupm. edu.s <accessed 15.3.2016>.
10. IBM,(2013). Intelligent Energy Management in cities, How to transform the urban energy chain" Available at https://www.capgemini.com/…/intelligent-energy-management-in-cities- how-to transf.. <accessed 12.8.2016>.
11. IBM,(2014).The Smarter City – ENERGY&UTILITIES, Available at http://www-03.ibm.com / innovation /us / the smarter city/energy/index.html. <accessed 12.8.2016>.
12. ICLEI , 2009,– Local Governments for Sustainability, Sustainable Urban Energy Planning , A handbook for cities and town in developing countries . UN-HABITAT and UNEP publications
13. IPCC Fourth Assessment Report(2013). "Climate Change 2007: Mitigation of Climate Change", Working Group III Report "Mitigation of Climate Change", Chapter 6. Available at www.ipcc.ch/…/publications_ipcc_fourth_assessment_report_wg3_repor… <accessed on 10.3.2016>
14. Kumar, P.(2014). "Evaluation of thermal comfort of Naturally Ventilated University Students' Accommodation on basis of Adaptive Thermal Comfort Model and Occupant Survey in Composite Climate." International Journal of Architecture, Engineering and Construction, Vol. 3 no: 4, 2014 (pp 298-316)
15. Kumar, P.(2014). "Building Performance Assessment and Evaluation of Existing Buildings forEnergy Efficiency: Case Study of Students' Accommodation in a University Campus". Tekton Vol.1, Issue 1. (pp 76-95)
16. Menezes, A.C., Cripps, A., Bouchlaghem ,D., Buswell, R.(2012). "Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reducet h e performance gap ." Applied Energy, Vol. 97, Pages 355–364.
17. MoUd. (2015). , Smart Cities, Mission Statement & Guidelines, Paper for India: Strategies forLow Carbon Growth. Ministry of Urban Development Government of India, Delhi.
18. National Action Plan on Climate Change (2008). "National Mission on Sustainable Habitat". Ministry of Urban Development, Government of India.
19. Paula,C. (2014). "Sustainable Habitat for developing Societies." 30th International PLEA Conference ,Ahmedabad, India, pp. 1-2.
20. Pisello, A.L. , Taylor, J.E. , Cotana, F.,(2013), Simulating The Effect Of Urban Morphology On Indoor Thermal Behavior: An Italian Case Study, Proceedings of the 2013 Winter Simulation Conference, Italy
21. Preiser, W. F.E. (1995) ."Post occupancy evaluation: how to make buildings work better", Facilities, Vol. 13: 11, pp.19 – 28
22. Rode, P., Keim, C., Robazza, G., Viejo, P. , Schofield, J. , (2014), Cities and Energy: Urban Morphology and Residential Heat-Energy Demand, Environment and Planning , Planning and Design , Vol. 41 no. 1, pp 138-162
23. Shang, C. C., Lin, K. Y. , Hou, G., (2013). ,Simulating the Impact of Urban Morphology on Energy Demand - A Case Study of Yuehai,. 49th ISOCARP Congress ,2013.
24. Waldron ,D., Jones, P., Lannon, S., Barrett, T., Iorwerth, H., (2013) .Embodied Energy And

Operational Energy:Case Studies Comparing Different Urban Layouts, Proceedings of BS2013:13th Conference of International Building Performance Simulation Association, France.

25. World Bank Report, (2008), Residential Consumption of Electricity in India, Background Paper.
26. Xavier ,L., Peter, W., Vandaele ,L.(2007). "Roadmap for energy efficiency measures/ policies in the existing building sector, Applying the EPBD to improve the Energy Performance Requirements to Existing Buildings."ENPER-EXIST, Belgian Building Research Institute .
27. Zia, H., Sharma, C.,(2015). Green growth and buildings sector in India. The Energy and Resources Institute, New Delhi.

ENERGY MANAGEMENT FOR SMART HABITAT

Dr. V. Devadas*, Dr. Nand Kumar and Manoj Panwar*****

Abstract

Human on an average spend two-third of his life at home and consumes energy in different forms and from all interacting sub-systems. Underdeveloped countries consume very low quantity of energy in the residential sector as compared to the secondary and the tertiary sectors of the economy whereas in the developing economy energy consumption in the residential sector is considerably higher as compared to the other sectors. Energy is considered as the basic input for the development of any system. The increase in income leads to desire for appliances offering greater human comfort and thereby number of appliances for human comfort are also increasing. Different subsystems of the system, such as demographic, socio-economic, architectural, environmental, etc., are more or less using energy supply system, and other extraneous parameters; and their interaction with energy subsystem, are identified through the literature survey.

