Speical Issue

निर्माण सारिका

A NEWSLETTER FOR BMTPC

CITIES AND CLIMATE CHANGE

World Habitat Day

3 October 2011

bmtpc

निर्माण सामग्री एवं प्रौद्योगिकी संवर्द्धन परिषद्

आवास एवं शहरी गरीबी उपशमन मंत्रालय, भारत सरकार

BUILDING MATERIALS & TECHNOLOGY PROMOTIONS COUNIL

Ministry of Housing and Urban Poverty Alleviation, Government of India

"Creating Enabling Environment for Affordable Housing for All"

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From the Desk of Executive Director

I am immensely happy to bring out the special newsletter ***Nirman Sarika*** on the occasion of World Habitat Day 2011 on the theme ***Cities & Climate Change***. World Habitat Day is being celebrated on the first Monday of October every year on a topic which is relevant in the context for the habitat. It also gives us opportunity or rather do SWOT analysis to take stock and understand the current scenario on the theme chosen and take preventive measures before it becomes preposterous for the posterity.The theme chosen by United Nations for this year is pertinent because all over the globe, there has been mass exodus of people towards urban centres i.e. cities and cities have been found deficient as regards necessary paraphernalia required to cater the basic needs/services of the people and thereby creating imbalance of ecosystem. It is this vitiated ecosystem which brings in climate change and poses hazards which are unfathomable.

In order to tackle the climate change, we need to adopt ways and means which affect the ecosystem least and are in harmony with nature. Green houses gas (GHG) emission on account of human activity alone is one of the biggest source responsible for these climate changes. Let me give example, for the sake of development, land use changes are done injudiciously, the settlements are coming up in flood plains, hazard prone areas, forest land, catchments etc. and it is seen the deforestation alone contribute more than 30% emissions of CO_2. The example of Singapore is worth emulating here. It is one of the smallest tropical countries and their entire settlements are concentrated to city area giving rise to higher household density but at the same time, they are able to preserve their precious forest and catchment area.

BMTPC since its inception is advocating use of environmentally friendly building materials and construction technologies. The construction sector is second highest polluter of the environment as regards GHG emissions after the energy sector for Indian subcontinent and, therefore, the role of organisations like BMTPC is crucial to take forward sustainable development of cities especially for habitat. The time is not far when the cooperative/colonizers/developers including individual house owners will be asked to produce energy ratings of their houses. The words like low carbon habitat, green growth are being coined and India being one of the leading developing country should also take a call and become conscious about emissions etc. in every sphere of development. We are sure the World Habitat day celebration throughout the globe would throw deep insights into the climate change and the cities would offer green, clean environment to live with.

I show my gratitude to all the authors who have contributed the articles and to the team at BMTPC responsible for this publication for putting untiring efforts.

(Dr. Shailesh Kr. Agrawal)

BAN KI-MOON
Secretary - General
UNITED NATIONS

This year, World Habitat Day falls during the month when demographers predict our planet's seven billionth inhabitant will be born. The future that this child and its generation will inherit depends to a great degree on how we handle the competing pressures of growing population growth, urbanization and climate change.

Experts predict that by the year 2050, global population will have increased by 50 per cent from what it was in 1999. Also by that time, scientists say, global greenhouse gas emissions must decrease by 50 per cent compared to levels at the turn of the millennium. I call this the "50 – 50 – 50 challenge."

Rising sea levels are a major impact of climate change – and an urgent concern. Sixty million people now live within one meter of sea level. By the end of the century, that number will jump to 130 million. Major coastal cities – such as Cairo, New York, Karachi, Calcutta, Belem, New Orleans, Shanghai, Tokyo, Lagos, Miami and Amsterdam – could face serious threats from storm surges.

The nexus between urbanization and climate change is real and potentially deadly.

Cities are centres of industrialization and sources of emissions, but they are also home to solutions. More and more municipalities are harnessing wind, solar and geothermal energy, contributing to green growth and improving environmental protection.

Local efforts are critical to success, but they must be supported by international initiatives. We have already seen progress, including the creation of the Climate Change Adaptation Fund and adoption of the action plan to Reduce Emissions from Deforestation and forest Degradation, known as "REDD plus." All countries agree on the goal of limiting global temperature rise to below 2 degrees Celsius. Developed and developing countries have committed to lower greenhouse gasses in a formal, accountable international agreement.

Now we need to build on these advances. The United Nations Climate Change Conference in Durban this December must achieve decisive progress. Urbanization will be on the agenda at next year's Rio+20 UN Conference on Sustainable Development.

On this observance of World Habitat Day, let us reaffirm our commitment to the important journey to a more sustainable future, and let us focus greater attention on addressing climate change in the world's cities and beyond.

Statement on the occasion of World Habitat Day 2011

DR. JOAN CLOS
Under-Secretary-General of the United Nations
Executive Director of UN-HABITAT

Each year on World Habitat Day, the first Monday in October, we bring to the world's attention a matter of great concern in our rapidly urbanizing world. This year we look at the impact of cities in creating climate change, and, in turn, the impact of climate disruption on cities, and what cities are doing about it.

We live in an age where the world's population will have grown to 7 billion by the end of this month and where more than half of them live in towns and cities. Projections indicate that this will increase to two-thirds in just over a generation from now. How we manage this rapid urbanisation is one of the greatest challenges facing us.

We must bear in mind that the greatest repercussions of climate disasters both begin and end in cities.

According to UN-HABITAT's Cities and Climate Change: Global Report on Human Settlements, it is estimated that by 2050, there could be as many as 200 million environmental refugees worldwide, many of whom will be forced from their homes by rising sea levels and the increased frequency of flooding or drought.

Prevention should be addressed through better urban planning and building codes so that city residents, especially the poorest, are protected as far as possible against disaster. Such measures can also help to keep their ecological footprint to the minimum.

Climate induced risks such as rising sea levels, tropical cyclones, heavy precipitation events and extreme weather conditions can disrupt the basic fabric and functioning of cities with widespread reverberations for the physical infrastructure, economy and society of cities. These include public health risks in urban areas.

We already know that the impacts of climate disruption will be particularly severe in low-elevation coastal zones where many of the world's largest cities are located. And always it is the urban poor, especially slum dwellers, who are most at risk when disaster strikes. We need to stress the provision of adequate adaptation measures based on urban planning.

Even though we are still trying to understand some of these extreme climatic events, we have the know-how and the strategies to take preventive measures.

Urbanization offers many opportunities to develop mitigation and adaptation strategies to deal with climate change. Given that most global energy consumption occurs in cities, roughly half of it from burning fossil fuels in cities for urban transport, the solution seems obvious.

This is due to the fact that the economies of scale produced by the concentration of economic activities in cities also make it cheaper and easier to take action to minimize both emissions and climate hazards.

The social, economic and political actors within cities must therefore become key players in developing these strategies.

Many towns and cities, especially in developing countries, are still grappling with climate change strategies, working out how to access international climate change funding and how to learn from pioneering cities.

We should reflect on this World Habitat Day on how we turn our cities – arguably the greatest achievements of human civilisation – into better cities for the future.

Joan Clos

सत्यमेव जयते

KUMARI SELJA
Minister of Housing and Urban Poverty Alleviation
and Minister of Culture
Government of India

MESSAGE

The theme of this year's World Habitat Day "Cities and Climate Change" has been declared at a very opportune time. The Global Report on Human Settlement 2011 argues that "the effects of urbanization and climate change are converging in dangerous ways that seriously threaten the world's environmental, economic and social stability". This gives an opportunity to all of us to seriously analyze the subject, take stock of different factors responsible for climate change and chalk out an Action Plan for better adaptation so as to mitigate its effect. With about 50% of the world's population living in urban areas, the world is becoming more of an urbanized place, putting unprecedented pressure on urban areas. The world cities collectively cover only around 2% of the land but contribute up to 70% of the world's emission of greenhouse gases - the main threatening reason for the climate change phenomena.

Cities with concentration of energy intensive activities mostly powered by fossil fuels, transport hubs, centres of business and their infrastructure and buildings, are the most vulnerable. An integrated approach, therefore, is required to deal with the problem, which necessarily requires involvement of various stakeholders. Recognizing the importance of this global phenomenon, Hon'ble Prime Minister has initiated a National Action Plan for Climate Change. One of the eight missions under the Action Plan is National Mission on Sustainable Habitat, which aims to make cities sustainable by improving energy in buildings, management of solid waste and shift to public transport.

The Ministry of Housing & Urban Poverty Alleviation, with an integrated approach for slum upgradatión under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Rajiv Awas Yojana (RAY), aims for better living conditions of the urban poor who are the most vulnerable in cities to the effects of climate change. In this context, the Building Materials and Technology Promotion Council (BMTPC) can play a pro-active role in introducing materials and construction technologies, which will be able to replace high energy intensive materials and technologies in construction leading towards sustainable habitat.

I hope 'Nirman Sarika' to be published on the occasion of World Habitat Day will address these issues for wider dissemination on the subject. I extend my best wishes to BMTPC for their effort.

Selja

(Kumari Selja)

Conceptual Framework for Climate Change Vulnerability Mapping

*Dr. V.K. Verma***

*Dr. R.K. Khandal**

Introduction

Worldover cities have been considered not only as significant centres of productive activity and economic growth but also plays vital role towards social development thereby recognized as important contributor towards the socio-economic development of a nation. Cities, particularly metropolis, attracts wider cross-section of population through internal migration due to the availability of the range of basic services such as potable water, sanitation, education, health and housing, employment, infrastructure etc. In order to achieve, economic growth, regional economies undergo a transition from an agrarian base to urban-based industry and services thereby resulting into the conversion of rural land to urban landuses such as residential, commercial, and industrial. Cities are therefore becoming hub of progress, culture and knowledge and are also responsible for indiscriminate urbanization.

The rapidity of urban expansion not only has negative effects on the quality of environment but also have detrimental effects on the sustainability of the social and economic progress achieved. Intensive human activity put pressure on local landuses in terms of generation of waste which generally exceeds the assimilative capacity of the area and thereby having varying degrees of impacts on environment, ecology and climate change.

Vulnerabilities of Cities to Climate Change : Causative Factors and Impacts

Not only do cities and urbanization exerts impact on climate change, but also, climate change has profound impacts on cities keeping in view of following:

- Cities are generally not self-supportive in terms of the demand of raw materials and natural resources such as energy, food, water and other inputs for the sustenance of inhabitants.
- Resources are generally imported from other areas and some times distant places through the network of highways, railways, ports, airports, pipelines etc.
- Natural phenomenas like earthquakes, floods, droughts, cyclones etc. have wide implications on city's dynamism and configuration of human settlements.
- Assimilative capacities of urban areas varies widely to absorb impacts and hence the socio-economic conditions and institutional arrangements to prevent or mitigate the effects of climate change impacts and other extreme events varies from place to place.
- Cities generally have a high concentration of population density and economic activity, and consequently are vulnerable to climate change.

Above factors are responsible for transformation of urban zones and cities into extremely vulnerable zones, both physically and socially. The confluence of all these elements creates a situation of urban vulnerability and magnitude of impact is more on lower income communities in particular, as they are forced to inhabitate areas which could be at greater physical and environmental risk. In India most of the cities are characterized by high density of population, housing stock, and poor infrastructure and hence vulnerability to climate change varies accordingly.

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सत्यमेव जयते

ARUN KUMAR MISRA
Secretary
Ministry of Housing and Urban Poverty Alleviation
Government of India

MESSAGE

This year's theme of Habitat Day celebration "Cities and Climate Change" gives us an opportunity to focus on the various challenges cities are facing due to the threat of climate change and to rededicate towards mitigation of these effects.

Climate change, caused by emission of Green House Gases (GHG) is one of the most dreadful threat ever faced by human kind, It is affecting cities and their residents specially the unprivileged ones. As climate extremes and variability increases, more severe impacts are expected, unless proper steps are taken for both adaptation and mitigation of climate change phenomenon. Amongst other factors, the design and use of the built environment is a critical arena of climate change mitigation because the building sector consumes roughly one third of the total energy used in most countries. The use of energy within the built environment is the result of complex interaction among building materials, design, the system used for energy, water and the ways in which buildings are used on day to day basis. A concerted effort is required to bring changes in planning, design, choice of materials, practices and uses so as to reduce energy requirement in built environment.

The Building Materials & Technology Promotion Council (BMTPC) has a significant role in the national efforts of mitigating climate change by promoting cost effective, environment friendly, energy efficient building materials and technologies. It is hoped that the Council will intensify its efforts in bringing new innovations in use of energy efferent building materials and technologies which are helpful in mitigating the effect of climate change.

I am happy that the BMTPC is bringing out its publication "Nirman Sarika" with special focus on the theme of the World Habitat Day. It is hope that the publication will bring out new ideas from experts in the country.

I wish BMTPC all success.

(Arun Kumar Misra)

Climate Vulnerabilities Mapping of Cities

According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability expresses the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climatic variability and extreme events. Vulnerability is a function of the character, magnitude and rate of climate change, as well as of the variation to which a system is exposed, its sensitivity and its capacity for adaptation.

According to the United Nations Development Programme (UNDP), vulnerability differs from risk. Whereas risk includes exposure to external hazards over which persons have little control, vulnerability is a measure of the capacity to manage these dangers without any loss of well-being that might be potentially irreversible in the long run.

Vulnerability of region is depending upon three major components:

- Exposure (the nature and degree to which a system is exposed to significant climatic variations),
- Sensitivity (the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli), and
- Adaptive capacity for response, or resilience, that is the ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

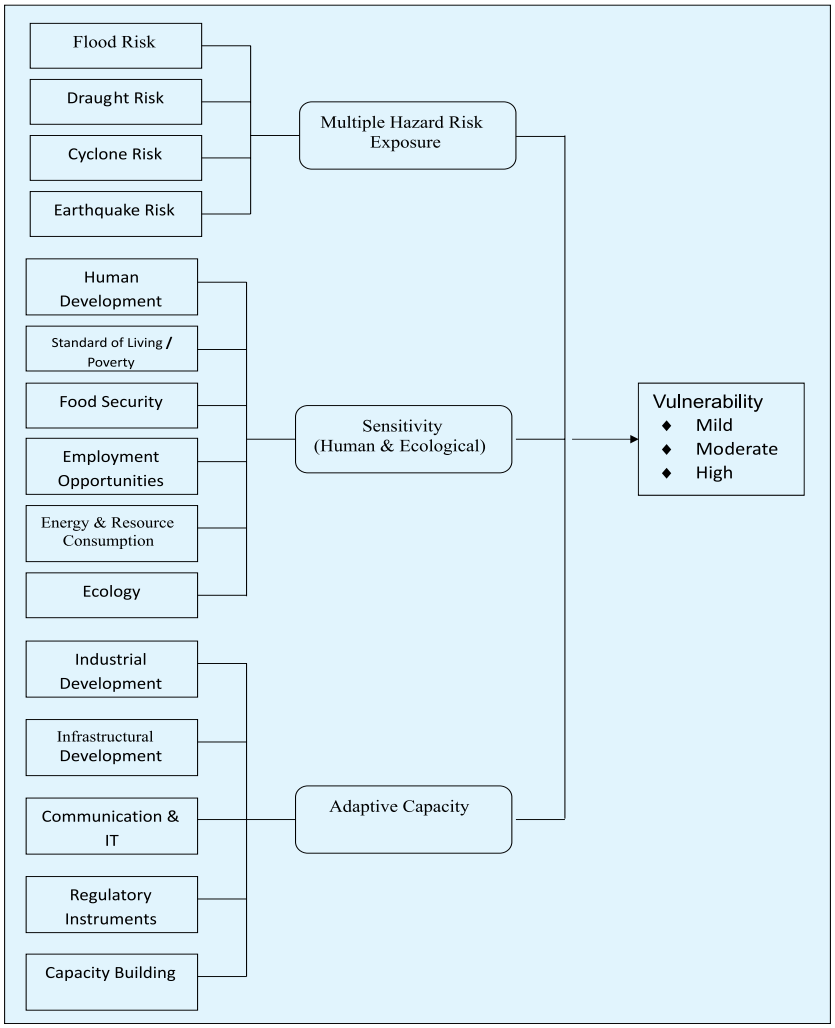
These three components may vary considerably from one individual to another, as well as from one social group or community to another. Additionally, vulnerability is multidimensional (effects of different stress factors at the same time) and depends on spatial and temporal scales (potential for change in the stress factors over time). In other words, risk can be seen as the overlay between vulnerability and hazard, both being dynamic over time.

The vulnerability mapping of the urban area shall be based on indicators of exposure (multiple hazard risk exposure), sensitivity (human and ecological), and adaptive capacity that would be categorized into varying magnitudes such as mildly vulnerable, moderately vulnerable and highly vulnerable.

DPSIR Matrix for Vulnerability assessments

The D-P-S-I-R methodology (UNEP) is an analytical tool that can be used to analyze the interactions between urban trends and the environment. It involves to establish a logical link between its components to evaluate the state of the environment based on the factors that exerts pressure on natural resources thereby indicating the causes of the current state of the environment based whereupon responses can be devised to deal with specific environmental problems.

The elements for D-P-S-I-R matrix involves:



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सत्यमेव जयते

DR. P. K. MOHANTY
Addl. Secretary & Mission Director (JNNURM)
Ministry of Housing and Urban Poverty Alleviation
Government of India

MESSAGE

Climate change is one of the defining challenges of our age. Coupled with the issue of urbanization, climate change has emerged as a major concern for sustainable development. Cities present enormous opportunities for economic growth and the generation of wealth of nations. However, ill-managed urbanization can contribute to environmental degradation and represent an immense ecological burden.

By 2030, India's urban population is expected to be 590 million representing 40 per cent of the total population. India's vast coastline is home to a number of cities and a vibrant urban culture. A vast majority of people in urban areas will be affected by rising sea levels, increased precipitation, inland floods, more frequent and stronger cyclones and storms, periods of extreme heat and cold and the spread of disease. Climate change can also negatively impact infrastructure and worsen access to basic urban services and the quality of life in cities. More than half the world's green house gas emissions come from urban areas. The most affected population is the urban poor, including the slum dwellers; today there are 93 million slum dwellers in India and by 2017, this number is expected to be 105 million.

However, if properly managed, our cities can be models of environmental efficiency because increased density and better management can reduce the cost of service delivery, promote innovation and enable prosperity through equitable and inclusive urban growth. The adaptive capacity and capability of systems to actively and adequately respond are largely influenced by access of cities to financial resources, availability of technology, appropriate decision-making structures and capacities, human and social capital and risk spreading.

Clearly then, climate change perspectives need to be fully integrated with broader aspects of provision of affordable housing and basic services, urban poverty alleviation, participatory urban governance, and urban spatial planning and environmental management.

The theme of this year's World Habitat Day, "CITIES AND CLIMATE CHANGE" is aptly chosen as it gives us the opportunity to access the magnitude and nature of challenges before us, to take measures for addressing these problems thereby laying the foundation of green and inclusive cities in the future. The Building Materials & Technology Promotion Council (BMTPC) has been playing a proactive role in the dissemination and promotion of cost-effective, environment-friendly, energy efficient building materials and safer construction technologies.

I am glad to know that BMTPC is bringing out a special issue of the newsletter "Nirman Sarika" focusing on the theme of "Cities and Climate Change" to create awareness among various stakeholders.

I wish BMTPC all success in its future endeavours

(Dr. P. K. Mohanty)

Driving forces	:	These are related to fundamental societal processes, which not only gives catalytic effects to promotion of activities that have a direct impact on the environment, but also influence human development index of an area. Key forces include: ♦ Population trends & demography ♦ Consumption pattern and production ♦ Scientific and technological innovations ♦ Economic & market demand ♦ Resources distribution patterns ♦ Institutional frameworks ♦ Policy instruments The characteristics and importance of each driving force varies substantially on local, regional and national scale and accordingly, resources and opportunities are distributed unequally within and among the regions.
Pressure	:	Pressures affect state of the environment variably depending upon trend of development, magnitude of resources extraction and level of replenishment and rehabilitation . Key components, which exerts pressures on environment includes ♦ Emissions of pollutants like gaseous, particulates, liquid effluents and solids (MSW & Hazardous). ♦ GHG emissions and climate change ♦ land use changes due to development
State	:	The State of Environment means the condition of the environment in quantitative terms as a result of pressures such as ♦ Level of atmospheric pollution in terms of – Air Quality Index – Water Quality Index – Pollution Load ♦ Socio-economic Index indicating demography & human development ♦ Quantification of GHG emissions, Carbon and Water Footprints ♦ Soil erosion due to water & wind ♦ Change in forest cover
Impacts	:	Impacts are the negative (detrimental) or positive (beneficial) effects due to the state of the environment in terms of ♦ Impacts on quality of life and human health ♦ Impacts of agricultural production ♦ Impacts on socio-economic & human development ♦ Impacts on ecology and bio-diversity ♦ Impacts on natural resources ♦ Other relevant impacts
Responses	:	Responses means collective or individual efforts or actions such as ♦ To mitigate or prevent the negative environmental impacts ♦ To protect or replenish/rehabilitate natural resources. ♦ To participate in regulatory proceedings ♦ Capacity building and training to enhance adaptation

NCT of Delhi and Climate Change

The National Capital Territory of Delhi is located in northern India between the latitudes of 28°24'17" and 28°53'00" North and longitudes of 76°50'24" and 77°20'37" East. It has an area of 1,483 sq. kms. with a maximum length of 51.90 kms and greatest width of 48.48 kms. It shares borders with the States of Uttar Pradesh and Haryana. The Yamuna River and terminal part of the Aravali hill range are the two main geographical features of the city. The Aravali hill ranges are covered with forest and are called the Ridges. The average annual rainfall in Delhi is 714 mm, three-fourths of which falls in July, August and September. Heavy rainfall in the catchment area of the Yamuna can result in a dangerous flood situation for the city. During the summer months of April, May and June, temperatures can rise to 40-45°C. Winters are typically cold with minimum temperatures during December and January falling to 4 to 5°C. *Contd. page 12*

सत्यमेव जयते

ARUNA SUNDARARAJAN
Joint Secretary (RAY)
Ministry of Housing and Urban Poverty Alleviation
Government of India

MESSAGE

In pursuance of the decision of the General Assembly of the United Nations, the first Monday of October is celebrated every year as the World Habitat Day the world over. The theme chosen for this year is "Cities and Climate Change".