The present study focuses at developing the model for energy management for smart habitat. In the present research, habitat is considered as a system, and system dynamic technique is applied to develop the habitat system model for analysing the electricity consumption for domestic purpose appliances. STELLA software is used to develop the habitat system model, and the function of the habitat is quantified. The study concludes with quantifying the function of the habitat system.

INTRODUCTION

Energy is the basic element for development of any system. The per capita energy consumption is much higher in developed countries, whereas it is much less in less developed and developing countries. Scientists have published literature pertaining to the importance of energy in socio-economic development of various nations with regard to energy input and GDP output (2, 14, 19, 20). India is not an exceptional one in this regard, and its per capita energy consumption is much lesser compared to even some developed and developing countries in Asian continent itself. If the country consumes more quantity of energy towards residential segments of the total energy consumption, the country's economic development grows slightly, whereas the country's more quantity energy is siphoned towards industrial development, then the country's GDP is growing considerably. Relationship between income and electricity consumption in residential, commercial, agriculture, small, medium and large scale industries are established and observed that the higher income countries consume more quantity of energy towards secondary and tertiary sector of the economy, whereas the underdeveloped and the developing countries consume more quantity of energy for residential purposes (1, 4, 9, 21). The developed countries consume more quantity of energy compared to the developing and under developed countries, and observed that the per capita energy consumption is nine-fold increase in the developed countries compared to the developing countries. In India, the gap between the demand and supply of energy resources is widening day by day due to various factors, and population explosion is one among them. Consumption of more quantity of fossil energy leads to greater of carbon emission, which further leads to climate change and other associated problems. This gave birth to the era of shifting from fossil fuel based

* *Faculty, Department of Architecture & Planning, Indian Institute of Technology Roorkee* ** *Faculty, Department of Architecture, Malaviya National Institute of Technology, Jaipur* ***Faculty, Department of Architecture, D.C.R. University of Science & Technology, Murthal*

conventional energy generation system to clean, green and limitless energy generation system. The concept of smart habitat and energy efficient system are discussed and developed.

VARIABLES DETERMINING DOMESTIC ENERGY CONSUMPTION

In India, the share of energy consumption in the residential sector has been increasing since the independence, and it has been observed that the share of energy consumption in the domestic sector was recorded almost one-fourth (23 per cent) of the total electricity consumption in the country. Energy is consumed for achieving different comforts in habitat and includes heating and cooling, ventilation, lighting, cooking, water supply, entertainment and the application of electrical appliances at the household level. Good number of authors studied the domestic energy consumption in the urban and rural system levels in different parts of the world and published literature (1, 3, 5, 6, 8-19, 22-25). It has been observed from the literature that the factors, which include demographic, social, economic, geographic, climatic, institutional subsystems play vital role in energy consumption. The use of energy on the basis of socio-economic profile is dependent on income, size of household, education, awareness, family composition, age distribution, occupation status, working hours, family type and interaction in family. Number and type of appliances used for the aforesaid purposes, efficiency of the appliances, usage duration are other factors influencing energy consumption. Type of dwelling, dwelling size, design, materials used for construction, thermal resistance, age of the house, contextual setting in urban / rural area, applications of improved energy efficient appliances are the architectural variables for fuel consumption. Type of fuel used, energy sources, access to clean energy, cost of fuel and alternatives also highly influence energy consumption. Extraneous variables in the form of climate, solar radiations and duration, water quality and quantity, water storage, usage and schedule of energy use, awareness among masses do contribute to energy consumption.

The disparities in household energy consumption were very much observed in urban and rural households due to higher variation in their disposable income. Once the income is increased, switching over of uses of the type of fuel for cooking and lighting is observed invariably among the rural and urban system. Change in institutional policies has been observed following education level, awareness among masses.

Demand for electrical energy in the households started to grow considerably, over the years, due to application of advance electrical appliances at the household level, like microwave oven, refrigerator, etc., which indicates that the economic development also took place over the years since modern energy consumption and application of modern electric appliances at the household level is increased, and economic development has direct linkage with energy consumption. A spread sheet model has been used widely to aggregate energy related issues at different level ranging from habitat to neighbourhood to cities to states and future energy demand has been forecasted. Discounted cash flow techniques are used for incorporating dynamic behaviour analysis and fast technology changes.

HABITAT AS A SYSTEM

Habitat has been considered as a system for conceptualizing the energy management and it has several subsystems. The various subsystems of the system are physical, social, economic, ecological, environmental, infrastructure, and institutional. All these sub-systems are interlinked and interdependent to each other and function as a whole dynamically (7). The dynamic functions of the system along with its different subsystems are presented in Fig. 1.

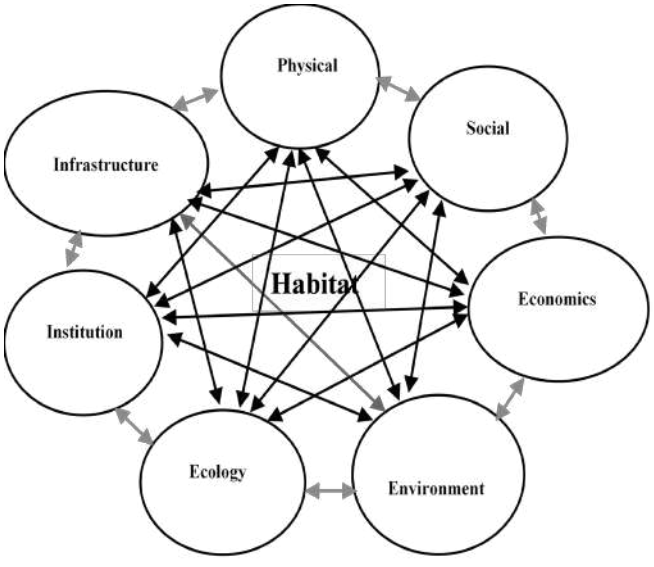


Fig. 1: Habitat System with Subsystems

Energy Interaction in the Habitat System

Energy is very much required for the functions of the system. Energy and its interactions in the urban system is discussed by various subsystem wise, and are presented as below:

The physical subsystem takes energy for its survival and gives energy to the rest of the subsystems for their survival. This built environment need energy very much for its survival; the household buildings need energy for different activities, which include lighting, heating, cooling, domestic cooking, water pumping, entertainment, doing work related activities at the household level, etc. It has been established that without energy these activities never function at all. Therefore, energy becomes the vital element for the functions of the physical subsystems.

Social subsystem consists of demography and its functions, and this demography needs energy for its survival. Though this demography (population) living in the built environment of the physical subsystems, it turns into pivotal point since whatever policies, plans, programs and schemes are evolved and implemented, it is purely for the development of this subsystems. It takes energy in the form of electricity, liquid and solid energy for its survival for different purposes and in turn gives services for the functions of the rest of the subsystems. The human resource is used for development of the other subsystems, and thus it takes energy from other subsystems, and gives energy to other subsystems for their survival.

Economic subsystems provides input for the energy consumption. Once the family income is increased, the energy consumption in habitat system increases due to higher comfort requirement. This fact has been established by various distinguish authors. Thereby, the importance of energy in economic subsystems and its contribution for development of other subsystems is established.

Ecology subsystem functions based on the interaction between the living and non-living organisms. The living organism needs energy, and supply energy for the survival of the same ecology subsystem and other subsystem too. Energy is very much required for the functions of the ecology subsystem. If the habitat has balanced ecosystems, then habitat would be developed in sustainable manner, and if the same habitat does not have balanced ecosystems, then the problems like heat, pollution, stress among the inhabitants, etc., would emerge, and this would pay wave for deterioration of the quality of the life of the people in the system. To have better living, balanced ecosystem is an important requirement in the habitat, energy is inextricably linked with the ecology subsystem.