As India becomes more populous, there is an increasing requirement of housing for the entire cross section of the society. Weaker sections, low-income and disadvantaged groups need special attention in the context of emerging challenges. Despite sustained economic growth in the last few years, India still faces challenges of addressing the issues of affordability, accessibility and availability that haunt a large segment of population. Climate change adds to the existing stresses on the sustainability of human settlements and society.

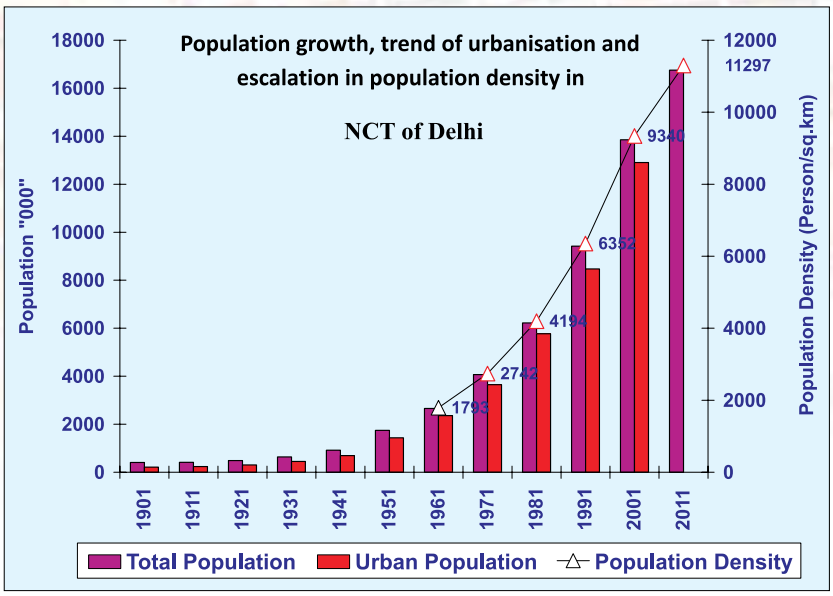
The National Action Plan on Climate Change (NAPCC) announced in June 2008, outlines a strategy by which India will adapt to climate change, while maintaining a high growth rate, protecting poor and vulnerable sections of society and achieving national growth objectives. It focuses on eight areas intended to deliver maximal benefits to development and climate change including its mitigation and adaptation.

The construction industry is today a key contributor to pollution. Cost-effective and alternate construction technologies play a vital role in reduction of green house gas emission. By careful selection of materials and technologies, it is possible to significantly reduce emissions.

The Building Materials & Technology Promotion Council (BMTPC) has been making concerted efforts to promote and popularize cost effective, environment-friendly and energy-efficient technologies in the housing and building sector. I would request that the Council should further intensify its efforts to ensure speedy dissemination of innovative concepts and technologies in the implementation of housing programmes.

I am happy to know that the BMTPC is bringing out a Special Issue of its Newsletter "Nirman Sarika" on the occasion of the World Habitat Day. I do hope that the efforts of the BMTPC will catapult the various agencies involved in the housing sector to take advantage of cost-effective materials and technologies.

(Aruna Sundararajan)



Total population of NCT of Delhi has increased from 0.40 million in 1901 to 16.75 millions in 2011. Percent of urban population during 1901 was 52.76%, which was estimated 89.93% and 93.18% during 1991 and 2001 respectively. Decennial growth of urban population was maximum during 1941-51 (106.58%) and minimum during 1901-11 (11.13%). Population Density, which was 1793 persons/ sq.km during 1961 has alarmingly increased to 11297 persons/ sq.km during 2011.

DPSIR Matrix for the NCT of Delhi

DPSIR Matrix	Parameters	Estimations/ Indications	Situation
Driving Forces	Population Growth	16.75 millions as per census 2011	Alarming
	Trend of urbanization	93.18% as per census 2001	High
	Population Density	11297 as per census 2011	Alarming
	Industrial Growth	31 Industrial Estates housing more than 25000 industries	High
	Transports	No. of registered vehicles increased from 45.08 lakhs in 2004-05 to 64.51 laks in 2009-10.	Alarming
Pressure	Housing Requirement	30 lakhs	High
	Water Demand	4000 MLD	High
	Energy Demand (Peak)	3600 MW	High
	Sewage Generation	3200 MLD	High
	Solidwaste Generation	7000 MT per day	High
	Effluent Generation	180 MLD	High
State	Air Quality Index	Considerable	Area of concern
	Water Pollution	Considerable	Area of concern
	Socio-economic Index	Appreciable in terms of ♦ Employment opportunities ♦ Basic amenities ♦ Housing	Positive
	Afforestation	Growth (last 10 years) from 30 km^2 to 300 km^2	Offsetting
	Infrastructure Development	Effective development in terms of Metro Rail, Flyovers, Road Network etc.	Appreciable
Impact	Air Pollution	Moderate to heavy	Area of concern
	Sewage Pollution	♦ 30 Nos. of operational STPs ♦ 2350 MLD of combined Treatment Capacity	In order to achieve desired performance, complete utilization to be ensured by regular monitoring.
	Effluent Treatment	♦ 12 Nos. of operational CETPs ♦ 177 MLD of combined Treatment Capacity	
	Solidwastes	♦ Controlled Sanitary Landfilling ♦ 500 TPD compost plant at Bhalswa ♦ 200 TPD compost plants each at Okhla & Tikri ♦ 1300 TPD integrated waste complex at Ghazipur ♦ 1950 TPD waste complex at Sukhdev Vihar	Offsetting the impacts

DPSIR Matrix	Parameters	Estimations/ Indications	Situation
	Human Development	High Human Development Index due to ♦ Adequate Amenities ♦ Appropriate Infrastructure ♦ Effective Transportation ♦ Best Educational Facilities ♦ Employment Opportunities	Positive Impact
Response	Regulatory Mechanism	Very strong & effective	Regular Monitoring
	Stakeholders Participation	Very effective	To frame policies
	Institutional Support	♦ Delhi Metro Rail Corporation ♦ Gas based power plant for Clean Power Generation ♦ Energy Conservation in Government Institutions ♦ CNG based public transport ♦ Green Building concept gaining importance.	Offsetting the impacts of Climate Change
	Capacity Building	Effective Training Institutions	Helps in Enhancing adaptations
	Natural Disasters	Flood threats mainly from River Yamua the level of which generally exceeds the danger mark during monsoon	Regular monitoring by Irrigation Department. Capacity building to create awareness & enhance adaptation
		Delhi is in Zone-IV, characterized by a significantly high intensity of seismic activities (may experience earthquakes of the magnitude of 3-6 on the Richter scale).	Efforts to increase adaptive capacity by training

In order to enhance sustainability, to increase adaptation and to address the issues pertaining to climate change, the government of NCT of Delhi has formulated Climate Change Agenda 2009-12 for Delhi

Path Forward

Cities are not only contributor to climate change but also vulnerable to its impacts. Cities can also play a key role in fostering green growth agenda. Cities need an integrated approach that considers mitigation, adaptation and urban development to address the issues of climate change and to enhance resilience. However, cities can also be transformed into environmental efficient hubs because of stronger linkages, social dynamism, better human development, adequate infrastructure and providing conducive environment for capacity building. In order to enhance resilience, to increase adaptation, and to mitigate climate change effects, there is a need to develop integrated approach for cities to include:

- Increasing energy efficiency of buildings and transportation by promoting eco-friendly building material and green building concepts.
- Participating in regional and national programs to increase resilience.
- Switching to low consumption lifestyles.
- Encouraging capacity building programmes to enhance the adaptations.
- Avoiding development in hazardous or sensitive areas
- Protecting buffering capacities of local ecosystems and minimizing degradation.
- Ensuring food security.
- Ensuring the efficiencies of utilities in terms of water supplies, sewage treatment and solid waste disposals.
- Participation in afforestation programmes to enhance assimilative capacities of ecosystem.

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Cities and Climate Change

*Dr. M.L. Khurana**

Introduction

Climate change today is one of the most serious problems facing humanity, effects of which long-term, global and even life threatening. The problem is not only environmental but it is encompassing social and economic issues within, which need to be addressed without delay.

Climate change refers to sustained changes in the earth's climate – including temperature, precipitation, wind and weather patterns. Global warming refers to the rise in the average temperature on the Earth's surface. Carbon dioxide levels are higher than at any time in the past which has been caused by human activities such as the burning of fossil fuels (oil, gas and coal), indiscriminate use of natural resources and their wastage and destruction of forests and natural biomes. The recently concluded International Conference on Climate change hosted by the University of Copenhagen have made alarming predictions from some of the world's leading scientists that sea levels could raise by one metre or more by the end of the century.

Projections for the 21st century indicate that the earth's average temperature will rise by anything between 1.4 and 5.8 degree Celsius. The ten warmest years on record have all occurred since 1990. Without coordinated and immediate action across the globe, the earth's climate will reach a critical 'tipping point' beyond which dangerous climate change will occur which would not be reversible, may be making human survival difficult.

There would be rise in the sea level which would eventually result in displacement of people. For instance, one metre rise in sea level would displace about 7 million people in India alone. The Gangotri glacier in the Himalayas is the source of water for the perennial river Ganga. This glacier like many others all over the world has also felt the impact of climate change. Studies carried out in the past few years have shown that the glacier is retreating at a speed of about 30 metres every year. If warming continues, it will melt rapidly, releasing large volumes of water but once this source begins drying, there may be dry periods with very little water flowing in the river.

The future impacts of climate change, identified by the Government of India's National Communications (NATCOM) in 2004 include:

- Decreased snow cover, affecting snow-fed and glacial systems such as the Ganges and Bramhaputra. 70% of the summer flow of the Ganges comes from melted ice.
- Erratic monsoon with serious effects on rain-fed agriculture, peninsular rivers, water and power supply.
- Drop in wheat production by 4-5 million tones, with even a 1ºC rise in temperature.
- Rising sea levels causing displacement along one of the most densely populated coastlines in the world, threatened freshwater sources and mangrove ecosystems.
- Increased frequency and intensity of floods. Increased vulnerability of people in coastal, arid and semi-arid zones of the country.
- Studies indicate that over 50% of India's forests are likely to experience shift in forest types, adversely impacting associated biodiversity, regional climate dynamics as well as livelihoods based on forest products.

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India is home to a third of the world's poor, and climate change will hit this section of society the hardest. Set to be the most populous nation in the world by 2045, the economic, social and ecological price of climate change will be massive. Although not an emitter historically, India currently has one of the fastest growing economies in the world. With a government target of 8% GDP to achieve developmental priorities, a share of one sixth of the global population, and changing consumption patterns, India's emissions are set to increase dramatically.

Growing at an almost breakneck pace, and guzzling coal, gas and oil in large quantities, we are today, the fourth largest emitter of greenhouse gases worldwide. Although our per-capita emissions are among the lowest in the world, our growth rates imply that the past is no predictor of the future. The most recent IPCC report suggests that India will experience the greatest increase in energy and greenhouse gas emissions in the world if it sustains a high annual economic growth rate. The International energy Agency predicts that India will become the third largest emitter of greenhouse gases by as early as 2015.

India imports large quantities of fossil fuels to meet its energy needs, and the burning of fossil fuels alone accounts for 83% of India's carbon dioxide emissions. Nearly 70% of our electricity supply comes from coal.

The following Tables provide a snapshot of vulnerabilities to climate change hazards in the four mega cities. The aim is not to assess definitively the vulnerability but instead to identify a set of data to understand the vulnerabilities in the four cities of analysis.

Table 1 : Vulnerability to Climate Change

City	Pop.	Pop. In 2020	Land Area Sq.Km	Density	Total Slum Population	% of slum population	Share of migrants in total population	Population in dry lands (000)	Population LECZ (000)	Per Capita water availability (M3)	Per capita Water 2035
Delhi	12.79	25.83	1295	11050	1851231	18.7	16.4	16.800 (100%)	-	-	-
Greater Bombay	16.37	25.97	484	29650	6475440	54.1	15.15	-	8.056 (46%)	277	101
Calcutta	12.22	18.54	531	23900	1485309	32.5	6.23	-	14000 (88%)	243	102
Chennai	6.42	8.88	414	14350	819873	18.4	6.64	2.358 (30%)	2.855 (36%)	224	113

Source: Slum Population, Census of India 2001.

Table 2: Climate Change Risks

City	Delhi	Mumbai	Calcutta	Chennai
Major risks of climate change	Raising intense rain fall, heat waves, cold waves, increased droughts, water scarcity	Coastal flooding, cyclones, sea level rise, increased rainfall, increased malaria risks	Tidal upsurge, cyclones, flooding and water logging.	Sea level rise, costal flooding, cyclones, landslides, tsunami, drought, salinity intrusion
Predicted Climate change	+1.5 to 2.5° Air temperature, Central Range +15 to + 35 percent precipitation Central range.	Annual average temperature increase 1.75° and 1.25°C by 2050 BAU, average annual decrease in precipitation 2%for the A@ and an increase of 2% for the B2 scenario (Sherbinin et al 2009)	Not available	Not available

Source: Centre for Climate Systems Research, Columbia University

Effect on Cities due to Climate Change

Cities are home to half the world's population and this population is steadily growing both due to population growth and migration. Cities world over consume over two-thirds of the world's energy and account for more than 70 percent of global CO2 emissions. The effects of climate change will be strongly felt in cities. Many of the world's major cities are at risk of flooding from rising sea levels. Heat-trapping urban landscapes (buildings and paved surfaces) can raise the temperatures and lower the air quality dangerously through the Urban Heat Island effect. In cities of the developing world, one out of every three people lives in a slum, making them particularly vulnerable to the health and environmental risks posed by climate change. The vulnerability of human settlements in the slums or mismanaged urban areas particularly will increase. Also the climate change may worsen the access to basic urban services and the quality of life in cities. Most affected are the urban poor – the slum dwellers in developing countries.

Climate change is likely to increase the present climate hazards these cities are facing and it is typically associated with vulnerability and hazard exposure. It is important to understand the different pathways through which climate change can impact the urban residents and increase their vulnerability to climate related risks. The four megacities mentioned in the table above are particularly vulnerable to the impacts of climate change for three reasons. First, a large and growing proportion of people at risk from climate change lives in the four megacities of India. Secondly, these urban centers in India are the engines of growth and successful national economies depend on the well-functioning and resilient urban centres. This provides an important economic rationale for addressing the current urban vulnerabilities to extreme weathers and expanding protection from likely future changes. Thirdly, very little attention has been given to the vulnerabilities of low income population in urban centres in India. For example populations living in the slum areas are most vulnerable to the impact of climate change. An Expert Committee set-up by the Ministry of Housing and Urban Poverty Alleviation to look into various aspects of slum Census in its report has stated that India's slum population is projected to rise to 93.06 million by 2011 and expected to cross 100 million by 2017. These people will be most adversely affected due to climate related impacts. Till now most of the attention has been given to the rural population's adaptation to the impacts of climate change.

Challenges Ahead

In the last few years several measures relating to environmental issues have been introduced. They have targeted increasing significantly, the capacity of renewable energy installations; improving the air quality in major cities (the world's largest fleet of vehicles fuelled by compressed natural gas has been introduced in New Delhi); and enhancing afforestation. Other similar measures have been implemented by committing additional resources and realigning new investments, thus putting economic development on a climate-friendly path.

At the local level UN-HABITAT strives to help cities in developing countries to address climate change and, at the national, regional and global levels, to raise awareness and to help counterparts to build the capacities needed to enable cities and local governments to address climate change effectively. Cities have the potential to influence the causes of climate change and they have the solutions to advance climate protection. The success of adaptation critically depends on the availability of necessary resources, not only financial, but also knowledge, technical capability, institutional resources and tools. UN-Habitat's Cities and Climate Change Initiative (CCCI) seeks to enhance the preparedness and mitigation activities of cities in developing and least developed countries. It emphasizes good governance, responsibility, leadership and practical initiatives for local governments, communities and citizens. Building on UN-HABITAT's long experience in sustainable urban development, the Cities and Climate Change Initiative helps counterparts to develop and implement pro-poor and innovative climate change policies and strategies

Steps to be taken by the Cities

Cities have greater responsibility now and must play a key part in finding solutions to this problem. The solution to this problem has to be directed towards the local and regional needs but certain basic steps that can be taken are :

- increasing the energy efficiency of their infrastructure such as buildings, outdoor lighting, and transportation systems;
- using resources more effectively for example through advanced waste management;

- producing clean energy at the district-level as well as sourcing clean energy from large-scale suppliers;
- encouraging and engaging the young generation and making them aware of the consequences of the climate change;
- implementing bold steps to reduce greenhouse gas emissions that others may follow; and
- Celebrating special days like independence day or republic day or festivals like Diwali and holi by either planting saplings or cleaning their immediate surroundings or taking out small processions to encourage others to join .

A similar step has been taken by housing cooperatives at the local level which is encouraging people to take positive steps for environment upgradation under the overall umbrella of the National Cooperative Housing Federation of India (NCHF), a nationwide organisation, the housing cooperatives are contributing in improving the environment of the dwelling place of an individual and thereby contributing in some way in the global challenge faced by humanity. There are more than 100,000 housing cooperatives with a membership of about 70 lakhs. These members can play a major role in joining hands with the National Action Plan by doing a simple task of planting at least one tree per member. Thus, there may be at least 70 lakh additional trees planted with the various housing cooperatives in India. This will be extremely helpful in cleaning the environment and combating the challenge of global warming.

An appeal was issued by NCHF to all the state apex housing federations, district housing federations, primary housing cooperatives as well as other cooperative institutions to play an effective role in protecting environment. All the 70 lakh members of housing cooperatives have been requested to join hands in protecting the nature and consequently helping the mankind to breathe fresh air; they have been urged to plant at least one sapling each for the cause. CHF Secretariat has received encouraging response regarding the appeal of tree plantation from housing and other cooperatives in various States. Some of the cooperatives are proactive enough in conducting awareness programmes on global warming and benefit of planting trees, while others are contributing their bit by undertaking plantation in collaboration with the State Governments and NGOs.

With only such small efforts we can bring great changes. Although we may not be able to reverse the damage already done but we can surely stop any further damage so that our future generations be able to have a good living.

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BMTPC's Display in TechMart during IITF 2010

Impact of Climate Change on Sanitation And Health

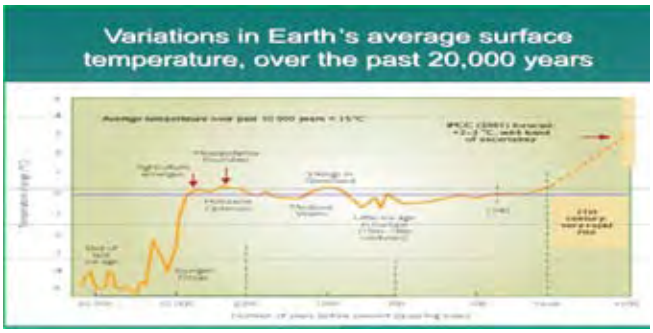
*Dr. Bindeshwar Pathak**

The theme of the World Habitat Day viz. "Cities and Climate Change" is rightly timed as the subject matter is the burning issue of today being faced by the whole world and needs to be tackled jointly for the survival of humanity.

Conflicts of Climate Change

Climate change is due to a significant shift in temperature and weather patterns around the world, since the beginning of the mid-nineteenth century. Our planet's climate is always changing. In the past, it has altered due to natural causes but at present the changes have accelerated as a result of human behavior rather than natural forces. Indeed, the natural "greenhouse effect" – by which the Earth's atmosphere traps energy from the sun, warming our planet to support life, is being heavily disturbed. Scientists agree that human activities are causing dramatic changes in the Earth's climate.

We are putting so much of carbon dioxide into the atmosphere that the planet is getting warm. The problem is commonly termed as 'greenhouse effect'. The 'greenhouse effect' is critical to life on earth; without it, the Earth would be 33ºC colder than present and the diurnal temperature range would increase significantly. According to the Intergovernmental Panel on Climate Change (IPCC), global temperatures on both land and sea have increased by 0.75°C degrees centigrade relative to the period 1860–1900, according to the instrumental temperature record. The last decade has been the hottest on record.



Greenhouse gases (GHG) include water vapour, carbon dioxide, methane, nitrous oxide, halocarbons and ozone. The effect of GHG absorbed by the Earth's surface and lower atmosphere, has a warming effect. Continuous human activity has increased many of these greenhouse gases leading to unusual warming in the past 50 years. The table provides examples of several greenhouse gases that are affected by human activities and summarized their 1790 and 1998 concentrations, their rate of change over the period 1990 to 1999 and their atmospheric lifetime. The atmospheric lifetime, highly relevant to policy makers because the emission of gases with long life times, entails a quasi-irreversible commitment to sustained climate change over decades or centuries.