Energy is very much essential for the survival of the environment, and better environment leads quality of life in the system. The physical subsystem consumes huge quantity of energy in the form of electricity, liquid fuel and solid fuel for producing goods and services. When the liquid and solid fuels are burnt in the production process, it generates huge quantity of smoke and soot in the habitat, which result in adverse effects in the system. This adverse effects lead into all kinds of pollution and also spoil the other subsystems. To maintain the balance in environment, application of appropriate technology along with required amount energy input (clean energy and other energy sources) is essential in the production systems. Production is the inevitable requirement for the development of the cities in particular, and the nation in general. Thus, energy becomes a vital element for the sustainability of the environmental subsystem.

Infrastructure subsystem is divided into three sectors including physical infrastructure, social infrastructure and economics infrastructure. The physical infrastructure consists of energy, water supply system, drainage, sewerage, solid waste management and transportation. Energy being a part of physical infrastructure, it not only serves the functions of the other subsystems but also giving input for the functions for infrastructure subsystem too. As already pointed out energy becomes the center point for the functions the entire system as a whole, it needs lot of attention to generate the required amount of energy for development of the habitat in particular, and the nation as a whole. Since the energy is the scarce resource, it is an inevitable requirement to manage this scarce resource in a systematic and scientific manner for the development of the system. So, the available energy sources should be judiciously utilized for the development of the system.

The institutional subsystem not only regulate the judicious use of energy resources, but also administer the entire system as a whole for its development, and thereby energy becomes a basic element for the development of the system. This can also regulate the uses of the scarce energy resources for the development of the system. Further, this institution subsystem also takes energy for its own survival.

Different sources of energy, such as solar, hydro, thermal, natural gas, diesel, petrol, kerosene, fuelwood, energy generated for solid waste are used as input for the development of habitat. As already pointed out, different sources of energy are used in is urban system, and are inextricably linked and functioning together since the energy supply system, and the energy consumption system are functioning together, and the output is used for reinvestment for energy generation, savings, import of commercial energy sources, import of energy technology, development of indigenous energy related technology, and energy generation at local level. Further, this output again put as an input for energy supply system and thereby, dynamics function of the habitat system with energy related interactions are established and this dynamic functions are presented in Fig. 2. If these input and output are balanced in accordance with the requirement, then the habitat system would be much vibrant and the people live comfortably. To maintain the balanced habitat system, conceptual habitat dynamics model is developed based on system dynamics techniques.

Energy management in habitat is one of the most important aspects, which needs thorough analytical works, decisions making at various level since this aspect is functioning with lot of uncertainties, and application of simple decision making techniques may not be suitable in this regard. System dynamics technique is one of the suitable techniques employed to understand the behavior of a complex system, and it becomes a powerful methodology for analyzing and simulating complex feedback system. Employing simulation techniques in system dynamic modeling promotes the understanding of dynamic functions of the system under various different conditions over a period of time.