While elaborating on the relationship between climate change and disasters, a report by the International Institute of Sustainable Development (IISD) notes: "The poor are already vulnerable to climate risks. Settlement on marginal or unstable lands such as steep slopes or floodplains heightens their exposure to the impacts of climate hazards. Heavy dependence on ecosystem services can place their

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Examples of greenhouse gases that are affected by human activities

	CO_2 Carbon dioxide	CH_4 Methane	N_2O Nitrous oxide	CFC-11 Chlorofluorocarbon-11	HFC-23 Hydrofluorocarbon 23	CF_4 Perfluoromethane
Pre-industrial concentration	~280 ppm	~700 ppb	~270 ppb	Zero	Zero	40 ppt
Concentration in 1998	365 ppm	1745 ppb	314 ppb	268 ppt	14 ppt	80 ppt
Rate of concentration change	1.5 ppm per yr	7.0 ppb per yr	0.8 ppb per yr	~1.4 ppt per yr	0.55 ppt per yr	1.0 ppt per yr

Source: IPCC

welfare and survival at the mercy of environmental conditions".

Climate change, therefore, threatens to exacerbate existing vulnerabilities and further entrench development disparities - those with the least stand to suffer the most. Thus, with regional changes and impacts already being observed, the need for adaptive response measures is urgent. For the poor and other vulnerable people, the need is imperative.

Affects of Climate Change

Health

Climate change impacts both health and development. In India, for example, more than 56% workers are engaged in agriculture and allied sectors, while many others earn their living in coastal areas through tourism or fishing. Most of India's poorest people live in rural areas, almost totally reliant on natural resources for their food, shelter and livelihoods. They are thus vulnerable to the impacts of climate change which puts stress on their limited resources.

The health risks posed by climate change are global and difficult to reverse. According to IPCC, eighteen heat waves were reported in India between 1980 and 1998. A heat wave in 1988 caused 1300 deaths while another one in 2003 caused more than 3000 deaths. Many risk factors and illnesses that are currently among the most important contributors to the global burden of disease are sensitive to climate, notably to temperature changes. These include malnutrition (estimated to kill 3.7 million people per year, globally), diarrhoea (1.9 million people) and malaria (0.9 million people). Warmer temperature will have adverse effect on food production, water availability and the spread of disease vectors.

Climate change over recent decades has already affected some health outcomes. Indeed, the World Health Organization in its World Health Report 2002 stated that climate change was estimated to be responsible for approximately 2.4 per cent of worldwide diarrhoea, and 6 per cent of malaria in some middle-income countries in the year 2000.

Weather

The impact of climate change on human health in India is significant and growing. Weather extremes and short-term weather fluctuations cause adverse health effects. Other negative outcomes are reduced access to drinking water, which could mean more recurrent and rigorous outbreaks of water-borne diseases.

Women and Livelihood

Impacts of climate change will increase hardship to women, particularly those who are poor, as women are often responsible for providing daily essentials such as food and water. When climate-related disasters strike, the health and workload of women and girls from low-income families are compromised with inequities.

Since health is most affected by climate change, action to protect health through adaptation and mitigation strategies is critical. Greater focus on livelihoods, access to improved health and mainstreaming gender are significantly important. Our understanding of the indirect impacts of climate change on human health still needs to be improved.

Sulabh approach

Sulabh approach to the problem of climate change is to contribute sustainable sanitation solutions in the public interest to enhance the quality of life of billions of under-privileged people in the developing world, predominantly through social transformation and development and application of innovative technologies that counter affect the effects of climate change on sanitation and health.

The effects of climate change on sanitation and thereby health has been predominantly due to open defecation, lack of access to safe water and sanitation, environmental pollution, lack of adequate utilization, bio-energy from human waste, etc.

Keeping the above in view, two technologies have been developed – one for individual household use and the other for public places in non-sewered areas.

The first technology is the twin-pit pour-flush compost toilet, popularized by the name of Sulabh Shauchalaya – or Easy Toilet. There are two pits, one being used at a time and the other kept as stand-by. When the first pit is full, the flow of waste is switched over to the other. In the first pit, after two years, the waste becomes manure containing nitrogen, potassium

and phosphate. It works as a bio-fertilizer to raise the yield of flowers, fruits, plants as well as productivity in the field.

It requires only 1-1.5 litre of water to flush per use, compared to 10-12 litres of water that gets used in each flush when connected to conventional sewerage system or septic tank, thus saving substantial quantity of water. By using the toilet developed by Sulabh, a saving of 96 billion litres of fresh water per day can be achieved if 6 billion people adapt this technology and use the toilet twice a day. With the existing 1.2 million Sulabh toilets in India, a saving of at least 268.8 million litres/day is being achieved.

In this technology there is no gas pipe. The methane gas produced is absorbed in the soil, hence it helps to reduce global warming. This technology remains functional even during winters. In Srinagar, India, the temperature sometimes goes down to the level of -14^{0}C but all Sulabh toilets installed function very well whereas the septic tank and the sewerage systems get frozen.

Though the use of septic tank has been very common in many countries including India, this approach contributes to climate change as the gases generated go into the atmosphere through a vent pipe. As a result, people are slowly shifting towards the Sulabh two-pit, pour flush toilets, which have a lot many advantages in negation to the adverse effects in climate.

Sulabh has so far installed over 1.2 million toilets. Based on this technology, the Government of India has constructed 54 million such toilets. Now women safely go to the toilet with dignity and girls can also go to school. Millions of 'untouchable' scavengers have been relieved from their earlier sub-human occupation and their rights and dignity restored.

The second technology developed tackles the problem of non-existent public toilets and its universal acceptance by the people.

In 1878, during the British period, an attempt was made to maintain public toilets on a 'pay and use' basis but it did not work. Public toilets were non-existent, and even if any existed, they were a veritable hell. Nobody liked going inside it.

Up to the 1970s, Indians were not in the habit of paying for the use of toilets. The first Sulabh public toilet was constructed in Patna, Bihar, in 1974 and maintained on the concept of 'pay and use' basis. Initially, people ridiculed and joked, saying who would pay for the use of a toilet. But on the very first day, 500 people came and used it, with a total collection of $5! Now over the last four decades, Indians have started paying for the use of toilets. This has helped to reduce the burden on the state exchequer for the maintenance of public toilet and bath facilities.

This is one of the notable examples of public-private partnership. Sulabh has itself installed more than 7500 public toilet complexes and now other NGOs and corporate houses have started working in this sector as well. Both toilet technologies for individual use as well as public use, built by Sulabh, are used by over 10 million people every day.

The human waste from public toilets can be disposed by connecting to the sewerage wherever available or by a septic tank. As the provision of sewerage was limited, most of the public toilets used to be connected to septic tanks. In a septic tank there are no technological benefits. The gases generated pollute the atmosphere. Besides after every 2/3 years it has to be cleaned, the sludge removed and kept separately for decomposition and later to be used as a fertilizer. This process contributes to environmental pollution and encourages scavenging.

To address this problem Sulabh developed a system of Biogas Digester with Effluent Treatment, which not only helped to contain the environmental pollution and omission of gases but also generated bio-energy from human waste. Under this system, human excreta from public toilets through a gradient, goes inside a biogas digester. Biogas is produced and used for various purposes including cooking, lighting lamps, body warming during winter, and conversion to electrical energy. Earlier, the conversion required 80% biogas and 20% diesel but Sulabh has upgraded the system to run 100% on biogas.

Each individual produces around 1 cft of biogas everyday from the waste he generates. Since biogas contains around 65% methane, 6 billion people worldwide produce 3.9 billion cft of methane per day. This methane could very well be used as an energy resource developed by Sulabh. A 1000 user public toilet can provide energy equivalent to 21 litres of diesel per day. This also saves methane from escaping to the atmosphere. In case of household twin-pit toilets, vent pipes are not needed and gases are absorbed through the leach pits into the soil.

The water discharged from the biogas plant is treated through sedimentation tank, sand filter, aeration tank, activated charcoal and finally exposed to ultraviolet rays. The water becomes pure

and the Biochemical Oxygen Demand (BOD) comes down so that it can be discharged into any water body with no chance of pollution. This technology may be utilized in housing colonies, high-rise buildings, hospitals etc., and in non-sewered areas. It has been functioning very well, even in cold climates.

Sulabh has set up five public toilets with biogas plants and SET devices in collaboration with Kabul Municipality at Kabul, Afghanistan. Even when the temperature in Kabul went down to - 30^{0}C in 2007, these biogas plants worked very well. Hence this technology is suitable for both cold as well as warm climates.

Sulabh has also developed a number of technologies for handling solid waste. In the context of climate change, the benefits predominantly include prevention of pollution caused by solid waste, reduction of greenhouse gases, etc.

Conclusion

Sulabh technologies help in achieving the Millennium Development Goals on sanitation. All these technologies also quantify for Clean Development Mechanism and there is an immense possibility to get carbon credits by adapting them.

In conclusion, it may be added that climate change is real, accelerating and it is threatening all. Health impacts are potentially huge and threaten public health security. Though greenhouse gas is emitted throughout the world, mostly in developed countries, the impact and health risks associated with these are concentrated in developing countries. The major impact will be felt in another 40-50 years, so the efforts should be towards conservation of natural resources and control the production of greenhouse gases to the extent possible and within the means.

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International Summit on Emerging Trends in Low Cost Construction Technologies at Bodh Gaya, Bihar

BMTPC and International Centre for Advancement of Manufacturing Technology (ICAMT-UNIDO) jointly organized the International Summit on Emerging Trends in Low Cost Construction Technologies at Bodh Gaya, Bihar from January 4-5, 2011. The International Summit focused on innovative building materials & manufacturing technologies and cost effective construction techniques.

The objective of the program was to discuss global and Indian perspective on cost effective housing technologies and also to present the innovative technologies for manufacturing precast building components. The program received a very good response from the target delegates. Thrust in the summit was given on dissemination of up-to-date information, knowledge and experience on design, production, certification and application of cost effective and innovative building materials.

The Summit was inaugurated by the Joint Secretary (Housing), Ministry of Housing & Urban Poverty Alleviation, Government of India. More than 60 delegates participated in the programme. The media also covered the Summit extensively.

Code of the Sustainable City

*Mukesh Khare** *Priyajit Pandit***

Introduction

'The primary intent of the Urban Genome is to map the code on which cities are written, thereby assembling an index of tools for improving the urban environment'.[1]

Much literature on prospects of urbanism and urbanisation addresses the issues of urban sprawl and the corresponding lack of infrastructural facilities along with the measures needed to sustain and provide for them or focuses on the need to develop cities which would be able to absorb the demands of the future.

However merely addressing the issues and needs of developed or growing cites may not be the only agents of change in the face of increasing urbanisation. What is needed in rapidly developing, changing, emerging economies is extensive logistics/database/ and integrated administrative work necessary for making the implementation of design/ improvement strategies possible. Contrary to the popular belief that cities are merely sites of wasteful consumption and pollution, it is now possible to make the growing cities having the potential for lower per capita environmental and ecological impacts than the rural areas if they are adequately designed and administered; and so increasing their chances of sustainable development. Further, most of these problems/issues would become easier to understand if we could comprehensively profile the *DNA* of a city through an understanding its *Urban Genome.*[2]

Classification of the process of building up a successful *Urban Genome* is:

1. Determination of **Growth Boundaries.**
2. Identification of **Indicators and Sustainability Coefficients.**
3. Simulative **Modelling Techniques** to predict the developmental profile of the city depending upon the priority of Indicators.
4. Use and creation of management tools such as **Decision Theatres** and/or **Global Design Studios**.
5. Dedicated City Satellites (*CitySats*) at international and state levels.
6. Creation of a dedicated organisation like **National Resource Centre for Sustainable Urban Management to** administer and assemble the resources.

(1) Determination of Growth Boundaries : The Complex inter-relationships between the *natural* and *manmade* parameters can be understood through the generation of an *ecological* base map, which delineates the ecological boundaries of the Site. The ecological boundaries could be one determinant of defining the **Growth boundaries of a city of a region.** Other related social, political, economical parameters may also be considered.

(2) Identification of Indicators and determination of Sustainability Coefficients : Indicators are measures of performance that aggregate information into a usable form.[3] A city is made up of many complex sets of indicators which may be broadly classified as follows:

(a) City Services such as urban planning, transportation, education, energy, finance, health, recreation, governance, safety and water and solid waste management.

(b) Quality of life includes indicators such as environment, shelter, social equity, technology, culture and economy.

1 http://urbangenomeproject.org

2 http://urbangenomeproject.org

3 Online at http://cityindicators.org/globalurbanindicatorsdatabase

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The information obtained from the indicators could be used to determinate the *Sustainability Coefficients* and also enable the generation of an a*nalytical matrix* which could be indicative of the DNA of the city. The indicators could also be used to develop tools for sustainable urban management.

(3) **Simulative Modelling Techniques to predict the developmental profile of the city depending upon the priority of Indicators :** The data collection and compilation programs provide a basis for characterizing the present state of cities or regions. But identifying the paths to reducing urban, environmental and social impacts requires the ability to make predictions and show the implications of alternative policies. The interactions between the Growth Boundaries and Sustainability Coefficients could be tested and predicted through simulative models. There are two general approaches to modelling urban systems: *comprehensive* and *partial*, both of which could be used to show how all components of a city interact and change as a function of intended choices.[4]

Currently, IBM, Cisco Systems, Siemens, Autodesk, Google, and Microsoft all have programs for improving how cities function. Although building urban models is technically complex process, their outputs would be useful to planners, politicians, various allied professionals and the public.

(4) **Use and creation of management tools such as Decision Theatres and/or Global Design Studios :** The provision of Decision Theatres and/or Global Design Studios could optimise policy making decisions. They could also provide an environment wherein decision making could become relatively simpler due to advanced visualisation techniques. It could also form a platform where depending upon the nature of the problem different professionals could interact with each other using a common platform[5].

(5) **Dedicated City Satellites (*CitySats*) at International and State Levels :** The *CitySats*[5], a satellite system dedicated to monitor various indicators and changes in the morphology of a city, is the need of the time for sustainable integrated growth planning of the cities. An integrated system of *CitySats* would give planners and policy makers an insight into the barriers and prospects sustainable development.

(6) **Creation of a dedicated organisation like National Resource Centre for Sustainable Cities to administer and assemble the resources :** For the successful management of the *Urban Genome Project* it is important to create dedicated organisation which may be named as the **National Resource Centre for Sustainable Urban Management** could monitor and facilitate in the decision making processes. The principal contributors to this would be the policy makers and strategic agents[6]. These may include Civil and Environmental Engineers, Architects and Planners supported by Mayors, Administrators, Councillors, and Members of Parliament who could contribute to the common pool of knowledge being accumulated by the UGP. Another category of individuals could include citizens, researchers, artists and architects, activists, writers and critics who can collectively transform the understanding of urbanism, policy and design practices. Their ideas, strategies, innovations and research could be included in the UGP database. Public participations in such dedicated institutions may be kept as one of the essential activities in form of regular contact meetings, seminars and workshops.

Conclusion

The profiling of the *Urban Genome* could perhaps be the way forward in aiding Sustainable Development. One of the ultimate goals of this project could be to create a database of strategies sufficiently vast as to serve as a general point of reference for urban policymakers, transcending political and geographical boundaries.

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Appropriate Technology and Sustainable Development

*Dr. J.S.Chauhan**

Synopsis: *Application of principles of engineering is called Technology. Technology can be imported or indigenous. The technology policy of GOI has been stated. The definition of Appropriate technology and its use in day to day life is stressed. Stress has been laid on the use of locally available materials giving incentives to the users of indigenously developed technology and to the products and processes resulting from such use. The necessity of reducing the demand on energy, particularly energy from non-renewable sources is emphasized. Development and utilization of solar energy, wind energy and other non conventional energy sources should be popularized. In this context, the example of Israel is given where use of solar energy for all the houses has been made mandatory.*

Ensuring harmony with environment is stressed by preserving ecological balance and improving the quality of habitat. A word of caution in poorly planned efforts to achieve rapid development ignoring the long term effect of many technologies on the environment has been given. The importance of analyzing the environmental impact of the application of each technology before it is introduced is stressed.

Linking technology with environment is the most crucial area of human concern. The role of NGO's and voluntary organizations in taking the fruits of Science and technology to the door steps of the common man is emphasized. Technology transfer mechanism should be vibrant and effective. The success of technology policy depends on the efficient monitoring, review and guidance. So an integrated approach of technology assessment, development, acquisition, absorption, utilization and diffusion is essential.

Sustainable development is defined. The necessity of introducing environmental and resource management into the policy making process is emphasized. Development that does not conserve the resource base over a sufficiently long period into the future can not be sustained. The future policy makers should not forget this aspect while addressing the issues of productivity, self reliance, equity and other fundamental aspects of development. Conserving resources is an important factor to be considered while planning for development. Much of the environmental degradation faced by the third world countries is also caused by over utilization of resources. Governments and international organizations have a role to play in designing and realizing such a development, but the ultimate responsibility and action for improving their lives rests with the people themselves. Drastic changes need to be made in the structure of the society, if Environmentally sound development should take place. The exploitation of nature by man is to be put to an end in an effective manner.

The preconditions for sustainable development have been narrated in the paper. People's participation in the over all development of the society is stressed. The basic needs of food, clothing, shelter, employment, transport, healthcare, education, energy etc. are still left unmet by past development strategies. New technologies and products have come up where in the resource base and environmental protection have been taken due care of. These products and technologies should be made popular.

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The various reasons for these appropriate technologies which have been developed for the betterment of society not becoming popular have been outlined in detail and the remedial measures have been mentioned point by point.

The range of products to be chosen is outlined emphasizing the need of keeping employment generation and resource conservation in mind.

In the end stress has been laid on the urgent need of changing the attitude of people from the rampant graft and greed to the much needed craft and creed which is vital for the development of society and the nation at large.

Technology

Application of principles of Engineering is called Technology. It is divided in three parts.

- Imported technology
- Indigenous technology
- Appropriate technology

Technology Policy of India announced by GOI a few years ago

The basic objectives of Technology Policy statement are **development of indigenous technology simultaneously with absorption and adaptation of the imported technology as and when required in an effort to attain technological competence and self reliance as early as possible**.

Appropriate Technology

The technology which serves the goals of development is defined as 'Appropriate Technology'.

Goals of Development

- Eradication of Poverty
- Environmental sustainability
- Improved equity

These goals can only be achieved if basic human needs are met. viz (a) Food (b) Clothing (c) Housing (shelter).

Appropriate technology springs from indigenous, creativity in response to local needs and conditions.

- It is relevant and ready for use by the common people and aims directly to improve the quality of their lives and aspirations.
- It derives maximum leverage from the **local cultural environment**, by drawing upon the existing managerial and technical skills and providing the basis for extending them.
- It uses the **physical potential of the area** and maintains **man's harmony with nature**.

Efforts should be made to use locally available materials and incentives should be given to users of indigenously developed technology and for products & processes resulting from such use. Preference should be given to indigenous items, though their cost may be more, in the initial stages, to promote indigenous technology, care being taken to **ensure quality**. Fiscal measures as necessary should be introduced to ensure these.

Efforts should be made to reduce the demand on energy, particularly energy from non-renewable sources as the fossil fuels are rapidly depleting and the oil prises are constantly increasing. Alternative / renewable sources of energy should be thought of. Development and utilization of solar energy, wind energy and other non conventional energy sources should be popularized and if necessary, should be made mandatory in rural and remote areas. Israel with a very less population is able to adapt solar energy and passed a legislation to that effect, which has become mandatory for all the house owners to install solar panels in their houses.

We should ensure harmony with environment, preserve the ecological balance and improve the quality of the habitat. Poorly planned efforts to achieve apparently rapid development ignoring the long term effect of many technologies on the environment have resulted in serious ecological damage. Air pollution, acid rain, industrial waste disposal, toxic effluent, noise and vibrations, crowding and congestion and many other side effects of urban and industrial activity are now widely recognized as the costly by-products of activities which otherwise produce useful outputs. More recently there is also a growing concern on global issues such as climatic change, global warming, sea level rise and stratospheric ozone depletion. So it is therefore essential to analyze the environmental impact of the application of each technology.

In addition to the deteriorating quality of air, water and other components of our environment, the quality of life for the poor comprises to a far larger degree on the lack of access to basic amenities such as food, water, housing, clothing, transport and other basic needs which for a majority of our people continue to be unfulfilled. This, perhaps, is the most crucial area of human concern **linking technology with environment**.

While governments must necessarily play a leadership role through education, creation of awareness, provision of infrastructure and overall planning, their policies on

Science and Technology must be geared primarily to the promotion of creative action at the individual and community level. The promise of Science and Technology can only be fulfilled through the introduction of the fruits of the scientific enterprise into the lives of common people. These fruits may be in the form of hardware (Products, technologies, tangible goods) or software (processes, methods, systems) designed to improve the lives of people in a variety of ways. It cannot be expected that Govt. alone can disseminate the technologies among the common people. NGO's and voluntary organizations should come up in the promotion and dissemination process so that the fruits of S&T can reach the common man effectively.

When to use imported technology?

Imported technology and foreign investment should be permitted only on a selective basis, where there is need and where such technologies does not exist within the country or where the time taken to generate the technology indigenously would delay the achievement of development targets.

Technology transfer

Special efforts need to be made for diffusion of technology in use to all beneficiaries who can adapt them optimally.

International competitiveness

It is necessary to maintain international competitiveness in products, services & technologies that has export potential.

Implementation

The success of technology policy will depend on efficient monitoring, review and guidance and a scheme of incentives & disincentives. Success demands a conscious integrated approach covering technology assessment, development, acquisition, absorption, utilization and diffusion and connects aspects of financing, based on overall national interests, priorities and the attainment of the most challenging technological goals.

Sustainable development

The rapidly growing population is putting lot of pressure on the increasing use of resources. The resource depletion should be controlled timely. If timely action is not taken it will result in ecological imbalance. It is high time to introduce **environmental and resource management** into the policy making process. The available land per capita has decreased by one half since 1950, while cost of the food grains has increased three to four times. To increase the agricultural productivity, chemical fertilizers and pesticides are being used which, in turn, is responsible for resurgence of malaria over the past few years.

Development that does not conserve over a sufficiently long period in to the future, the resource base (resources may be water resources, oil and natural resources) on which it stands, cannot be sustained. The future policy makers and planners should not forget this aspect while addressing the issues of productivity, self reliance, equity and other fundamental aspects of development.

Conserving the resources is an important factor to be considered while planning for development.

Wasteful overutilization of natural resources provides one of the primary threats to the health of our environment. If development is to lead to sustainable benefits for mankind, affluent people should change their habits of using the natural resources and should learn to conserve them for the future.

Much of the environmental degradation faced by the third world countries is also caused by overutilization of resources. Govts and international organizations have a role to play in designing and realizing such a development, but the ultimate responsibility and action for improving their lives rests with the people themselves. **Environmentally sound development (sustainable development)** can not take place unless drastic changes are made in the structure of the society. The exploitation of nature by man is to be put to an end in an effective manner.

Environmentally sound development requires several preconditions: infrastructure, capital, knowledge, systematic change. This is not possible without the peoples participation. People should have an access to the methods, tools and products of modern science and technology. Inspite of their successes in other spheres, the fruits of science have yet to fulfill their two most important promises: (1) Meeting the basic needs of the poor (i.e food, clothing, shelter, employment, transport, healthcare, education, energy etc.) (2) Achieving environmentally sound utilization of natural resources.

Almost all these basic needs have a close relationship with environmental values, and all have largely been left unmet by past development strategies. The poor earlier had no access to the capital, technology or know how

nor the importance of the resource conservation.

With evolution of societal perceptions & aspirations, and with recent developments in science, new materials and processes, technological innovations are becoming increasingly important for solving the problems of the poor. New products and technologies have come up wherein the resource base and environmental protection have been taken care off (e.g. biogas, wind mills, solar devices, like cookers, pumps, lighting devices etc, bicycle carts, mud block making machines, multifuel and multipurpose engines, Integrated village energy systems, food storage bins). The wide spread application of appropriate technologies are providing solution to the problems of poverty alleviation and defective resource use.

The appropriate technologies developed could not be made popular among the people due to the following draw backs.

- Lack of economic viability in production, marketing and use. The cost of the products are so high that they are not with in the reach of common man. (e.g. Solar Cookers, Solar water pumps, solar lighting, T.V. etc. are very costly)
- Lack of proper linkages between the processes of **innovation production & marketing**
- lack of active participation of people in using these technologies looking into the local needs, resources and their lack of interest in knowing the know-how of these technologies.
- Social acceptability not properly taken care of e.g community latrines in rural areas.
- Non availability of spare parts and ancillaries
- Problems of repairing and maintenance especially in rural areas in case of break down.
- Proper awareness not being created among the people in the importance of using alternate sources of energy, waste utilization & preventing the environmental degradation and resource depletion. (e.g. energy saving in using mud blocks over burnt clay bricks, top agricultural, soil being saved, rain water harvesting and nallah bunding for increasing the G.W. levels, use of smokless chulahs providing proper health care etc.)
- Technology transfer from 'lab to land' not done in an effective manner. Many such technologies are lying in the laboratories workshops & archives.
- Inadequate Govt. machinery to monitor the technology transfer to the grass root level, N.G.O.'s & voluntary organizations should come up and take up this task in a missionary zeal.
- Non existence of promotion, training and extension services.
- Improper managerial skills and lack of interest of social organizations in promoting these technologies as per local needs & requirements.
- Non availability of information or improper dissemination of information to the people.
- Unable to convince the people about the improvement of these technologies over traditional methods.
- Complicated operational methods & improper training regarding the use of these technologies.
- Unable to make these technologies mandatory for example : solar devices in rural & semi urban areas, mudblocks, MCR tiles etc in villages.
- Non existence of marketing organisations and unable to cope up with the demand and supply of certain products.
- Improper delivery mechanism – it should be such that it is self financing & self supporting.

Above all, the appropriateness of a technology must be measured by how well it satisfies the needs of the end client and with what success it takes advantage of the opportunities and constraints of the production and marketing processes.

Range of products

The products should be chosen after detailed feasibility studies and market analysis, and in direct response to the needs of the target clienteles- the poor, the deprived and the under privileged.

The design process integrates the modern multi disciplinary expertise and local traditional knowledge to ensure that each product does meet the needs of the people for whom it is intended and at the same time serves societal objectives such as **employment generation and resource conservation**.

The product range could include devices for energy, water, agriculture, shelter, transport, employment generation and other human needs; e.g. cooking stoves, stabilized soil brick m/cs, paper and board making equipment, producer gas units, solar lanterns,

pumps, biogas generator kits, food storage bins, multi propose hand presses, integrated village energy systems.

There is an urgent much needed transition from the **rampant graft and greed** which exists every where to day **to the craft and creed which** must form the basis of tomorrow.

Conclusions

Improved housing facilities in rural areas needs immediate attention in order to prevent migration of people from villages to cities. The technologies to be adopted should aim at improving the quality of lives of common people without causing resource depletion and environmental degradation. Locally available materials suitably improved by modern engineering techniques should be used in construction. NGO's, technical institutions and Building centres have a vital role to play in the technology transfer mechanism to the grass root level. People's participation in the various activities related to the improvement of their basic amenities and standard of living is a must in order to ensure that environmentally sound development takes place.

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Conference on "Preparing for an Urban future: Resilience, Sustainability and Leadership" at New Delhi

As a part of World Habitat Day 2010 celebrations, the Council organized a Conference on "Preparing for an Urban future: Resilience, Sustainability and Leadership" on 1st November, 2010 at New Delhi jointly with TERI. The Conference revolved around three selected themes, which inform UN HABITAT's Better City, Better Life theme:

- Resilience,
- Sustainability and
- Leadership.

These themes comprise crucial elements required for sustainable cities and in support of the UN World Habitat Day theme. The specific objectives for organization of the Conference were:

1. Outline a strategy to integrate sustainable building materials and technologies into India's national sustainable cities programs.
2. Create a dialogue among stakeholders – experts, policy makers, architects, planners – about the benefits and impact of environmentally sustainable materials and practices.
3. Share experiences and best practices from across India and the world as they relate to the three identified themes: resilience, sustainability and leadership.

The Conference was inaugurated by the Secretary, Ministry of Housing & Urban Poverty Alleviation, Government of India. The Conference was attended by government officials, policymakers, architects, planners, experts and stakeholders deliberating their vision for a sustainable urban future and the urgent need to establish and recognize crucial links between habitat and quality of life in growing cities.

Total and per capita GHG emissions ('top 20 countries')

Country	GHG emissions (2005)[a]			CO_2 emissions (2007)[b]			
	Thousand metric tonnes of CO_2eq	Percentage of total CO_2eq	Metric tonnes of CO_2eq per capita	Thousand metric tonnes of CO_2	Percentage of total CO_2	Metric tonnes of CO_2 per capita	Percentage change in CO_2 (2005–2007)
China	7,303,630	18.89	5.60	6,538,367	22.30	4.96	16.5
US	7,211,977	18.66	24.40	5,838,381	19.91	19.38	0.1
India	2,445,328	6.33	2.23	1,612,362	5.50	1.43	14.3
Russian Federation	2,115,042	5.47	14.78	1,537,357	5.24	10.82	1.4
Japan	1,446,883	3.74	11.32	1,254,543	4.28	9.82	1.0
Brazil	1,079,576	2.79	5.80	368,317	1.26	1.94	5.2
Germany	972,615	2.52	11.79	787,936	2.69	9.58	2.7
Canada	725,606	1.88	22.46	557,340	1.90	16.90	0.5
UK	672,148	1.74	11.16	539,617	1.84	8.85	0.8
Mexico	627,825	1.62	6.09	471,459	1.61	4.48	6.9
Indonesia	625,677	1.62	2.85	397,143	1.35	1.77	16.4
Australia	601,444	1.56	29.49	374,045	1.28	17.75	2.7
Iran	598,479	1.55	8.66	495,987	1.69	6.98	16.2
Italy	571,378	1.48	9.75	456,428	1.56	7.69	2.5
France	542,980	1.40	8.92	371,757	1.27	6.00	5.2
Republic of Korea	535,836	1.39	11.13	503,321	1.72	10.39	8.7
South Africa	499,842	1.29	10.66	433,527	1.48	9.06	6.2
Spain	457,776	1.18	10.55	359,260	1.23	8.01	1.6
Saudi Arabia	439,516	1.14	19.01	402,450	1.37	16.66	9.6
Ukraine	427,297	1.11	9.07	317,537	1.08	6.83	2.8
Other developed countries	2,237,764	5.79	9.46	1,791,983	6.11	7.55	1.1
Rest of Asia and Pacific	3,527,583	9.13	3.51	2,460,617	8.39	2.37	7.3
Rest of Latin America and the Caribbean	1,329,867	3.44	5.04	749,694	2.56	2.77	10.0
Rest of Africa	1,659,120	4.29	1.90	699,867	2.39	0.77	4.1
World total	38,655,189	100.00	6.00	29,319,295	100.00	4.45	6.0

Note: The world totals include only emissions that have been accounted for in national inventories.
Source: (a) http://data.worldbank.org/indicator, last accessed 21 October 2010; (b) http://mdgs.un.org/unsd/mdg, last accessed 21 October 2010; see also Statistical Annex, Tables B.7 and B.8 and
Global Report on Human Settlements 2011: Cities and Climate Change, United Nations Human Settlements Programme

Confined Masonry: A Solution for Seismic Resistant Construction

S.K. Bhattacharyya[**] *Ajay Chourasia*[*]

Recent earthquakes around the world have resulted in loss of human lives and high economic losses due to poor performance of unreinforced masonry as well as poorly-built reinforced concrete framed construction. This has prompted a need for alternative building technologies with improved seismic performance. Confined masonry (CM) construction, which has similar cost and skill requirements to unreinforced masonry and RC framed construction, has shown excellent behavior during strong shaking across the world. However, the technology is not prevalent in India. This paper summarizes the main features of generic construction and insight into the behavior of CM elements under earthquake excitations, representing a viable alternative for safe and economical construction in seismic areas, and may be adopted in India as well.

Preamble

The use of masonry as a composite material has been favored in construction of buildings because of its simplicity, durability, aesthetic appeal, material availability and economic advantages. However, the inherent weaknesses of masonry in tension has repeatedly been experienced during different seismic events, including the recent Sikkim-Nepal Earthquake of September 18, 2011. Typically observed seismic damage patterns in masonry construction are shown in Fig. 1. Past earthquakes have revealed that the causes for unsatisfactory performance lie in the use of inappropriate construction methods, absence of special seismic detailing of key structural elements, inadequate material quality, absence of construction supervision, and inadequate design. Poor performance of unreinforced masonry (URM) as well as the challenges related to the design and construction of reinforced concrete (RC) framed buildings in areas of high seismic risk, has prompted a need for an appropriate alternative construction technology with improved seismic performance. Confined Masonry Construction is a technology, which requires similar or less advanced construction skills

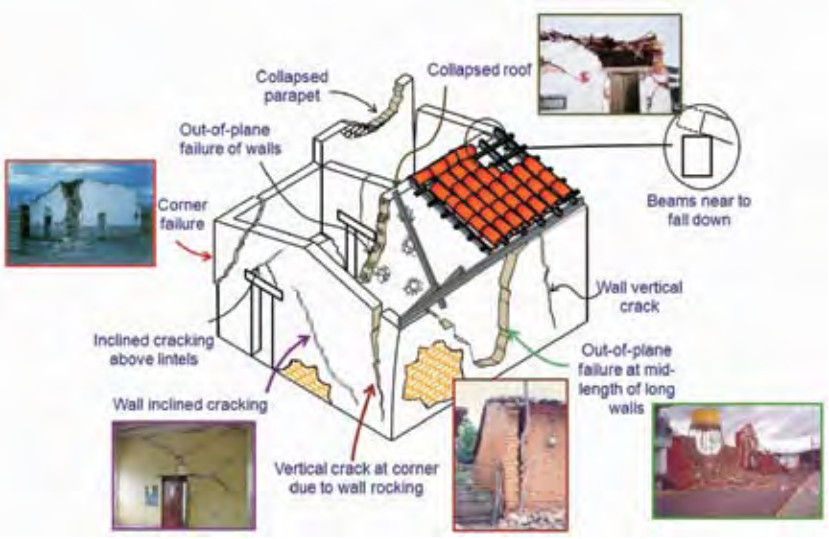

Fig. 1: Typical damage pattern in masonry construction due to seismic event

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using similar construction materials and may be used as an alternative for both unreinforced masonry and RC framed construction for low to medium rise buildings.

The use of masonry walls confined with slender vertical (tie column) and horizontal (bond beam) elements can be traced back to the beginning of the last century. CM walls, in fact, have been first utilized for the reconstruction of some Italian cities flattened in seismic events of 1908 Messina earthquake, and the earthquake of July 23, 1930 (Freeman, 1932). Confined masonry (CM), which comprises of an URM panel enclosed with slender columns and beams, is one such alternative. Confining elements, tie columns and bond beams, generally of reinforced concrete, are cast after the construction of the wall with grooves (~40 mm) along edges.

Confined Masonry Construction

Confined masonry construction consists of masonry walls (made either of burnt clay bricks or concrete block units) and horizontal and vertical RC confining members built on all four sides of a masonry wall panel. Vertical members, called tie-columns, resemble columns in RC framed construction except that they tend to be of smaller cross-sections. Horizontal elements, called tie-beams, resemble beams in RC framed construction. In worldwide applications, confined masonry is used for non-engineered low-rise construction (one- to two-storey buildings) and also for engineered construction such as medium-rise apartment buildings (up to six storeys high).

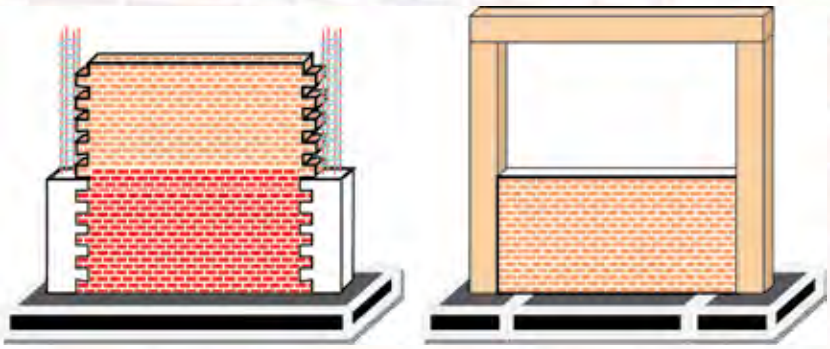

Fig. 2: Sequence of construction for Confined masonry (left) and RC frame (right)

The appearance of a finished CM construction and a RC framed construction with masonry infills may look alike, however, these two construction systems are substantially different. The main differences stem from the construction sequence (Fig. 2) and the manner in which these structures resist gravity and lateral loads. In confined masonry construction, confining elements are not designed to act as a moment-resisting frame; as a result, detailing of the reinforcement is less intricate in contrast to a moment resisting framed elements. In general, confining elements have smaller cross-sectional dimensions than the corresponding beams and columns in RC framed buildings. It should be noted that the most important differences between confined masonry walls and infill walls of RC frames is that infill walls are not load-bearing walls, while the walls in a confined masonry building are load-bearing elements. A transition from RC frame to confined masonry construction in many cases leads to savings related to concrete cost, since confining elements are frequently smaller in size than the corresponding RC frame members. Also, less reinforcement and less intricate detailing is required for confined masonry construction than for RC framed construction.

Confined masonry buildings have demonstrated satisfactory performance in several major

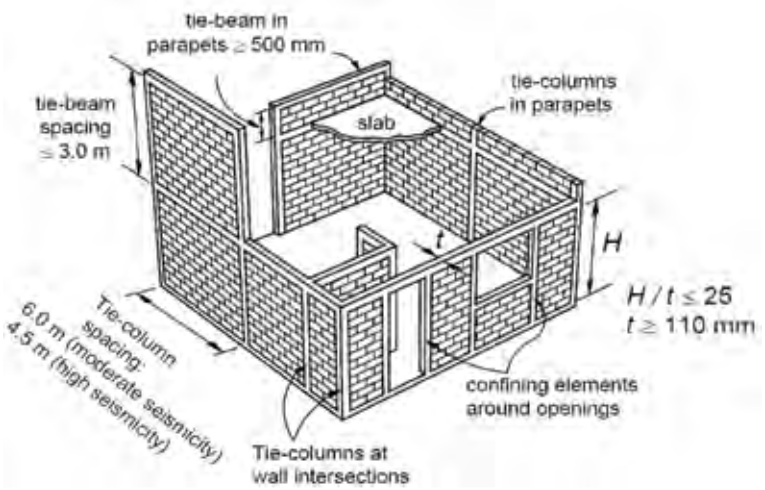

Fig. 3: Key Requirements for Confined Masonry Construction

earthquakes, worldwide, however the technology is not prevalent in India. Preliminary reports from January 12, 2010, Haiti earthquake (M 7.0); and February 27, 2010 Maule, Chile earthquake (M 8.8), document good performance of confined masonry construction. In general, buildings of this type do experience some damage in earthquakes, however, when properly designed and constructed they are able to sustain earthquake effects without collapse.

Key recommendations regarding the locate on and spacing of confining elements are illustrated at Fig. 3, Meli R., Svetlana Brzev et al (2011).

Damage Pattern & Seismic Behaviour

Despite the presence of stiffness decay due to formation of flexural cracks along the height of tie columns and micro cracks that exist in masonry units, in elastic range and at the early stages of loading, CM walls may still be approximated as elastic shear beams whose stiffness is provided by both panel and confining elements (Alcocer et al, 2004; Irimies, 2000; Gibu and Zavala, 2002). At this stage, as experimental results indicate, strain in tie-column longitudinal reinforcement changes alternately from positive to negative, implying the monolithic behaviour of CM walls (Tomazovic and Klemenc, 1997).

Onset of inclined shear cracks in the middle of solid panels and their extension towards tie columns result in further decrease in the stiffness of the panel. The time at which first major crack forms usually coincides with a substantial detectable decline in effective stiffness. These cracks usually pass through mortar joints in a zig-zag pattern (Marinilli and Castilla, 2004; Irimies, 2002).

Post-cracking behaviour of typical CM walls, whose response is mainly governed by shear deformations, is directly influenced by friction, brick interlock, and shear resistance of tie column ends (Flores and Alcocer, 1996). As is shown in Fig. 4, at this stage, the cracked wall pushes tie columns sideways, and produces permanent tension in them (Tomazevic and Klemenc, 1997). The masonry panel, in turn, would be under the effect of more compressive stresses, provided that an adequate bond allows sufficient load transfer between wall and confining elements.

Confinement, in fact, alters the failure mode of URM walls and slows down the rate at which stiffness would decay, therefore improving the post-cracking seismic performance of CM walls. Peak point of the recorded response which defines the maximum load state is usually sustained at the extension of cracks into tie columns ends. To prevent these cracks from opening up considerably, drift capacity of CM walls are restrained to some reasonable degree (Alcocer, 1996). The limit, however, is under the direct influence of panel and confining elements characteristics, and therefore should be determined for each wall appropriately.

The post-peak behaviour of CM walls is significantly influenced by reinforcement detailing of the ends of tie column and formation of vertical cracks at wall-column interface. Partial separation of these elements (Zabala et al, 2004), and penetration of cracks into masonry units (Tomazevic and Klemenc, 1997) at large deformation levels is usually followed by masonry crushing in the middle of the panel, extensive concrete cracking and crushing, and longitudinal rebar rupture/ buckling at end zones (Alcocer et

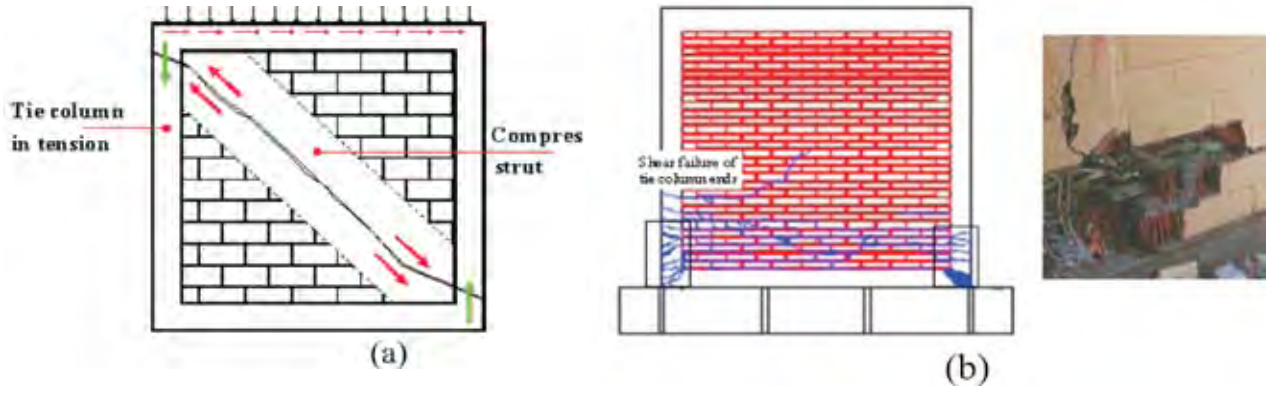

Fig.4: Seismic behaviour of CM panel (a) at cracking limit state (b) flexure failure

al, 2004; Tomazevic and Klemenc, 1997) of the column. Stiffness of the panel at large deformation levels is mainly provided by confining elements which act to slowdown the rate of stiffness degradation (Ishibashi et al, 1992). The residual stiffness of a CM wall is about 20% of its initial stiffness at 20% strength loss from the maximum measured shear (Alcocer et al, 2004). For multi-storyed CM walls, damage mainly concentrates in the first story, and in the direction of motion. This damage concentration leads to the softening action of first storey panels which may be ascribed to the larger-than-unity shear span ratios that these walls usually have, and is confirmed by close match of the first story response curves of such multi-story walls with the seismic response of an isolated CM wall. Dissipation of almost all energy in the critical first story further stresses the leading role of proper confinement of these CM walls (Irimies, 2002; Alcocer et al, 2004; Tomazevic and Klemenc, 1997).