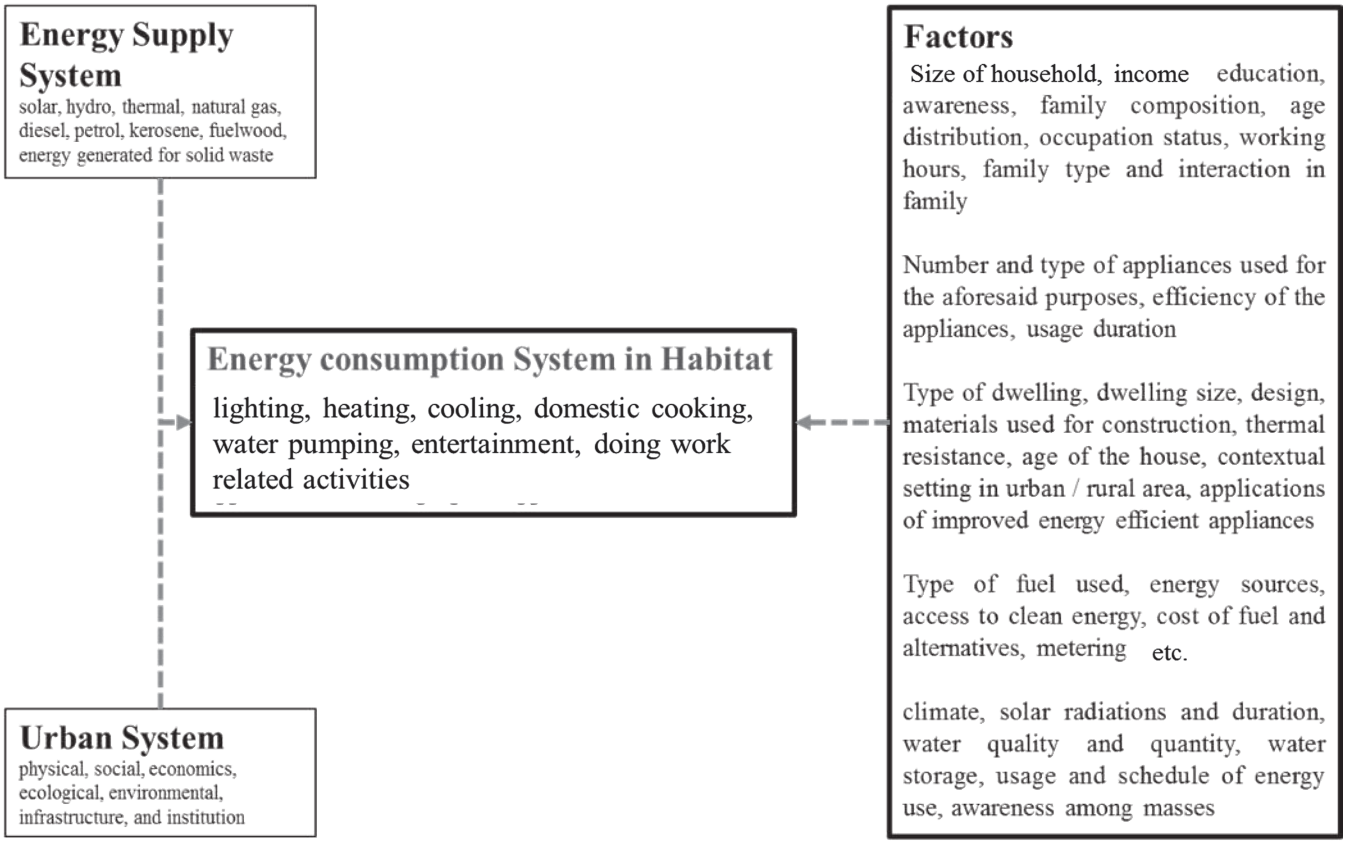


Fig. 2 Dynamic Functions of the Urban System with Energy Related Interactions in Habitat System

A major element in system dynamic modeling is mathematical equations presenting level and rate variables and establishing their causal relationship. They are represented by the use of short term, medium term and long term causal loops relationship. In this manner, variables are considered together in feedback loops. This helps decision makers to test the different plausible scenarios by employing simulation techniques in the model, and thereby results can be used to improve the decisions. When different alternative scenarios are tested in the model by employing simulation technique, the investigator arrives at number of alternatives decisions, and from these decisions optimal decision can be obtained by employing either DCF techniques, or by employing the other relevant techniques. Thus, conceptualization of problems by employing system approach, developing mathematical model by employing system dynamics techniques, validating the model, forecasting the model, testing the scenarios in the forecasted year model by employing simulation techniques, and arriving at decisions is the best option to take plausible decision for energy management in a habitat at city level.

The total energy of habitat system is subdivided and classified in various ways based on fuel used, appliances used, usage schedule, etc. Impact of socio-economic factors, dwelling unit factors, food preparation appliances, cooling / heating appliances, water pumping appliances, water heating appliances, lighting appliance, entertainment appliances, and other purpose appliances can be evaluated by considering the energy consumption at habitat system level. STELLA software is used to develop the habitat system model considering energy input function as catalyst for development.

In this present investigation, physical, social, economics, infrastructure and environment subsystems are considered for modelling. Models are prepared for population and population density, electricity consumption for street lights, electricity consumption for different domestic buildings, electricity consumption for domestic purpose appliances; and are considered for evolving an integrated model for energy management. To quantify the functions of the habitat system, electricity consumption for domestic purpose appliances model is developed, and is presented as below.