Such characteristics as low tie column longitudinal reinforcement and high panel aspect ratio, however, may lead to the predominance of flexural deformations. When seismic behavior of CM walls is governed by flexural deformations, as shown in Fig. 4, horizontal bending cracks at lower courses of the panel may extend into tie column ends and shear them off at large deformation levels (Zabala et al 2004).This further emphasizes the vital role of tie column ends shear resistance in the overall seismic behaviour of CM walls.

Masonry Unit and Mortar Characteristics

As one of the key constituent components of the panel, masonry units should possess satisfactory properties to ensure acceptable seismic performance of the resultant CM. Experimental tests indicate that the solid burnt clay bricks, which are among the most frequent unit types used for the construction of CM, possess superior seismic characteristics compared to their hollow counterparts (Alcocer et al, 2003; Meli, 1991).

To ensure sufficient bond, high-quality mortar with sufficient fluidity and bricks without smooth surfaces should be utilized. In addition, masonry units and mortar should be compatible in their mechanical and absorption properties to compensate somewhat for the high heterogeneity that masonry, as a composite material, suffers from. Similar elastic modulus is one of the essential aspects of compatibility which leads to the propagation of cracks through both constituent materials of the panel (cracks usually initiate in mortar joints and at larger deformation levels pass through the units as well). If shear strength of bricks is very low compared to mortar, inclined cracks, however, will mainly pass through the units, thus increasing the potential for masonry crushing at high seismic demands (Ishibashi et.al, 1992).

Wall Density

Depending on the number of stories, seismicity, soil conditions, and the code used as the basis of design and construction of CM structures, wall density (total wall area in each principal direction divided by the floor area) can vary considerably. However, as damage observations and the results of analytical studies by Astroza et al, 1993 indicate, a minimum wall density of 1.15% for moderate wall damage and 0.85% for light wall damage should be provided in each principal direction.

Wall density per unit weight (wall density in the first storey divided by total weight of the structure), as research results of Moroni et al, 2000 indicate, may be employed as a better measure of seismic vulnerability compared to the wall density itself. To confine low damage in walls, its density per unit weight should exceed to 0.018 m^2/ton while for moderate damage the corresponding value shall be 0.012 m^2/ton (Moroni et al, 2000). As the results of an extensive survey suggest, many CM buildings that satisfy minimum wall density fail to comply with the suggested minimum wall density per unit weight (Moroni et al, 2000). Sufficient wall density in both principal directions, is required to prevent extensive damage to the structure at the event of severe earthquakes.

However, acceptable seismic performance of CM structures is guaranteed only if adequate wall density is supplemented with proper material quality and reinforcement of tie columns. Furthermore, large wall densities, although beneficial to the load-carrying capacity of CM structures, would limit deformation demands. In consequence, providing the building with as many walls as possible is not always the best

solution for improving seismic performance and there is always a trade-off between resistance and ductility.

Confining Elements

Confinement improves post-cracking seismic performance of masonry walls, in tie columns and bond beams, preventing premature wall disintegration at the occurrence of cracking (Tomazevic and Klemenc, 1997; Yoshimura, et al, 2004). The effectiveness of confining elements is directly influenced by the parameters; location, type, size, shape, reinforcement detailing, and the number of tie columns and bond beams.

Tie columns should be provided with minimum longitudinal reinforcement (0.8% of cross sectional area of concrete) to avoid the predominance of flexural deformations and wall uplift as a result of rebar yielding at the base of columns (Zabala et al, 2004). The minimum longitudinal reinforcement in tie column is recommended to be higher than 1% in Eurocode 8 (2002). Increase in the amount of column longitudinal reinforcement substantially improves load-carrying capacity of CM walls. Therefore, critical columns at first storey level located at wall corners are provided with larger longitudinal reinforcement ratios, especially when CM buildings are founded on firm soil. Transverse reinforcement, on the other hand, augments the dowel action of longitudinal rebar and introduces some level of confinement to the core concrete. As a result, its presence is beneficial to the deformation and energy dissipation characteristics of CM. Columns with closely spaced stirrups at ends (Fig. 5), lead to less damage and delay in final collapse of the wall (Aguilar et al, 1996).

Intermediate tie columns and bond beams are recommended for use in the critical first stories of CM buildings in highly active seismic regions, and when panel shear resistance is insufficient on its own.

Openings

In masonry construction, shear cracks usually initiate at the corners of openings and extend towards the middle of piers under earthquake loading. Size, shape, location and confinement detailing of openings have a great impact on the seismic performance. Furthermore, symmetrical distribution of openings and utilizing a spandrel below them are among key factors that can alleviate the harmful effects of openings (UNIDO/ UNDP, 1984; Alcocer et al, 2003).

Despite the fact that many codes call for horizontal and vertical confining elements around opening, it is sometimes not clear as what size of openings should be provided with tie columns and bond beams.

PANEL ASPECT RATIO

Panel aspect ratio is among key factors which alter both damage pattern and failure mode of CM walls. Relatively squat CM walls with aspect ratios close to one are frequently used in practice. Seismic behavior of such walls, as has been repeatedly demonstrated in previous earthquakes, is usually governed by shear deformations. However, as *H/L* increases, flexural deformations become more dominant, leading to early crack formation, higher stiffness degradation, thereby affecting strength characteristics of the panel.

Although of paramount importance, the effect of panel aspect ratio has been overlooked in many codes and regulations that address seismic behaviour of CM walls. For particularly slender CM walls, flexural deformations greatly surpass those of shear, and, therefore, these walls are likely to fail in flexural mode. As a result,

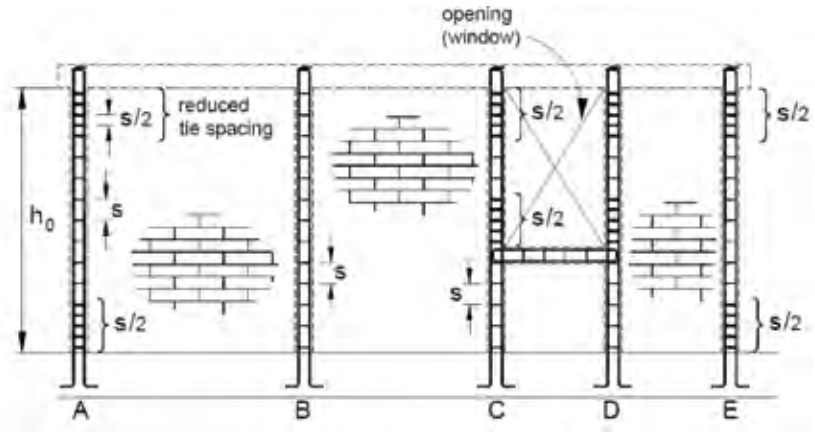

Fig.5: Tie-column reinforcement details- reduced tie spacing requirements at ends (S.Braze 2011)

walls with higher aspect ratios always possess greater deformation capacities compared to their squat counterparts.

Axial Stress

Axial stresses are highly beneficial to shear capacity and energy dissipation characteristics of CM walls. These effects are more pronounced when panels are left unreinforced in both vertical and horizontal directions, as is the case for typical CM walls (Ishibashi et al, 1992). However, axial stress adversely affects the ultimate deformation capacity of CM walls, especially when its value is excessively high compared to masonry compressive strength. The use of two-way slab, by planning square room/grid sizes in plan, distributes vertical loads more evenly is therefore highly favored (Bariola and Delgado, 1996).

Masonry-Concrete Interface

Effectiveness of tie columns to confine masonry panels and to improve their seismic performance depends on the direct influence of the existing bond at the masonry-concrete interface. Fig. 6 indicates that when concrete-masonry adherence merely provides the required bond, the occurrence of vertical separation cracks and partial disintegration of the panel and confining elements at large deformations adversely affect the seismic performance of CM walls (Alcocer and Meli, 1993).

To overcome above problem, casting concrete against toothed (~40 mm) end walls which act as shear keys, or providing the CM wall with connection rebar (U-shape or L-shape rebar that are anchored adequately into walls) helps to improve the bond and load transfer/deformation capacity (Arya, 2000).

Panel Reinforcement

Panel horizontal reinforcement improves shear resistance, deformation capacity, and energy dissipation characteristics of CM walls because, in its presence, cracks are distributed more evenly throughout the panel as shown in Fig. 7. Moreover, the rate at which stiffness and strength degrade will substantially decline, and therefore, more stable response curves are achieved, even at large deformation levels, obviously it depends upon amount of horizontal reinforcement.

Furthermore, the ratio of horizontal reinforcement to tie column longitudinal reinforcement should always be precisely controlled in order to avoid the predominance of flexural failure mode of over-reinforced CM walls (Zabala, 2004). However, when first-storey panels are provided with insufficient reinforcement, fracture of rebar usually occurring near shear cracks and in the middle zones of the wall (where maximum strains are reached) will give rise to sliding of upper stories over these cracks (Aguilar et al, 1996).

As the experimental results suggest, horizontal reinforcement ratio in wall should be kept in the range of 0.005 to 0.017, with an optimum value being about 0.01 (Alcocer and Zepeda, 1999). The horizontal reinforcement may either be embedded in mortar joints (bed-joint reinforcement), or implemented in the form of wire mesh covered with thin layers of mortar of good quality and high-strength masonry unit to avoid premature masonry crushing.

Epilogue

The paper attempted to address different aspects of CM elements, as a feasible alternative to URM, its

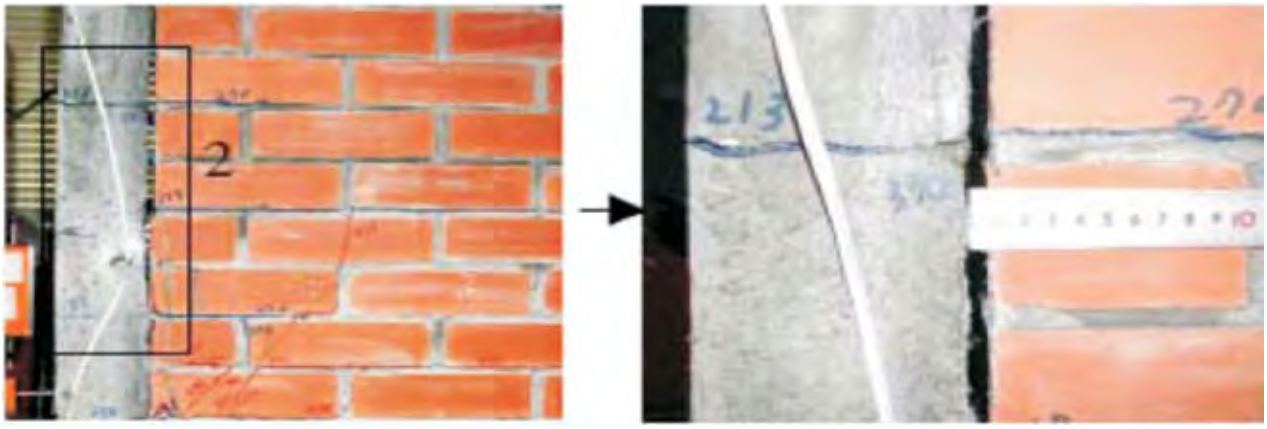

Fig.6: Separation of masonry-concrete element due to lack of bond

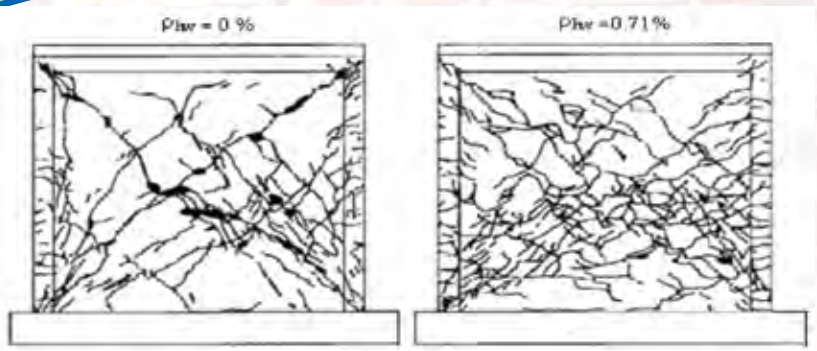

Fig.7: Effect of panel reinforcement on damage distribution (Aguilar et al, 1996)

merits and limitations compared to other structural systems, and the seismic performance of this typology in earthquakes. The effect of different reinforcement methods, the characteristics of masonry units and mortar as panel constituent materials, and reinforcement detailing of the panel and tie columns have been examined to identify both deficiencies, and the solutions that could be proposed to overcome. Out-of-plane seismic behaviour of CM walls, despite its significance for tall thin walls, and characteristics of bond beams are, however, much less discussed in the literature, and only tie columns and in-plane behaviour have received significant attention. Furthermore, although some research has stressed the effectiveness of opening confinement in improving the seismic performance of CM walls, the size and shape of openings which require confinement has not clearly been expressed. Moreover, masonry codes are not consistent over the question of opening confinement.

The performance of confined masonry constructions was exceptionally well in several earthquakes worldwide and has a great potential for saving lives and property in high seismic zones of India, as well. This construction practice is widely used in many countries and can be adopted in India, for the reasons viz. *it is based on traditional masonry construction practice; it does not require qualified labor (as is the case with RC frame construction); and the technology falls in between that of unreinforced masonry and RC frame construction*. The technology is best suited for low to medium rise residential buildings with the premises like use of good quality materials (concrete and masonry) and simple architectural design for its better seismic performance. There is a need to strongly advocate the technology in India to achieve seismic resilient construction.

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Retrofitting – A step towards disaster preparedness

*Dipan Shah**

Abstract : *In Indian context when we have 55% of our land mass vulnerable (seismic zone III to V) to earthquake, 5700kms of coastline vulnerable to cyclones and about 40Mha of land vulnerable to floods, it is very important that we proactively work on Disaster Preparedness and mitigation. Retrofitting of a structure is one such method which can help reduce vulnerability of all our structures. In our country large number of masses stay in Non-engineered houses and vulnerability of such structures is very high even in small seismic activity. We have faced disasters like Latur Earthquake, Kutchh earthquake and Indian Ocean Tsunami which have again and again exposed vulnerability of our housing stock. Retrofitting of structure is a very cost effective methodology to strengthen the existing buildings against future disaster and reduce life loss. Cost of Retrofitting an existing structure is hardly 20% to 30 % of the new construction cost of the same building.*

Retrofitting - A step towards Disaster Preparedness

Retrofitting of structures is one of the "largely talked" but less known a subject. Retrofitting is one of the very simple techniques to make structures safe and prepared for future disasters.

What is retrofitting ?

Most people believe retrofitting to be a technique for making good a damage structure. But it is not so. To get into the subject, we need to understand the fine lines between the following terms; A) Repair B) Restoration C) Renovation D) Retrofitting. Most of the time in general talk we consider all of them same or use one for the other.

(A) Repair : Is a terminology used to make good a damage or deteriorated part. For instance, if a part of the compound wall is fallen or weathershed has broken; the intervention taken to make it good and aesthetically pleasing is called repair. It is something which we keep doing as a part of our regular maintenance of structures. Structurally saying when I repair the structure I may restore it strength or may not.

(B) Restoration : Is a term which is used commonly as a synonym of repair and it is true when working on a normal day to day structure. But "Restoration" becomes a very important term when one is talking about "Repair" of historic structures or similar kind of structure. The whole focus of restoration is to match the properties and methodologies of the repair work undertaken to that of the original structure. It is technically a term largely linked with "Conservation of structures". Structurally saying in the process of Restoration, we restore the structure to original condition as it was before the damage. We don't tend to upgrade its performance or re-evaluate its behavior with reference to disaster or change in use or what ever.

(C) Renovation : Is a term used to do a facelift of structure. While the above two terms (i.e. Repair and Restoration) had to do with the condition of the structure, the renovation

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is independent of the status or condition of the structure. The Renovation can be undertaken because of change in use of structure, want of aesthetic, for creating spaces or any other similar requirement.

(D) Retrofitting : As the term suggest it is made of two terms "Retro+fitting" which simply means fitting some thing with retrospect effect. It means a scientific and technical intervention done on the structure so as to increase/ upgrade its performance. This up-gradation can be requirement of Disaster Preparedness or "Change in loading condition of structure". For example if we are talking about earthquakes with focus then "Retrofitting of structure means action taken to upgrade the seismic resistance of an existing building so as to achieve desired seismic performance level. This may include strengthening of structural element, increasing ductility of members, reducing loads or even addition of new structural members, etc.

Why is retrofitting needed ?

Retrofitting of a structure has technically nothing to do with the damage of the structure. Generally it is presumed that retrofitting is an intervention needed when structure is damage. This is not completely true. When the structure is damage, one needs repair or restoration. If as a part of carrying out of Repair or Restoration if the intervention is designed in such a way that "it also adds to performance of the structure and increases its seismic resistance" then and then only it can be coined as "Retrofitting" of the structure. Apart from above, structure may demand retrofitting due to any of the below mentioned reasons :

- New building not designed as per Indian codes
- Lack of knowledge, understanding or training in the use of these codes by local engineers
- Old decaying buildings predating modern construction practices
- Building build without specific knowledge or seismic zones and provisions there off.
- Building erected without owner seeking proper engineering advice
- Improper detailing of masonry and reinforced structures
- Use of Poor material, construction and workmanship
- Alteration and extensions carried out without proper regard for effect on structure due to earthquake or cyclone.
- Building having poor quality of foundation or building built of poor soil
- Up-gradation of Codal provisions in light of new research and scientific know how.
- Change of use or occupancy of the building

Any of the above reasons will demand for "retrofitting of the structure".

Above figure reflects the seismic zone map as per IS 1893 in 1970 and now in 2002. If one observes the map it will be clear that in; in light of latest studies and know-how; the zone 1 has been completely removed in the latest (2002) revision of the code and similarly many areas are upgraded to higher zones. Now, this in reality means that all standing structures in that upgraded zone are designed for lower zone; based on earlier knowledge and know-how and hence they need to be retrofitted so as to take care of the higher seismicity.

Systematic Approach to Diagnosis

Diagnosis is the first step of retrofitting. This requires systematic documentation and scientific analysis of the building as a whole and the possible behavior of the building during natural disaster.

Choice of Course of Action

There are range of retrofitting methodologies and techniques available. The choice of particular methodology or technique will depend on variety of factors like :

- Type of building i.e. single storey, low rise or high rise
- Usage of building i.e. public or private building, hospital, school, etc

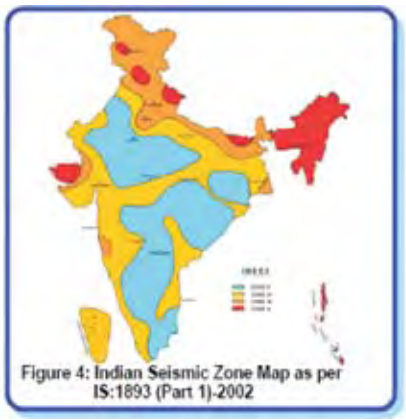


Figure 4: Indian Seismic Zone Map as per IS:1893 (Part 1)-2002

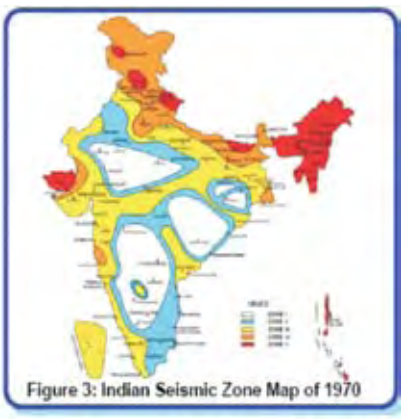
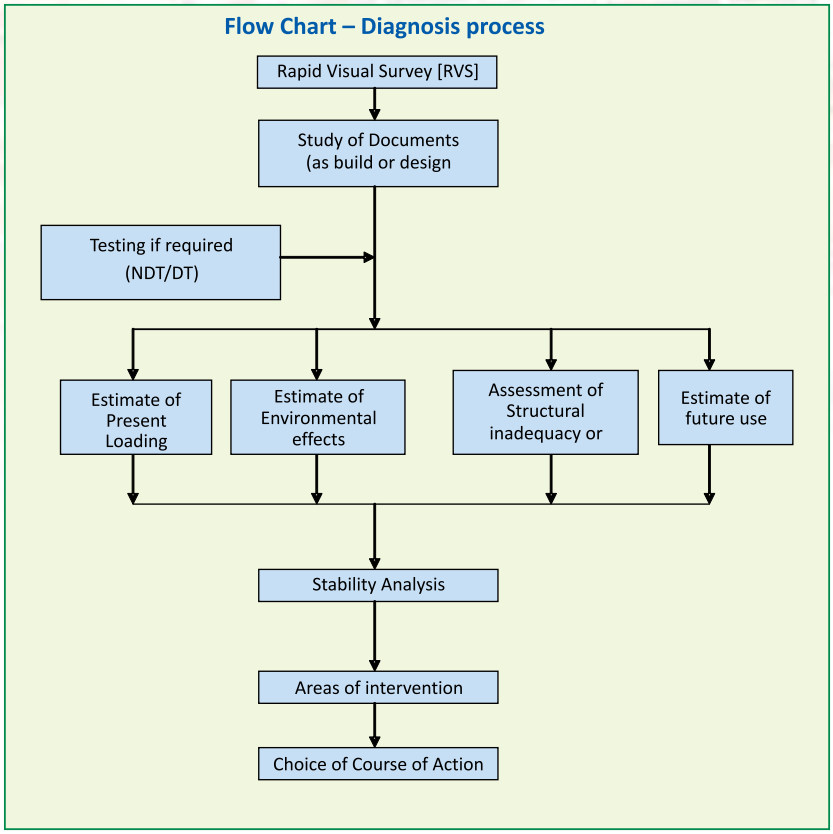


Figure 3: Indian Seismic Zone Map of 1970

Sketch 1



- Kind of weakness or structural inadequacy of the members (walls, roofs, rafters, etc)
- Material used in construction i.e. adobe, masonry, RCC, steel, etc
- Category of damage i.e. G1 to G5
- Future use / exposure conditions of the building
- Availability of material and machinery/tools for carrying out the retrofitting work
- Availability of skill manpower
- Scale of work

Also, it will be important to mention here that with the development of Performance based Earthquake Engineering intervention system, the goal of retrofitting intervention can be

Human life safety : The goal is to protect human life and ensure that structure does not collapse on its occupants or passers by and give sufficient time to the occupants for evacuation of the structure; saving life loss. Under sever seismic conditions, such structure may be rendered totally useless and may need to be demolished.

Structure survivability : The goal of the intervention is such that structure while remaining safe for exit, may require extensive repair/ retrofitting (but not replacement) before it is generally useful or considered safe for occupation.

Life line buildings : The life line buildings are retrofitted to the highest possible scenario for a region, so that even after a disaster, the building can be immediately put to use. These include structure like hospitals, public administration buildings, etc. In such building even intervention like base isolation or additional mechanism to counter / weakened the effect of earthquake can be installed.

The retrofitting of building structures involves improving its performance in earthquakes through one or more of: (i) increasing its strength and / or stiffness; (ii) increasing its ductility; (iii) reducing the input seismic loads.

Elements of Retrofitting of Non – Engineered Structure

Non – Engineered structures are those which are built with little or no understanding of proper engineering, while using local materials and technology. Usually these structures are executed considering only 'gravity load' making them highly vulnerable to lateral or other loads during disasters.

There are few basic actions that can be taken for retrofitting a non-engineered structure. They are

(a) Installing lintel belt : Most of the non engineered construction does not have a lintel band or if they have cut lintel i.e. they will have just a piece of stone or wood as a lintel for spanning opening. There won't be any member running continuously at lintel level. To retrofit such structures, we install a FC belt i.e. Ferro-Cement belt around the house. This will act as a lintel and will tie complete structure. Usually it is done using Weldmesh. **(Photo 1)** The specification of mesh reinforcement is as per the **Table 1**

Photo-1 : Chipping of plaster for Installation of lintel and corner belt

Table 1 : Mesh reinforcement (as per IS Code) in seismic belt in various building category

Length of wall	Cat B			Cat. C			Cat D			Cat E		
M	Gauge	N	H	Gauge	N	H	Gauge	N	H	Gauge	N	H
≤5.0	g 14	9	250	g 13	9	250	g 12	9	250	g 10	10	280
6.0	g 13	9	250	g 12	9	250	g 10	10	280	g 10	14	380
7.0	g 12	9	250	g 10	10	280	g 10	14	380	g 10	18	380
8.0	g 10	9	250	g 10	14	380	g 10	18	480	g 10	23	580

1. Gauges : g10=3.25 mm, g11 = 2.95mm, g12=2.64 mm, g13=2.34mm, g14=2.03mm
2. N = Number of made longitudinal wires in the belt at spacing of 25mm
3. H = height of belt on wall in mico-concrete, mm
4. The transverse wires in the mesh could be spaced upto 150mm
5. The mesh should be galvanized to save from corrosion.

(b) Corner strengthening : Corners are among the most vulnerable location of structure. Lot of forces accumulates in the corner and also it is at this point where forces also change directions or force from two perpendicular directions meet. Traditionally when the walls are constructed, masons keep construction joint at the corner making them more vulnerable. As per seismic code, these corner needs to be reinforced as per the **Table 2** below:

The corners can be retrofitted either with the corner reinforcement or by FC belt. In case of corner reinforcement, as shown in the photo, holes are bored in the wall and a vertical reinforcement as per code is erected imparting needed strength to the corner. Similarly a strip of Ferro-Cement belt can also be installed as shown in **Photo 2 and 3.**

(c) Installation of header (critical in stone walls):Is a very critical step when one is working in stone walls typically made with two layers of stone as shown in **Photo 4**. They act as a pin and "stitches" both layers of wall together. One such header is needed at approximately every

Photo 2 Photo showing installation of Corner reinforcement in the Non – Engineered structure. The reinforcement is then covered in M20 Concrete

Photo 3 Photo showing installation of Ferro-Cement plate using weldmesh on the corner in the Non – Engineered structure.

Table 2 : Vertical steel Reinforcement required in low strength masonry walls

No. of Storeys	Storeys	Diameter of HSD (415 Mpa) Single bar; in mm, at each critical section for			
		Categ A	Categ B	Categ C	Categ D
One	Nil	Nil	Nil	Nil	10
Two	Top	Nil	Nil	10	10
	Bottom	Nil	Nil	10	12
Three	Top	Nil	10	10	10
	Middle	Nil	10	10	12
	Bottom	Nil	12	12	12

Note All bars are to be embedded in M20 concrete to protect them from corrosion

Photo 4 A typical photo showing stone masonry done in 2 layers so as to achieve the required thickness of the wall.

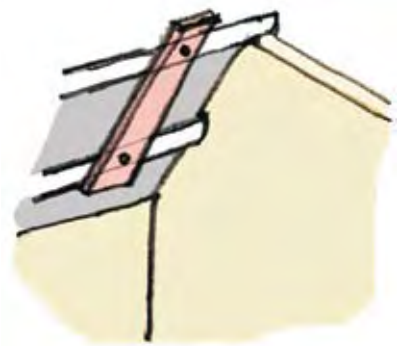
600mm vertical and 1200 mm horizontal spacing. **Sketch 2**

(d) Gable tying : Gable being a free standing triangular wall portion, does not have lateral stability. Also it is the one which takes majority of load from the sloping roof. If gable is not secured properly, then the thrust from the roof will tend to push gable out of its plane leading to total collapse of roof. To avoid this; a simple technique of anchoring gable to each other so that they have lateral stability is used. The same is shown in the sketch. Generally to do so, GI wire of g12 is used in 5 to 7 continuous layers and then twisted to provide post tensioning. **Sketch 3**

Sketch 2 A typical sketch depicting installed header in stall masonry wall so as to stitch the wall and keep two layers together

Sketch 3 A typical sketch depicting GI wire installation for Gable strengthening

(e) Installation of roof bracings : Most of the time, the sloping roof of the non-engineered construction is built using individual pieces of timber tied/ nailed to each other loosely. In the event of earthquake or cyclone, these members behave independently and transfer large amount of thrust on the supporting wall. If an additional in-plan brace is nailed to the roof members; as shown in the sketch, the entire roof structure will behave as a single entity and reduce differential movements or excessive stresses on the wall. **Sketch 4**



Sketch 4 A typical sketch depicting installation for In-plan bracing of Roof members

(f) Plinth protection : Is done to increase protection to the foundation and also serve as a protection against flooding. The plinth protection if done properly and extended over foundation, can help in reducing possible scovering when water is suddenly receding in case of Tsunami or flash floods like condition. **Photo 5**

Photo 5 A photo depicting weld mesh installation done as plinth protection on the outer surface of the house. The same is further anchored in concrete.

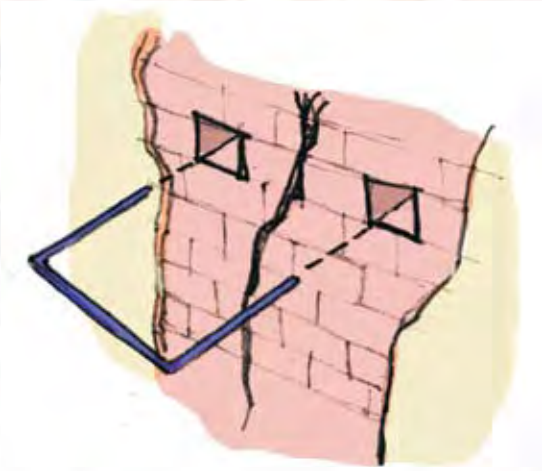
(g) Strengthening of distress or Cracks. – This simple intervention will help restore and upgrade the strength of the loss or damage section. One of the commonly used techniques for crack sealing is "Stitching". In this technique as shown, steel dowels are stitched perpendicular to the crack. **Sketch 5** Alternatively, a ferro-cement plate using chicken mesh or weldmesh can also be installed. **Photo 6**

Elements of General Retrofitting of any structure

Retrofitting of any structure can be divided into two level of interventions. One which are "**Global in nature**" and second which are "**local in nature**".

The Global intervention can be

- Addition of Shear wall
- Adding infill wall



Sketch 5 Sketch elaborating the installation of stapler reinforcement across the crack. It is very important the stapler rod is perpendicular to the crack as far as possible.

Photo 6 A photo depicting weld mesh installation done as crack. In this photo one can also see the dowel bar of the stapler reinforcement.

- Adding wing wall or buttresses
- Increase the wall thickness
- Mass reduction
- Supplemental damping and base isolation
- Reducing opening
- Bracings

Local intervention can be

- Jacketing of Beams
- Jacketing of columns
- Jacketing of beam-column joints
- Strengthening individual footings
- Crack sealing

Retrofitting of an engineered structure will generally demand higher technical investigation and inputs. One will have to follow the steps to systematic diagnostic and then based on the weakness found or vulnerability identified; the intervention will have to be designed.

Range of advance technologies for Retrofitting are also available. Significant amount of research has been done on hazard reduction technologies such as damping devices, advanced composite materials, building isolators or external pre-stressing. While passive damping devices like friction dampers and viscous dampers reduces the overall seismic demand upon the structural system, the use of carbon fiber reinforced plastic, fiber reinforced cement or external pre-stressing improves the performance of individual structural elements such as columns, beam and walls.

Costing Implication of Retrofitting

Retrofitting of a structure will cost about 20 to 30% of the new construction cost of the same structure. Also, in other terms, retrofitting of an existing inadequate building may involve as much as 2.5 to 3 times the extra cost required on installing seismic resisting features compare to the one installed in during the new construction itself. This cost can go up if the structure is already damage and requires addition repair work. Thus, it is always good to retrofit the structure so as to make it safe against any future disaster.

In India, where; 55% of the total area is falls in seismic zone III to V, 5700 km long coastline which is vulnerable to cyclone and where we have about 40Mha of land mass prone to flooding; promoting Retrofitting is the only way to stay prepared against any future disaster. There is need to explore linkages of retrofitting with the insurance premium and also develop special incentive packages to promote Retrofitting. Doing so, we will be able to stand prepared for future disasters.

Reference Standards

IS 456 :2000 – Indian standard for Plain and reinforced concrete. Code of practice

IS 1893: 2002 – Indian standard criteria for Earthquake resistant design of structures Part 1 – General provision for buildings

IS 4326 : 1993 – Earthquake Resistance Design and construction of Buildings, Code of Practice

IS 13827: 1993 – Improving earthquake resistance of Earthen buildings, Guidelines

IS 13828 : 1993 – Improving earthquake resistance of low strength Masonry Buildings.

IS 13935 : 1993 – Repair and seismic strengthening of Buildings

IS 13920 : 1993 – Indian standard code of practice for ductile detailing of Reinforced concrete structure subjected to seismic forces.

◆◆◆

शहर एवं जलवायु परिवर्तन

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*,l- d- xIrk****
*nyhi dekj*****

बड़े पैमाने पर किये जाने वाले आवासीय विकास कार्यों से पर्यावरण पर अनेक तरह के कुप्रभाव पड़ रहे हैं। यदि इस समस्या से सही ढंग से नहीं निपटा गया तो, या तो पारिस्थितकी संतुलन बिगड़ जाएगा या फिर ग्लोबल वार्मिंग का खतरा बढ़ जाएगा। भारत जैसे विकासशील देश में भवन निर्माता (बिल्डर्स) और भवन सामग्री उत्पादक ज्यादातर पारंपरिक एवं कम ऊर्जा बचाने वाली तकनीकों और अधिक प्रदूषण फैलाने वाले पुराने प्रचलन के उपकरणों का इस्तेमाल करते हैं और साथ ही उनमे स्वच्छ और ऊर्जा संरक्षण के तरीकों द्वारा होने वाले उत्पादन की जानकारी का अभाव रहता है। पूंजी निवेश की कमी, देशी उपकरणों की उपलब्धता, ढीला प्रबंधन और सामग्री उत्पादन एवं उनका निर्माण जगहों पर प्रयोग में मानसिकता के कारण सुधार लाने में अडचनें आती हैं। डिजाइनरों और भवन निर्माताओं द्वारा निर्माण में पर्यावरण अनुकूल तकनीकों को बढ़ावा देने के लिए सरकार की अपर्याप्त नीतियां एवं प्रवर्तन तंत्र तथा मानकों एवं भवन विनियमों की कमी के कारण अत्यधिक ऊर्जा खपत वाली सामग्रियों एवं तकनीकों का लगातार उपयोग हो रहा है।

tyok;q ifjorZu vkj Hkkjr dh igy

जलवायु प्रक्रिया की बढ़ती गर्माहट के कारण ग्लोबल औसत वायु और समुद्र के बढ़ते तापमान, बड़े पैमाने पर हिम पिघलन और ग्लोबल औसत समुद्र के बढ़े स्तर आदि को देखा गया है। ग्लोबल वार्मिंग और जलवायु परिवर्तन का मुख्य कारण ग्रीनहाऊस गैसें हैं जो मानवीय कार्यप्रणालियों से उत्सर्जित होती हैं। यह मानव सभ्यता के द्वारा भुगता जाने वाला गंभीर खतरा है। जीवाष्म ईंधनों के जलने से उत्पन्न 'कार्बन डाई आक्साइड' मुख्य ग्रीनहाऊस गैस है।

भारत में उत्सर्जित कार्बन डाई आक्साइड का बहुत बड़ा भाग जीवाष्मीय ईंधनों से उत्पन्न होता है। छः देशः अमेरिका, चीन, युरोपीय संघ, रूस गणराज्य, भारत और जापान वायुमंडल में सबसे ज्यादा CO_2 उत्सर्जित करने वाले देश हैं। भारत लगभग 1.42 बिलियन टन CO_2 वायुमंडल में छोड़ता है जो विश्व के उत्सर्जन का कुल 5% है। भारत ने भी क्योटो प्राटोकोल पर हस्ताक्षर किये हैं और इसके तहत युनाईटेड नेशंस फ्रेमवर्क कनवेशन आन क्लाईमेट चेंज (यूएनएफसीसीसी) के उद्देश्यों का पालन करते हुए पहले ही कई कदम उठा चुका है। ये ज्यादातर सभी क्षेत्रों में है जैसे कि कोयला, तेल, गैस, बिजली उत्पादन, परिवहन, कृषि, औद्योगिक उत्पादन, आवास और निर्माण। हालांकि इन सभी क्षेत्रों में ऊर्जा दक्षता को बढाने और संरक्षण पर जोर दिया गया है लेकिन साथ में यह भी महसूस किया गया है कि ऊर्जा गहन प्रणालियों के प्रयोग का कम उपयोग एवं युक्तिकरण, ग्रीनहाउस गैस और ग्लोबल वार्मिंग को कम करने में देश के प्रयासों में काफी योगदान दे सकता है।

* कार्यकारी निदेशक, **प्रमुख (पी.एम.टी.), ***उप प्रमुख (टी.डी.ई.एण्ड.आई.सी), **** वरिष्ठ फील्ड ऑफिसर (डी.सी.ई) बी.एम.टी.पी.सी.

tyok;q ifjorZu esa fuekZ.k m|kx dh Hkwfedk

प्रदूषण बढ़ाने के मामले में निर्माण उद्योगों का सबसे बड़ा हाथ होता है। बड़ी मात्रा में CO_2 उत्सर्जन में भी निर्माण उद्योग बड़े भागीदार होते हैं। अब ग्लोबल वार्मिंग के मद्देनजर भवन निर्माण उद्योग की भागीदारी को नकारा नहीं जा सकता।

निर्माण क्षेत्र में ऊर्जा का उपयोग बहुत उपयोगी होता है। निर्माण सामग्रीयों के उत्पादन, परिवहन एवं भवन निर्माण में ऊर्जा की जरूरत होती है। शुरूआती ऊर्जा उपयोग के अतिरिक्त, भवन के जीवन समय में इसको संचालित करने के लिए भी ऊर्जा की जरूरत होती है। चूंकि ऊर्जा निर्माण उद्योग में सबसे मंहगा संसाधन है और ज्यादातर प्रदूषण प्रभावों का स्रोत है, इसलिए ऊर्जा दक्षता में सुधार करना एक बहुत बड़ा और जरूरी कार्य हैं। इसके लिए ऊर्जा गहन सामग्रियों का कुशल उपयोग, उत्पादन प्रक्रिया में उन्नत ऊर्जा–दक्ष तकनीकों का इस्तेमाल, कम ऊर्जा खपत सामग्रियों का ज्यादा इस्तेमाल और पुनः चर्क्रित एवं अपशिष्ट आधारित सामग्रियों का उपयोग किया जाना चाहिये और कम ऊर्जा खपत के भवन निर्माण डिजाइनों के सिद्धांतों को खासकर सौर आर्किटेक्चर के सक्रिय व निष्क्रिय उपयोग को बढ़ावा देना चाहिए।

भवन निर्माण में सन्निहित ऊर्जा का ज्यादा उपयोग सामग्रियों के उत्पादन करने में होता है जबकि निर्माण कार्य और परिवहन में इतना नहीं होता है। एक यूनिट भार भवन सामग्रियों के उत्पादन के लिए कुल ऊर्जा की आवश्यकता के आधार पर इन सामग्रियों को तीन वर्गों में बाँट सकते हैं:–

- कम ऊर्जा गहन सामग्रियां जैसे रेत, रोड़ी, उडन राख, मिट्टी और कच्ची ईंट।
- मध्यम ऊर्जा गहन सामग्रियां जैसे चूना, मिट्टी की ईंट एवं टाईल्स, कंक्रीट ब्लॉक्स, लकडी और
- उच्च ऊर्जा गहन सामग्रियां जैसे सीमेंट, स्टील, काँच, एल्युमीनियम, प्लास्टिक एवं ताँबा।

लागत प्रभावी और वैकल्पिक निर्माण प्रौद्योगिकियॉ, जो उन्नत और नवीन तकनीक या वैकल्पिक कम ऊर्जा खपत वाली सामग्री के उपयोग के माध्यम से, निर्माण सामग्री की मात्रा कम कर निर्माण लागत को कम करने के अलावा, CO_2 उत्सर्जन को कम करने में एक बडी भूमिका निभाती हैं और इस तरह पर्यावरण के संरक्षण में मदद करती हैं।

fuekZ.k lkexh mRiknu dk nkjku CO_2 mRltZu

साधारण और आसानी से उपलब्ध निर्माण सामग्री का उत्पाद जब कोयला एवं तेल से किया जाता है तब बहुत मात्रा में ऊर्जा की आवश्यकता होती है और ग्रीनहाऊस गैस का बड़ी मात्रा में उत्सर्जन होता है। वैकल्पिक तकनीकों का ज्यादा से ज्यादा उपयोग करने से उत्सर्जन को घटाया जा सकता है और ग्लोबल वार्मिंग की समस्या को सुलझाने में लाभदायक होगा। इस परिस्थिति से निपटने के लिए महत्वपूर्ण यह है कि प्रति यूनिट सामग्री से उत्सर्जित CO_2 की सही मात्रा का ऑकलन किया जाए। भारत में टिकाऊ व 'पक्के' भवन निर्माण में प्रयुक्त मुख्य सामग्रियां स्टील, सीमेंट, चूना और ईंट है।

परिष्कृत स्टील संयंत्र (प्लांट) में क्रूड स्टील के उत्पादन में लगभग 2.40 टन प्रति टन क्रूड स्टील CO_2 उत्सर्जित होती है।

सीमेंट उत्पादन प्रक्रिया में भी बहुत ज्यादा ऊर्जा की खपत होती है। पाया गया है कि 1 टन सीमेंट के उत्पादन में 0.92 टन CO_2 उत्सर्जित होती है।

चूना के निर्माण में प्रति 1 टन पर 1.3 टन CO_2 उत्सर्जित होती है।

रेत नदियों के तली से मिलने वाली प्राकृतिक सामग्री है इसलिए इसमें कोई ऊर्जा खपत नहीं होती सिवाय परिवहन के दौरान हुई खपत के।