MODEL FOR ELECTRICITY CONSUMPTION FOR DOMESTIC PURPOSE APPLIANCES

Electricity consumption at the household level for domestic purposes appliances is quantified by developing a sub system model by employing system dynamic technique. In this sub system model, electricity consumption by various types of appliances by different uses are considered, such as entertainment, food preparation, cooling, water heating, room heating, water pumping, lighting and other purpose appliances. The quantification of total electricity consumption by different typology of houses and their growth rate are considered in this sub model, and clubbed with appliance wise electricity consumption, therefore in this sub model, there is no level and rate variable presented separately, however these things are linked with this sub system model for quantification. Further to calculate the energy efficiency, energy efficient appliances in various activities have been considered along with the appliances and equations are written as per the requirement. In this model, electricity consumption for lighting appliances is considered as a function of effect of tube light fraction, effect of energy efficient electronic ballast fraction, effect of compact florescent lamp fraction, electricity consumption for different domestic buildings and share of lighting appliances. Electricity consumption for entertainment appliances is considered as a function of effect of energy efficient entertainment appliances fraction, electricity consumption for different domestic buildings and share of entertainment appliances; electricity consumption for food preparation. Appliances is considered as a function of effect of energy food preparation, appliances fraction, share of food preparation appliances and electricity consumption for different domestic buildings. Electricity consumption for cooling appliances is considered as a function of effect of energy efficient cooling appliances fraction, electricity consumption for different domestic buildings and share of cooling appliances; electricity consumption for room heating appliances is considered as a function of effect of energy efficient room heating appliances fraction, electricity consumption for different domestic buildings and share of room heating appliances. Electricity consumption for water heating appliances is considered as a function of effect of energy efficient water heater fraction, effect of domestic

solar water heater fraction, electricity consumption for different domestic buildings and share of water heating appliances. Electricity consumption for water pumping appliances is considered as a function of effect of energy efficient water pumping appliances fraction, electricity consumption for different domestic buildings and share of water pumping appliances. Electricity consumption for other purpose appliances is considered as a function of effect of energy efficient other purpose appliances fraction, electricity consumption for different domestic buildings and share of other purpose appliances. Electricity consumption for domestic purpose appliances is considered as a function of electricity consumption for lighting appliances, electricity consumption for entertainment appliances, electricity consumption for food preparation appliances, electricity consumption for cooling appliances, electricity consumption for room heating appliances, electricity consumption for water heating appliances, electricity consumption for water pumping appliances and electricity consumption for other purpose appliances.

RESULTS AND DISCUSSION

The developed model has been validated in year 2016 using base year 2011 data pertaining to study area (Jaipur city) (26) and is projected for the year 2031 A.D., as detailed below:

Base Year Model Results

The investigator looked at all the developed sub-system models and checked their reliability, and developed an intergraded energy management model by integrating all the developed subsystem models together by considering the population as the focal point since energy management in the system (study area) is aiming at to strengthen the welfare of the population in the system. Data pertaining to all the control variables (level and rate variables) are consider and fed in the computer carefully, and subsequently, the model is run in the computer. The developed model results are considered as base year model results (year 2011 A.D.), and are: electricity consumption for food preparation appliances is 25475.84 (MWh/year), electricity consumption for cooling appliances is 407972.19 (MWh/year), electricity consumption for room heating appliances is 1315.65 (MWh/year), electricity consumption for domestic water heating appliances is 14113.37 (MWh/year), electricity consumption for water pumping appliances is 33848.18 (MWh/year), electricity consumption for lighting appliances is 230119.76 (MWh/year), electricity consumption for entertainment appliances is 178211.25 (MWh/year), electricity consumption for other purpose appliances is 304992.40 (MWh/year).

Projected Year Model Results

Domestic Electricity Consumption for Different Purpose Appliances has been considered. Electricity consumption for domestic purposes is projected for the year 2031 A.D., by considering the year 2011 as base year in the model, and the following purposes are considered in projection, such as electricity consumption for food preparation, cooling, room heating, water heating, water pumping, lighting, entertainment and other usages; and the results are presented in Table 1. The table reveals that the electricity consumption for all aspects including for entertainment, food preparation, cooling, room heating, water heating, water pumping, lighting and other usages are increasing considerably from the year 2011 to 2031 A.D. The percentage share for these aspects to total electricity consumption for domestic purpose in the year 2011, 2016, 2021, 2026 and 2031A.D. are considered same, since the primary survey data is considered as benchmark. However, it can be deduced from the table that considerable amount of electricity consumption is increased for domestic purpose, i.e., 319 per cent increase (1196048.63 MWh to 3817416.77 MWh) from the year 2011 to 2031 A.D.

CONCLUSION

In the present research, the authors have developed a habitat system dynamic model with energy interaction as energy is considered as catalyst for the development of any system. System dynamics technique has been employed to develop this model. STELLA software has been used to develop the model. Various variables are considered for developing the habitat system model with energy interaction and they are cooking, cooling, room heating, water heating, water pumping, lighting, entertainment and other purpose appliances. Base year results have been simulated and validated. This study establishes the relationship among the different subsystems of the habitat system and the functions

Table 1: Domestic Electricity Consumption for Different Purpose Appliances

(Units in MWh/year)

S.No.	Year	Electricity Consumption for Entertainment	Electricity Consumption for Food Preparation	Electricity Consumption for Cooling	Electricity Consumption for Room Heater	Electricity Consumption for Domestic Water Heating	Electricity Consumption for Water Pumping	Electricity Consumption for Lighting	Electricity Consumption for Other Appliances	Electricity Consumption for Domestic Purpose by Appliances
1	2011	178211.25 (14.90)	25475.84 (2.13)	407972.19 (34.11)	1315.65 (0.11)	14113.37 (1.18)	33848.18 (2.83)	230119.76 (19.24)	304992.40 (25.50)	1196048.63 (100.00)
2	2016	238098.55 (14.90)	34036.91 (2.13)	545069.90 (34.11)	1757.77 (0.11)	18856.13 (1.18)	45222.74 (2.83)	307450.74 (19.24)	407484.09 (25.50)	1597976.83 (100.00)
3	2021	319465.87 (14.90)	45668.61 (2.13)	731340.99 (34.11)	2358.47 (0.11)	25299.98 (1.18)	60677.07 (2.83)	412518.34 (19.24)	546736.89 (25.50)	2144066.23 (100.00)
4	2026	427369.64 (14.90)	61093.78 (2.13)	978360.96 (34.11)	3155.08 (0.11)	33845.38 (1.18)	81171.55 (2.83)	551851.80 (19.24)	731404.41 (25.50)	2868252.59 (100.00)
5	2031	568795.1 (14.90)	81310.98 (2.13)	1302120.86 (34.11)	4199.16 (0.11)	45045.52 (1.18)	108032.89 (2.83)	734470.99 (19.24)	973441.28 (25.50)	3817416.77 (100.00)

are quantified. This type of research is very much useful for quantifying the functions of the system and evolving policy intervention for the development of the system. The quantitative benefits of passive measures, use of energy efficient appliances for different purposes (food preparation, cooling, room heating, water heating, water pumping, lighting, entertainment and other purposes appliances), use of solar energy can be analysed by simulation technique using integrated model considering other subsystems too. Therefore, phase-wise replacement implementation of energy efficient techniques can be planned in a habitat system. Further reduction in electricity consumption can be checked by simulating the model employing energy efficient appliances, use of LED based street lights, energy efficient electrical motors in public water supply, industrial energy audit and employing ECBC guidelines in residential and commercial buildings. It is advocated to have accurate metering system, incentive to CFL manufacturing companies, setting up of a standard organization to certify the quality of the CFL and minimisation of cost of CFL lamps, etc., in the system. Once the income is increased, switching over of uses of the various type of fuel for cooking and lighting is observed invariably among the rural and urban systems. It is further advocated that energy efficient stoves and other appliances may be used for cooking, lighting and other domestic purpose. If any of the above energy efficient techniques show important results, that can be converted into a plausible policy. The study concludes with quantifying the functions of the system and it advocates the need for further research pertaining to simulations for evolving alternative policy option in various alternative conditions.