ईंट मुख्य निर्माण सामग्री है और भारत में यह उद्योग बड़े पैमाने पर चलता है। ग्रीनहाऊस गैस के बढ़ते उत्सर्जन के मद्देनजर इस उद्योग पर ध्यान देना जरूरी हो जाता है क्योंकि ईंट निर्माण में भट्ठियों में उच्च स्तर पर कोयला जलता है और ऊर्जा की खपत बहुत ज्यादा होती है। प्रति 1000 ईंट उत्पादन में लगभग 0.29 टन CO_2 उत्सर्जित होती है।

इसलिए ग्रीनहाऊस गैसों के उत्सर्जन को कम से कम करने के लिए ऊपर बताई गयीं भवन सामग्रियों का कम प्रयोग किया जाए तथा पर्यावरण मैत्री, ऊर्जा प्रभावी और लागत प्रभावी तकनीकों को अपनाया जाय।

Hkkjr e yxr izHkkoh Hkou fuekZ.k lkexh vkSj fuekZ.k dh rduhd

भारत में उपलब्ध और प्रयोग करने योग्य लागत प्रभावी भवन सामग्रियों और निर्माण प्रौद्योगिकियां, जो कठोर अनुसंधान एवं विकास के बाद देश के विभिन्न भागों के वैज्ञानिकों, इंजीनियरों और वास्तुकारों द्वारा परीक्षण के वर्षों बाद सफल साबित हुई हैं, उनमें से कुछ निम्नलिखित हैं।

nhokj fuekZ.k ¼okfy;ksx½

- उडन राख की ईंट/ब्लॉक्स
- राख, चूना, जिप्सम की ईंट/ब्लॉक्स (एफ ए एल–जी)
- कम वजन की सेलुलर कंक्रीट ब्लॉक्स (सीएलसी)
- ऑटोक्लेवड ऐरिएट्ड (भाप सहवातित) (ए ए सी) ब्लॉक्स
- मिट्टी, उडन राख वाली ईंट
- दबाव वाली मिट्टी की ईंट/ब्लॉक्स
- गुंथी हुई (इंटरलॉक्ड) दबाव वाली मिट्टी की ईंट/ब्लॉक्स
- फेरोसीमेंट पैनल्स
- ठोस कंक्रीट ब्लॉक्स
- खोखले कंक्रीट ब्लॉक्स
- प्रीकास्ट (पूर्व निर्मित) पत्थरों से चिनाई ब्लॉक्स
- बाँस चटाई के बोर्ड
- ईंटों में रेट–ट्रेप बांड
- जूट मिश्रित बोर्ड
- कॉयर (नारियल रेशे) मिश्रित बोर्ड
- सीमेंट में बंधे पार्टीकल बोर्ड
- फॉस्फोजिप्सम आधारित पैनल्स
- बैंबूक्रीट
- पोर्टलैंड पोजोलाना सीमेंट [उडन राख/केलसाइंड (चूर्णित) मिट्टी आधारित/पोर्टलैंड स्लैग (धातुचूर्ण) सीमेंट]
- मिश्रित सीमेंट में पोजोलोनिक गारा

Nr fuekZ.k ¼:fQx½

- फिलर स्लैब
- पूर्वनिर्मित प्रबलित ईंट के पैनल और कड़ियाँ
- पूर्वनिर्मित आरसीसी छत पट्टे एवं कड़ियाँ
- फेरोसीमेंट चैनल्स
- माइक्रो कंक्रीट टाइल्स
- बाँस चादर की नालीदार भीट
- बाँस चादर की रिज कैप
- जूट बांस मिश्रित रूफिंग भीट
- आर सी सी कड़ियों पर कुडप्पा स्लैब
- एल पैनल की ढलवाँ छत
- फनीकुलर आवरण छत
- उल्टी टी कड़ियों पर पूर्वनिर्मित ब्लॉक्स

tkbUjh ¼tkMd½ vkSj fofo/k

- दरवाजे और खिड़की की आरसीसी चौखटें
- फेरोसीमेंट के भाटर दरवाजे
- आर सी सी जाली
- पूर्वनिर्मित पतले लिंटल
- पूर्वनिर्मित सनशेड़
- फेरोसीमेंट सनशेड एवं लिंटल
- खड़ी ईटों का लिंटल
- लिंटल के लिए कोरबेलिंग
- लिंटल के लिए ईंट के आर्च
- पूर्वनिर्मित आरसीसी शैल्फ इकाईयाँ
- फेरोसीमेंट सीढ़ियाँ

इन सभी भवन निर्माण सामग्री और तकनीकों की सहायता से ग्रीनहाऊस गैस के उत्सर्जन में कमी की जा सकती है। चूंकि भारत एक विविधताओं और समृद्ध संस्कृति और वास्तुकला विरासत का एक देश है, हो सकता है कि इनके अलावा भी और तकनीकें प्रयोग में लाई जा रही हों। ये लागत प्रभावी भवन निर्माण सामग्री और तकनीकें, भवनों की गुणवत्ता और सुरक्षा व बचाव से कोई समझौता नहीं करती वरन् यह प्रचलित भवन निर्माण कोड के अनुसार तैयार की जाती है।

ykxr çHkkoh Hkou lkexh o fuek.k rduhdk l xhugkÅl xl mRl tu vkj fuek.k ykxr e deh

जैसे कि पहले भी बताया जा चुका है कि लागत प्रभावी भवन सामग्री व निर्माण तकनीकों से CO_2 उत्सर्जन और निर्माण लागत दोनों में महत्वपूर्ण रूप से कमी लाई जा सकती है। स्पष्टतौर पर यह प्रदर्शित किया जा चुका है कि इन तरीकों को अपनाने से निर्माण लागत में, भवनों की गुणवत्ता, टिकाऊपन, सुरक्षा और सौंदर्य के पहलुओं को प्रभावित किये बिना, 15 प्रतिशत की कमी हासिल की जा सकती है। भारत में आज भवन निर्माण की साधारण चिनाई और स्लैब बनाने की पारंपरिक तकनीकों की लागत, प्लिन्थ क्षेत्र दर के हिसाब से 9000रू. प्रति वर्ग मीटर आती है। ये क्षेत्र और सामग्री की उपलब्धता के अनुसार 15 से 20 प्रतिशत तक घट–बढ सकती है। लागत मे 15 प्रतिशत की बचत का अर्थ है कि प्रति वर्गमीटर मे 1350 रू कम होना। यदि किसी मकान का कारपेट क्षेत्रफल 25 वर्गमीटर और निर्मित क्षेत्रफल लगभग 32 वर्ग मी. है तो बचत 43,200 रू. की हो जाएगी। लागत निर्माण में कमी के अलावा इन तकनीकों से शीर्ष उपजाऊ मिट्टी, वनीय लकड़ी, ऊर्जा, स्टील और सीमेंट की खपत को भी बचाया जा सकता है। इसके अतिरिक्त इन लागत प्रभावी तरीकों से रोजगार का भी सृजन हो सकता है इन्हें उपलब्ध श्रम शक्ति के द्वारा आसानी से बनाया जा सकता है और विकेन्द्रीय उत्पादन इकाइयॉ स्थापित करने के लिये उपयुक्त ढंग से प्रयोग में लाया जा सकता है, विशेष रूप से निम्न आय वर्ग की बस्तियों एवं कालोनियों में।

नीचे दी गई सारिणी में एक मकान जिसका कारपेट क्षेत्र 25 वर्गमीटर और निर्मित क्षेत्रफल 32 वर्गमीटर है उसके निर्माण मे प्रयोग की जाने वाली सामग्रियों से उत्सर्जित CO_2 की कमी को दर्शाया गया है। इसमें लागत प्रभावी भवन सामग्री और तकनीकों को मिलाजुला कर इस्तेमाल किया गया है।

ijijkxr rduhdk d i;kx e lqij LVDpj dk;l gr ,d efty edku d fy, vif{kr ie[k Hkou lkexh ¼tku IV & V½	ykxr iHkkoh rduhdk dk mi;kx djr g, vif{kr Hkou lkexh	ykxr iHkkoh rduhdk d mi;kx l lkexh d mi;kx e deh	Hkou fuek.k lkexh d mRiknu l CO_2 dk mRl tu	CO_2 d mRl tu e deh ¼fdykxke½
	¶ykbl,'k bV] vkjlhlh lyUdl ,o tkbLV rFkk vkjlhlh d njokt@f[kMdh Ýe ¼pk[kV½			
ईंटे (12000 संख्या)	12000 संख्या	12000 संख्या	0.29 टन/1000 ईंटें	3480
सीमेंट (70 बोरी या 3.5 टन)	130 बोरी या 6.5 टन	(–) 60 बोरी या 3.0 टन	0.92 टन/टन	(–) 2760
स्टील (700 किलोग्राम या 0.7 टन)	400 किलोग्राम या 0.4 टन	300 किलोग्राम या 0.30 टन	2.4 टन/टन	720
CO_2 mRl tu e dy deh				1440 fdykxke vFkkr 1-4 Vu
	jV Vi ckM] fQyj Lyc ,o vkjlhlh d njokt@f[kMdh Qe ¼pk[kV½			
ईंटे (12000 संख्या)	9600 संख्या	2400 संख्या	0.29 टन/1000 ईंटें	696
सीमेंट (70 बोरी या 3.5 टन)	56 बोरी या 2.8 टन	14 बोरी या 0.7 टन	0.92 टन/टन	644

ijijkxr rduhdk d i;kx e lijLVDpj dk;l gr ,d efty edku d fy, vif{kr ie[k Hkou lkexh ¼tku IV&V½	ykxr iHkkoh rduhdk dk mi;kx djr g, vif{kr Hkou lkexh	ykxr iHkkoh rduhdk d mi;kx l lkexh d mi;kx e deh	Hkou fuek.k lkexh d mRiknu l CO_2 dk mRl tu	CO_2 d mRl tu e deh ¼fdykxke½
स्टील (700 किलोग्राम या 0.7 टन)	525 किलोग्राम या 0.525 टन	175 किलोग्राम या 0.175 टन	2.4 टन/टन	420
CO_2 mRl tu e d|y deh				1760 fdykxke vFkkr 1-8 Vu
	lihfMr ¼diLM½ feVVh bV@Cykd] fQyj Lyc ,o vkjlhlh d njokt@f[kMdh Ýe ¼pk[kV½			
ईंटे (12000 संख्या)	12000 संख्या	12000 संख्या	0.29 टन/1000 ईंटें	3480
सीमेंट (70 बोरी या 3.5 टन)	100 बोरी या 5.0 टन	(–) 30 बोरी या 1.5 टन	0.92 टन/टन	(–) 1380
स्टील (700 किलोग्राम या 0.7 टन)	525 किलोग्राम या 0.525 टन	175 किलोग्राम या 0.175 टन	2.4 टन/टन	420
CO_2 mRl tu e d|y deh				2520 fdykxke vFkkr 2-5 Vu
	lihfMr ¼diLM½ feVVh bV@Cykd] vkjlhlh lyUd ,o tkbLV ,o vkjlhlh d njokt@f[kMdh Qe ¼pk[kV½			
ईंटे (12000 संख्या)	12000 संख्या	12000 संख्या	0.29 टन/1000 ईंटें	3480
सीमेंट (70 बोरी या 3.5 टन)	90 बोरी या 4.5 टन	(–) 20 बोरी या 1.0 टन	0.92 टन/टन	(–) 920
स्टील (700 किलोग्राम या 0.7 टन)	400 किलोग्राम या 0.4 टन	300 किलोग्राम या 0.30 टन	2.4 टन/टन	720
CO_2 mRl tu e d|y deh				3280 fdykxke vFkkr 3-3 Vu
	jV Vi ckM] vkjlhlh lyUdl ,o tkbLV ,o vkjlhlh njokt@f[kMfd;k Ýe ¼pk[kV½			
ईंटे (12000 संख्या)	9600 संख्या	2400 संख्या	0.29टन/1000 ईंटें	696
सीमेंट (70 बोरी या 3.5 टन)	60 बोरी या 3.0 टन	10 बोरी या 0.5 टन	0.92टन/टन	460
स्टील (700 किलोग्राम या 0.7 टन)	400 किलोग्राम या 0.4 टन	300 किलोग्राम या 0.30 टन	2.4टन/टन	720

ijiijkxr rduhdksa dh i;kx esa lqij LVªDpj dk;l gsrq ,d efty edku dh fy, vif{kr ie[k Hkou lkexh ¼tkau IV&V½	ykxr iHkkoh rduhdksa dk mi;kx djrs gq, vif{kr Hkou lkexh	ykxr iHkkoh rduhdksa dh mi;kx ls lkexh dh mi;kx esa deh	Hkou fuekZ.k lkexh dh mRiknu ls CO_2 dk mRltZu	CO_2 dh mRltZu esa deh ¼fdyksxzke½
CO_2 mRltZu esa dqy deh				1876 fdyksxzke vFkkZr 1-9 Vu
	[kk[ky dksØhV CykWDl] vkjlhlh lyUdl ,oa tkbLV ,oa vkjlhlh dh njokt@f[kMfd;k Ýse ¼pkj[kV½			
ईंटे (12000 संख्या)	1250 संख्या	12000 संख्या	0.29 टन/1000 ईंटें	3480
सीमेंट (70 बोरी या 3.5 टन)	130 बोरी या 6.5 टन	(–) 60 बोरी या 3.01 टन	0.92 टन/टन	(–) 2760
स्टील (700 किलोग्राम या 0.7 टन)	400 किलोग्राम या 0.4 टन	300 किलोग्राम या 0.30 टन	2.4 टन/टन	720
CO_2 mRltZu esa dqy deh				1440 fdyksxzke vFkkZr 1-4 Vu

इस सारिणी के अनुसार यह देखा जा सकता है कि विभिन्न लागत प्रभावी भवन सामग्री व निर्माण तकनीकों को मिलाजुलाकर इस्तेमाल कर CO_2 उत्सर्जन में 1.4 टन से 3.3. टन तक की कमी की जा सकती है जो कि कार्बन से जुडे व्यापार में उपयोगी हो सकती है। यूरोपीय बाजार में कार्बन उत्सर्जन में कमी (सी इ आर) की प्रति इकाई की वर्तमान दर 14–15 यूरो है (वर्तमान यूरो की दर 65.27 रू है) । अतः CO_2 उत्सर्जन कमी के एवज में 25 वर्गमी. कारपेट क्षेत्रफल और निर्मित क्षेत्रफल 32 वर्गमीटर के मकान में प्रति मकान से 1400 से 3200 रू प्राप्त किये जा सकते हैं।

Hkkjrh; vkoklh; fLFkfr dk vuqlkj CO_2 mRltZu esa deh dh xtkb'k

बड़े पैमाने पर हो रहे शहरीकरण के कारण भारत में आवासीय समस्या खतरे की घंटी बनती जा रही है। ज्यादातर उनके लिए जो कमजोर वर्ग से हैं, गरीब है, वंचित है हॉसिये पर हैं, और जो अल्प वेतन आय समूह से हैं। ग्यारहवीं पंचवर्षीय योजना के अंत में देश में कुल आवासीय कमी 2 करोड़ 60 लाख 53 हजार (26.53 मिलियन) पाई गयी। खासतौर पर यह कमी जनसंख्या के अल्पवेतन आय समूह और आर्थिक रूप से कमजोर वर्ग के लिए थी। हमारे शहरों को देखा जाए तो भयानक दृष्य देखने को मिलता है क्योंकि शहरों की कुल जनसंख्या के 21 प्रतिशत लोग गंदी बस्तियों में या वैसे ही इलाकों में रहते हैं और 35 प्रतिशत लोगों के मकान मात्र एक कमरे की कोठरी के समान हैं। कुछ बड़े शहरों में जनसंख्या के केंद्रीकरण के कारण नगरीय संसाधनों की कमी अधिक बढ़ गयी है जैसे जल आपूर्ति, सीवर और नालों का प्रबंधन, कूड़े करकट के निपटारे का प्रबंधन, पार्क व खुले स्थान और परिवहन आदि। इन सबसे भाहरी पर्यावरण की गुणवत्ता को भी भारी नुकसान पहुंच रहा है।

राष्ट्रीय भाहरी आवास और पर्यावास नीति (एनयूएचएचपी) 2007 के तहत सबके लिए किफायती आवास (एफोर्डेबल हाऊसिंग फॉर ऑल) पर ध्यान दिया है। इनमें ज्यादातर वे हैं जो कमजोर वर्ग और अल्प वेतन आय समूह से हैं। एन.यू.एच.एच.पी. ने इस बात पर भी जोर दिया कि नए व वैकल्पिक निर्माण सामग्री और तकनीकों का ज्यादा से ज्यादा विकास तथा उपयोग हो, वहीं पर्यावरण सुरक्षा पर भी जोर दिया और कहा कि घटते दुर्लभ

प्राकृतिक संसाधनों के प्रयोग को घटाने एवं नवीकरणीय संसाधनों के उपयोग की योजना की हिमायत के साथ–साथ स्थानीय आधार पर उपलब्ध कच्ची सामग्री का उपयोग किया जाए।

भारत सरकार ने इस संबंध में कई योजनाएं शुरू की हैं जैसे जवाहर लाल नेहरू शहर नवीनीकरण योजना (जे एन एन यू आर एम), भागीदारी से सुलभ आवास, शहरी गरीबों के लिए ब्याज सब्सीडी योजना से आवास (आइ एस यू एच पी) और ई डब्ल्यू एस तथा एल आइ जी मकानों के लिए राजीव आवास योजना। इन योजनाओं के उद्देश्यों को प्राप्त करने हेतु बड़े पैमाने पर निर्माण कार्य चल रहे हैं।

भारत सरकार ने आवासीय कमी को कम करने के लिए प्रति वर्ष 20 लाख मकान बनाने का लक्ष्य निर्धारित किया है। विभिन्न सरकारी योजनाए जैसे जेएनएनयूआरएम और राजीव आवास योजना के तहत प्रत्येक मकान का कारपेट क्षेत्र कम से कम 25 वर्गमीटर निश्चित किया है। इस आधार पर एक मकान का निर्मित क्षेत्रफल लगभग 30–32 वर्गमीटर होगा। जो कि भवन निर्माण में उपयोग लाई जाने वाली तकनीकों पर निर्भर होगा। इस लक्ष्य के आधार पर प्रति वर्ष 20 लाख मकानों के लिए प्रति यूनिट 32 वर्ग मी. निर्मित क्षेत्रफल का कुल निर्मित क्षेत्रफल 64 मिलियन वर्गमीटर होगा। यदि ऊपर बताई गयीं लागत प्रभावी तकनीकों व निर्माण सामग्री को अपनाया जाता है तो प्रतिवर्ष अकेला भारत ही CO_2 उत्सर्जन में 20.8 से 60.6 लाख टन की कमी ला सकता है और वहीं 86,400 मिलियन रू की बचत हो सकती है। जिन्हें राज्य के कोष में डालने से सरकार द्वारा चलाई जाने वाली विभिन्न योजनाओं में इस्तेमाल किया जा सकता है। रूपयों के हिसाब से CO_2 उत्सर्जन प्रतिवर्ष कार्बन उत्सर्जन कमी की दर से 2800 मिलियन से लेकर 6400 मिलियन के बराबर होगा।

fu"d"k

सबसे ज्यादा आवश्यक है कि इन लागत प्रभावी भवन सामग्री व निर्माण तकनीकों के इस्तेमाल को बड़े पैमाने पर तालमेल के साथ किया जाए और इनकी उपयुक्तता, महत्ता और क्रियाशीलता को स्वीकारा व अपनाया जाये। निर्माण में लागत प्रभावी तकनीकों के अनुप्रयोग पर राष्ट्रीय माडल बनाने के लिए निम्नलिखित हस्तक्षेप की भागीदारी की आवश्यकता है।

leh dj.k % इन तकनीकों और तरीकों को तकनीकी शिक्षा संस्थानों में पढ़ाया जाए।

tkx:drk % समुदायों, तकनीकविशेषज्ञों, उद्योगों और बड़े पैमाने पर लोगों द्वारा उपयोग व अपनाया जाये।

ikR lkfgr djuk % तकनीक विशेषज्ञों और भौक्षणिक संस्थानों को शामिल किया जाये।

vuqi;kx ¼vxhdj.k vkj nksgjkuk½ अभ्यास पेशेवरों, उद्योग और बडे पैमाने पर लोगों द्वारा।

आने वाले वर्षों में लागत प्रभावी निर्माण सामग्री और प्रौद्योगिकियां उच्चतम मानव रचनात्मकता के पारंपरिक ज्ञान, वैज्ञानिकी और तकनीकी विकास और नवाचारों का एकीकरण कर उचित आवास एवं मानव बस्ती क्षेत्र में सहायता कर सकती हैं।

ग्लोबल वार्मिंग को घटाने के उपाय हमारे हाथों में ही हैं। अब वक्त आ गया है कि हम स्वच्छ व उन्नत पर्यावरण–मैत्री तकनीकों के प्रयोग द्वारा ग्लोबल वार्मिंग को रोकने के लिए केंद्र व राज्य के संस्थाओं और विभागों को इन तकनीकों को अपनाने के लिए प्रेरित करें। दूसरे मुख्य क्षेत्रों के साथ, निर्माण क्षेत्र भी CO_2 उत्सर्जन तथा ग्लोबल वार्मिंग को कम करने में बहुत बड़ी भूमिका निभा सकता है। सभी स्टेकहॉल्डर की सकारात्मक पहल के जरिये जलवायु परिवर्तन कम करने के उद्देश्यों को हासिल कर सकते हैं।

जलवायु परिवर्तन की प्रक्रिया से हमारे सामने काफी चुनौतिया खड़ी होने की संभावना है। जबकि कई कदम उठाए जा चुके हैं और कई योजनाएं बनाई जा रही है परन्तु जलवायु परिवर्तन की समस्या से मुकाबला करने के लिए हमें लगातार अनुसंधान और विकास की क्षमता विकसित करने की जरूरत है। भारत सरकार स्थायी पर्यावास विकास के लक्ष्य को प्राप्त करने के लिए सभी शमन और अनुकूलन कदम उठाने के लिए प्रतिबद्ध है।

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Introducing Emerging Housing Technologies – BMTPC's Initiative

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Introduction

With annual growth rate of 2.7%, urban population in the country rose to 286.1 million as per 2001 Census. It is projected that urban population will continue to grow and reach 470 million in 2021 and 700 million in 2041. With this pace of urbanization, our cities are facing major shortage of housing stock and also despite of best efforts by the Government, the gap between available housing stock and required is ever increasing. According to the estimates made by the Technical Group, constituted by the Ministry of Housing & Urban Poverty Alleviation, Government of India, for assessment of the urban housing shortage at the end of the 10th Five Year Plan, the total housing shortage in the country is 24.71 million and 99% of this shortage pertains to economically weaker section and the lower income group of the society. The total urban housing shortage at the end of the 11th Five Year Plan period (2007-2012) is estimated to be of the order of 26.53 million units. Housing and habitat related services for the urban poor and low income groups are estimated to cost a sum of about Rs.6,00,000 crores. Obviously it requires proper planning, policy frame work and technical interventions to deal with the subject.