REFERENCES

1. Alam, M., and Barnes, D. (1998). Urban Household Energy Use in India: Efficiency and Policy Implications. Energy Policy, 26(11): LBNL-43942.
2. Banister, D. (1996). Energy, Quality of Life and the Environment: The Role of Transport. Transport Review, 16: 23-35.
3. Baxter, L.W., Feldman, S.L., Schinnar, A.P., and Wirt Shafter, R.M. (1986). An Efficiency Analysis of Household Energy Use. Energy Economics, 8(2): 62–73.
4. Bose, R.K., and Shukla, M. (1999). Elasticities of Electricity Demand in India. Energy Policy, 27: 137-146.
5. Brounen, D., Kok, N., and Quigley, J.M. (2012). Residential Energy Use and Conservation: Economics and Demographics. European Economic Review, 56(5): 931–945.
6. Bukarica, V., and Tomsic, Z. (2007). Energy Efficiency in Croatian Residential and Service Sector Analysis of Potentials, Barriers and Policy Instruments. WSEAS Transactions on Advances in Engineering Education, 12(4):259-264.
7. Devadas, V, and Kumar, N. (2007). Integrated Development Plan: A Scientific Approach, Journal of Indian Building Congress, New Delhi, 14 (1):35-42.
8. Fung, W., Lam, K., Hung, W., Pang, S., and Lee, Y. (2006). Impact of Urban Temperature on Energy Consumption of Hong Kong. Energy,

31: 2623–2637.

9. Garbacz, C. (1983). A Model of Residential Demand for Electricity Using a National Household Sample. Energy Economics, 5(2): 124-128.
10. Gupta, G., and Köhlin, G. (2006). Preferences for Domestic Fuel: Analysis with Socio-Economic Factors and Rankings in Kolkata, India. Ecological Economics, 57(1): 107–121.
11. Gupta, R. (2009). Moving Towards Low-Carbon Buildings and Cities: Experiences from Oxford, UK. International Journal of Low-Carbon Technologies, 4(3), 159-168.
12. Haas, R. (1997). Energy Efficiency Indicators in the Residential Sector. Energy Policy, 25(7-9):789–802.
13. Heltberg, R. (2003). Household Fuel and Energy - A Multicounty Study. Oil and Gas Policy Division, The World Bank, 1–86.
14. Holtedahl, P., and Joutz, F.L. (2004). Residential Electricity Demand in Taiwan. Energy Economics 26: 201–224.
15. Kadian, R., Dahiya, R.P., and Garg, H.P. (2007). Energy-related Emissions and Mitigation Opportunities from the Household Sector in Delhi. Energy Policy, 35: 6195–6211.
16. Lenzen, M., Wier, M., Cohen, C., Hayami, H., Pachauri, S., Schaeffer, R. (2006). A Comparative Multivariate Analysis of Household Energy Requirements in Australia, Brazil, Denmark, India and Japan. Energy, 31: 181–207.
17. Link, C.F., Axinn, W.G., and Ghimire, D.J. (2012). Household Energy Consumption : Community Context and the Fuelwood Transition. Social Science Research, 41: 598–611.
18. Mahlia, T.M.I., Said, M.F.M., Masjuki, H.H., and Tamjis, M.R. (2005). Cost-benefit Analysis and Emission Reduction of Lighting Retrofits in Residential Sector. Energy and Buildings, 37: 573–578.
19. Mu, T., Xia, Q., and Kang, C. (2010). Input-output Table of Electricity Demand and its Application. Energy, 35: 326–331.
20. Narayan, P. K., Smyth, R., and Prasad, A. (2007). Electricity Consumption in G7 Countries: A Panel Co-integration Analysis of Residential Demand Elasticities. Energy Policy, 35: 4485–4494.
21. Pachauri, S. (2004). An Analysis of Cross-sectional Variations in Total Household Energy Requirements in India Using Micro Survey Data. Energy Policy, 32: 1723–1735.
22. Rao, M.N., and Reddy, B.S. (2007).Variations in Energy Use by Indian Households : An Analysis of Micro Level Data. Energy, 32: 143–153.
23. Rao, N.D. (2012). Kerosene Subsidies in India: When Energy Policy Fails as Social Policy. Energy for Sustainable Development, 16(1): 35–43.
24. Reddy, B.S. (2004). Economic and Social Dimensions of Household Energy Use: A Case Study of India. Proceedings of IV Biennial International Workshop "Advances in Energy Studies". Unicamp, Campinas, SP, Brazil June 16-19, 469–477.
25. Tiwari, P., (2000). Architectural, Demographic, and Economic Causes of Electricity Consumption in Bombay. Journal of Policy Modeling, 22(1): 81–98.
26. Nand Kumar (2016), Energy management in Jaipur City, India, Phd thesis, Department of Architecture & Planning, India Institute of Technology Rooters 247667, India