Realizing the challenge, the Government of India took several initiatives to create opportunities and supporting environment to overcome this housing shortage in most effective manner. The National Urban Housing and Habitat policy 2007 by the Ministry of Housing and Urban Poverty Alleviation, inter-alia, lays emphasis on using technology for modernizing the housing sector for enhancing energy and cost efficiency, productivity and quality specially to meet the housing needs of the poor. It encourages use of prefabricated factory made building components so as to achieve speedy, cost effective and better quality construction. Through ongoing Jawaharlal Nehru Urban Renewal Mission (JNNURM) and newly launched Rajiv AwasYojna (RAY), the central Government gives State Governments the opportunity to eradicate slum and create necessary housing stock and basic services to the poor. This gigantic task needs a review of our construction practices and study of emerging technologies so as to introduce best technologies and practices suiting our condition for construction of housing stock in different parts of the country.

BMTPC has been promoting cost-effective, environment-friendly, energy-efficient and disaster resistant technologies developed in India. With fast depleting natural resources; need for environment protection to protect greenhouse effect; need for bringing more speed, durability and quality in construction; it is prudent to widen the horizon to look for alternate cost effective technologies within and outside the country. BMTPC took an initiative to study/select emerging and alternate cost effective technologies suitable to Indian geo-climatic conditions and construct demonstration houses at various parts of the country to showcase the technologies.

BMTPC's Initiative

BMTPC invited Global Expression of Interest (EOI) from Construction System/Technology Developers/ Providers for introducing emerging and alternate cost effective housing technologies suitable to Indian geo-climatic and hazard conditions through construction of demonstration houses at various

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parts of the country. The Global EOI was invited in two stages. The first stage of Global EOI includes selection and evaluation of suitable technologies which the technology developers/providers are willing to bring to India for mass housing, as a cost effective substitute for conventional system. After evaluation, the technologies will be ranked for suitability in Indian condition for mass housing. The second stage includes construction of demonstration houses using selected technologies/ systems, in different parts of country.

The Council received the expression of interest from the 12 agencies for different technologies and systems from all over the world. A Technology Advisory Group was constituted by BMTPC for identification, evaluation and selection of the suitable technologies/systems, comprising of eminent experts from Government, CSIR, academic and private agencies.

Based on the information given by the bidders through their individual presentations before the TAG for their respective technologies/ systems with respect to material and structural details, status of evaluation, actual construction carried out in India or elsewhere and their performance, economic scale of construction, status of transfer of the technology to India, suitability for mass construction in urban areas, durability & speed of construction, cost effectiveness, innovation in technology, ease of working & adaptability in Indian condition, etc., the following broad parameters were considered for evaluation of technology/system:

- Structural stability
- Material specification and its durability
- Green concept
- Joints and connections specially for prefabricated system
- Cost effectiveness of the emerging technologies vis-à-vis conventional construction system (RCC and masonry construction)
- Speed of construction and quality
- Sanitation
- Suitability to Indian climatic and hazard conditions
- Scale of minimum number of houses
- Adoptability of Services.
- Expected life span of the proposed system
- Maintenance scheme for the system
- Resistance of the system against fire, blast, etc.
- Users' feedback and certification, wherever possible.
- Compatibility and adherence of the system to BIS
- Any shortcoming of the system

Based on the above broad parameters, the TAG short listed following seven technologies/ systems for further evaluation:

S. No.	Technology/System
1	Panel building system using steel mesh, polystyrene core and chipping concrete
2	Technology using expanded steel mesh panels, polystyrene beads & alleviated concrete
3	Pre-stressed precast prefab technology using hollow core slab, beams, columns, solid walls, stairs, etc.
4	Monolithic concrete system using plastic formwork
5	Monolithic concrete construction using aluminium formwork
6	Precast concrete panels system using concrete, welded mesh and plates, polystyrene core
7	Industrialized 3-S system using cellular light weight concrete slabs & precast columns.

Details of Shortlisted Technology/System

1. Panel building system using steel mesh, polystyrene core and chipping concrete

The panel Building system is a load bearing wall construction which is seismic resistant and thermally insulated. It is reported that buildings of any typology or architectural structure, ranging from most simple to the most complex one, could be constructed. The base element of the building system is a modular panel composed of two electro-welded galvanized steel meshes , reciprocally joined by connectors , in the middle of which is a suitably shaped foam polystyrene plate. High resistance steel meshes composed of bars having dia. 2.5 to 5 mm. are made in factory. Panels could be supplied with meshes having different dia. and different geometrical characteristics. Polystyrene is self- extinguishing foam polystyrene suitably shaped, used both as a disposable form and as an insulating layer. The EPS is made of carbon, hydrogen and for 98% air. Thickness, shape and density of the polystyrene core may change according to specific

requirements. The minimum density normally used is equal to 15 kg / m^3.

Once the panels are installed, they are anchored and finished with the application of light concrete on both of their sides. Thus, buildings with load bearing walls consisting of two reinforced concrete plates are made integral by a thick network of connectors, with an insulating core. Single panel is finished, by applying on each a layer of chipping concrete having characteristic resistance of 30 Mpa at least. As load bearing element, the double panel and the floors are finished during the installation with concrete of suitable grade placed into the slab ribs as well. Should the panels carry out a non load bearing function , a concrete plaster , even a pre mixed one , is applied for a thickness of at least 25 mm.

Materials used: Meshes manufactured using high resistance steel bars of dia. 2.5 – 5mm, Self - extinguishing Polystyrene core (min density 15 kg / m^3), Chipping Concrete having characteristic strength 30 Mpa

Salient features: Good heat and sound insulation properties, versatility in construction, lightweight but strong, resistance to seismic, hurricane/tornado forces including blast explosion of 50 psi, fire rating of 60 min, cost effective building system utilizing local raw materials and labour force, speed of construction (30% less than conventional construction system), environment friendly being, CFC free and non-toxic, energy efficient

Evaluation: Wind projectile resistance test – Wind Science and engineering, Texas Tech University, Texas; Fire resistance test - Centro Technologico De La Madera, spain; Dynamic Tests – RITAM-ISRIM-Universita Di Perugia- CSM; Sound insulation test- SIRIM QAS International Sdn. Bhd, Malaysia

2. Technology using expanded steel mesh panels, polystyrene beads & alleviated concrete

The system is entirely a "on-site" construction process, not based on prefabricated, pre cast or preassembled elements and is a most spectacular, versatile and efficient construction system. The houses are entirely, including the roof, made up of structure panels assembled with Beams. Alleviated concrete, a special mix of concrete and expanded polystyrene beads, hence incorporating both the thermal and the sound insulation, is injected into a steel structure made of panels reinforced with beams (galvanized steel wire studs/ steel rods).

The Concrete base and the foundations of the houses are prepared in a conventional manner. They can be made from regular, poured, heavy concrete, but more generally the use of alleviated concrete or at least of one more layer of alleviated concrete, will provide good thermal insulation

and good comfort from the ground also. Prior to the pouring of the concrete of the base, the panels are tied to the soldered wire mesh and to the iron rods in the base and in the foundations and assembled in accordance with the design of the house. They are then, held together by special made galvanized steel wire studs, which fit one into the other, horizontally and vertically, to form the complete skeleton of the construction, roof included.

The assembled panels form a rigid, extremely robust, self-supporting steel skeleton, comprising the outside walls and all other bearing walls and partitions, the floors and ceilings, including the roof. Doors and walls are then simply "cut out", using steel scissors or other steel cutters. Cut-offs is recovered and re-used. Templates of doors and windows are positioned. Instead of using framework, both sides of each panels are then simply covered with a galvanized wire mesh/fencing mesh/Chicken mesh, which is clipped to the panels, and will serve as a frame when the alleviated concrete injected.

"Alleviated" or "light" concrete is then injected with a special concrete pump. This pump can operate from a distance of 60 meters and to a height of up to 60 meters (almost 20 floors). The alleviated concrete is a custom-made mixture of cement, fiber, sand and Expanded Polystyrene (EPS) beads (1 to 4 mm), resulting in a low-density concrete (50-700 kg/m^3) and hence incorporating thermal and sound insulation. The injected walls are then finished / leveled / smoothened from both sides. The concrete-injected then forms a true and quasi-homogeneous composite with incomparably better properties than plain steel reinforced concrete; Offers excellent thermal and phonic insulation; has walls that breathe; is completely resistant to fire; Offer complete protection against earthquakes and hurricanes and; is immune to termites and other insects.

Materials used: Expanded steel type of galvanized steel mesh

panels, cast and expanded in continuous process from a 1.6 mm thick and 30 cm wide galvanized steel sheet coil and Alleviated concrete made up of cement; fiber; sand and expanded polystyrene beads(1-4 mm).

Salient Features: Well insulated, earthquake/hurricane/tornado resistant, fire and termite resistant, built on site in less time, minimal manpower, equipment and logistics, high quality and durability, cost effective, sound, safe, healthy, energy efficient, environment friendly, architectural flexibility, higher strength of walls and roof, wires and pipes embedded in the walls, no forms, shuttering frames or casings.

The system is composed of tri-dimensional panels, realized without welding in one piece, without any loss of materials by special cutting process and using galvanized steel plates. It is made of two sides of longitudinal ribs which are linked together at the knots by jambs. The layout of jambs in relation to the ribs defines the sides.

Evaluation: Thermal, sound and structural certification by GINGER-CEBTP, France; fire resistance certification by EFECTIS, France; Certification by CSTB, SOCOTEC, VERITAS

3. Pre-stressed precast prefab technology using hollow core slab, beams, columns, solid walls, stairs, etc.

Pre-stressed precast RCC technology using hollow core slabs, beams, columns, solid walls, stairs etc. are designed and manufactured in factory, shipped and erected at site. Multi-storey precast concrete frames are constructed with columns and

beams of different shapes and sizes, stair and elevator shafts and floor slabs. The joints between the floors elements are executed in such a way that concentrated loads are distributed over the whole floor. This system is widely used for multi storey buildings.

The structural frame is commonly composed of rectangular columns of one or more storeys height. The beams are normally rectangular, L-shaped or inverted T-beams. They are single span or cantilever beams, simply supported and pin-connected to the columns. Hollow core floor slabs are by far the most common type of floor slabs in this type of structure.

Materials used: Cement concrete, steel strands, reinforcing steel.

Salient Features:

- Saving in Cost: Precast Prefab buildings can be constructed in less than half the time it takes to construct using conventional construction. This results in huge financial savings.
- Material Savings: Precast pre-stressed technology results in 40% reduction in slab weight. This reduces in building weight, material & foundation cost resulting in direct cost savings.
- Savings in Exterior Painting & Finishing: All exterior surfaces can be provided with aggregate or other such colored finishes which require no additional painting over the life time of the building. Alternatively the walls are made with a very smooth mirror like finish saving in plastering costs.
- Increased Carpet Area: Because of the high strength of the concrete structure small sized walls can be used in lieu of thicker ones. This results in the increased carper area for a similar construction of in-situ buildings.
- Energy Savings: Hollow core slabs act as a natural insulator & thereby result in savings in air conditioning cost. Additionally, walls can have in-built foam insulation resulting in increased savings.

- Environmental Benefits: Prefab concrete can have fly ash as a ingredient in the concrete mix. This results in higher strength concrete while at the same time utilizing an otherwise waste product.
- Long Life Cycles: As buildings components are manufactured & cured in controlled conditions the resulting elements have better strength & durability. This results in buildings having much longer life cycles than conventional in-Situ construction
- Water Savings: Water requirement for curing of elements is minimal as compared to in-situ construction. Also in the factory the water is recycled thereby saving this precious commodity.

4. Monolithic concrete technology using plastic/ aluminium composite formwork

In the monolithic concrete technology, Walls and slabs are cast in one operation in specially designed light weight form/ moulds in concrete. Concrete is poured in the forms & forms are removed after the setting of concrete takes place, resulting in box like cubical structure of required architectural design. The pre-designed formwork also acts some sort of assembly line production and enables rapid construction of multiple units of repetitive type.

Materials used: Primarily M20 grade concrete walls, slabs & HYSD reinforcement of Fe 415/ Fe500 grade.

Specification:

- Foundation : Strip footing based on SBC of soil. Foundation & plinth wall to be 150 mm thick.
- Work above Plinth: load bearing cement concrete of M20 Grade walls with single layer of vertical & horizontal reinforcement.
- Slab & Staircases: 100 mm thick M20 Grade concrete slabs. Plain soffit staircase with concrete/masonry riser.
- Reinforcement: HYSD reinforcement of Fe 415/ Fe500 grade
- Shuttering/Form works : PVC-Aluminium Formwork with minimum propping
- In addition, IPS/Ceramic Tile flooring in rooms, dado in WC & bath. Metal doors for main & internal walls, PVC doors for bath & WC etc.
- As indicated, the specifications/ items are indicative & can be changed to suit the needs of users as per local conditions/ practices.

Evaluation: CEPT University, Ahmadabad

5. Monolithic concrete construction using aluminium formwork

In the Monolithic concrete construction with aluminium forms system, Concrete walls and slabs are cast monolithically at one pour. The system allows reduction in thickness of concrete members below the minimum value than the conventional construction, thus reducing the consumption of natural resources. Single floor with built up area of about 300 sqm. can be completed in two days using the aluminium formwork system.

The technology reduces the cost of repair and maintenance compared to conventional system.

Materials used: Cement, aggregate, sand, steel and aluminium formwork

Salient features: structurally sound, safe, durable against earthquakes, cost effective technology, resistant to fire etc.

Evaluation: Wind Engineering Research Deptt., Texas Technical University, USA

6. Precast concrete panels using concrete, welded mesh and plates, polystyrene core

Pre-cast concrete load bearing panels are made of reinforced concrete with a polystyrene insulated core that varies in size from 40mm to 200mm depending upon the insulation requirements. The reinforced concrete panels are moulded in specially designed steel moulds under controlled factory conditions. Then the panels are removed from the moulds and stacked vertically for curing. Power and water conduits are installed in the panels during production. The buildings and houses can be designed to suit any geographical position or environment and can withstand wind speed in excess of 285km/hr. The system does not impose any design restrictions and can be used for any kind of architectural and aesthetic design as these panels are custom designed and manufactured. The panels have smooth surfaces. However, any kind of texture can be added on to the panel surface. Due to cohesive structural design, the system requires only strip foundation for most buildings.

Concrete panels can be designed with strength of 5000 psi. These results in stronger panels than concrete blocks or most poured concrete walls but are thinner and light weight. The panels are of good quality and uniformity as they are cast and cured in controlled

factory environment. The panels can be installed in fraction of time. The foundation takes two hours to prepare and the panels are set in three hours.

Materials used: Cement, aggregates, sand with additives, Welded mesh and plates, polystyrene core

Salient features: Reduced labour cost due to quicker/ easier assembly, in some cases no mason is required; tornado/ hurricane damage resistance, fire, termite and dry rot resistance; requires less insulation; low maintenance and improved sound proofing; can be erected in cold temperature, preventing concrete pour delays; buildings constructed using the system are resistant to earthquakes measuring up to 6 on Richter Scale; save air conditioning energy; higher upfront cost, requires on-site crane including certified installer sometimes; offers a 10 year warranty on the structure using the technology.

Evaluation: Building Research Association of New Zeeland (Fire Rated and structural load testing), Structural Engineering Research centre, Chennai and Jawaharlal Nehru Technological University, Hyderabad.

7. Industrialized 3-S system using cellular light weight concrete slabs & precast columns

The industrialized total open prefab construction technology is based on factory mass manufactured structural prefab components conforming to norms of IS standards and BIS Certification mark. In this system Dense Concrete hollow column shell of appropriate size are used in combination with pre-cast dense concrete rectangular T Shape/L shape beams and lightweight reinforced autoclaved cellular concrete slabs for floors and roofs.

The hollow columns are grouted with appropriate grade of in–situ concrete. All the connections and jointing of various structures are accomplished through in situ concreting along with secured embedded reinforcement of appropriate size ,length and configuration to ensure monolithic continuous resilient ductile behavior.

Materials used: Concrete, Cellular light weight concrete Slabs, Precast column

Specification: As per relevant Indian Standards; IS 2185-Part 3 specification for autoclaved cellular concrete blocks, IS 6041 construction of autoclaved cellular concrete block masonry, IS 6072SP autoclaved reinforced cellular concrete wall slab, IS 6073 autoclaved

reinforced cellular concrete floors and roof slab.

Evaluation: Stanford University, USA; IIT, Mumbai; CBRI, Roorkee; SERC, Chennai; TSRF, Bangalore. It is mentioned that all the above Institutions have concluded that the 3 S prefab System satisfies all the technical parameters, codal requirements and most suitable for mass housing projects.

In addition to the above emerging technologies, the Council has also evaluated GFRG/ Rapidwall Building System technology under its Performance Appraisal Certification Scheme (PACS) and is one of alternate technology having potential for mass housing projects. The details of technology are as under:

GFRG/ Rapidwall Building System Technology

Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwallis a building panel product, made essentially of gypsum plaster, reinforced with glass fibres. This product, suitable for rapid mass-scale buildings construction, was originally developed and used since 1990 in Australia. GFRG is of particular relevance to India, where there is a tremendous need for cost-effective mass-scale affordable housing, and where gypsum is abundantly available as an industrial by-product waste. The product is not only eco-friendly or green, but also resistant to water and fire. GFRG panels are presently manufactured to a thickness of 124 mm under carefully controlled conditions to a length of 12 m and a height of 3 m. The panel can be cut to required size. Although its main application is in the construction of walls, it can also be used in floor and roof slabs in combination with reinforced concrete.

The panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. The panels may be unfilled, partially filled or fully filled with reinforced concrete as per the structural requirement. Experimental studies and research have shown that GFRG panels, suitably filled with plain reinforced concrete, possess substantial strength to act not only as load-bearing elements, but also as shear walls, capable of resisting lateral loads due to earthquake and wind. It is possible to design such buildings up to ten storeys in low seismic zones (and to lesser height in high seismic zones). However, such construction needs to be properly designed by a qualified structural engineer. Manufacture of GFRG panels with increased thickness (150 mm, 200 mm) with suitable flange thickness can facilitate construction of taller building.

GFRG panels can also be used advantageously as infills (non-load bearing) in combination with RCC framed columns and beams (conventional framed construction of multi-storey buildings) without any restriction on the number of storeys. Also, GFRG panels with embedded micro-beams and RCC screed (acting as T-beams) can be used as floor/roof slabs.

GFRG panels can be unfilled when used as partition walls, but when used as external walls, need to be suitably designed (with reinforced concrete filling) in order to resist the design wind pressures. For single-storey construction (suitable for mass low-cost housing), unfilled GFRG panels can be used for walls as well as roof (which may be pitched suitably), with local reinforced concrete filling at the joints between walls and between the roof and walls. It is mandatory to provide embedded RCC horizontal tie beam over all the walls below the floor slab/roof slab.

Materials used: Gypsum plaster reinforced with glass fibres.

Salient Features: Substantial reduction in the structural weight of the building**,** no plastering requirement for walls and ceiling, increased speed of construction with less manpower, saving of cement, steel, river sand, burnt clay bricks/concrete blocks and hence saving of energy and reduced CO_2 emissions, contributing to environment protection and mitigate climate change, use of reprocessed/recycled industrial by product, waste gypsum, to

manufacture GFRG panel, helping to abate pollution and protect the environment.

GFRG building systems can be constructed only with technical support or supervision by qualified engineers and constructors, based on structural designs carried out in detail to comply to prevailing standards; this is applicable even for low-rise and affordable mass housing, to provide for safety against natural disasters (such as earthquakes and cyclones).

Evaluation: IIT Madras and SERC Chennai, Building Materials & Technology Promotion Council (BMTPC), New Delhi. Detailed design manual has been developed for construction of buildings using GFRG panel.

Road Ahead

Based on available technical details and evaluation, the technologies have been shortlisted. Now, it is required to see their application in the field for which demonstration construction have been planned. This alone would instill confidence in the mind of users and will also give an opportunity to examine the finer points, if any, of the construction. Some of the technologies identified, however, require setting up of manufacturing units and transfer of technologies. Such types of technologies need a big market for sustainability. It would also be necessary to develop specification, code of practice based on Indian conditions and analysis of rates. Since these technologies are unique in themselves, suitable methodologies would be required to be developed for their selection by government agencies in their projects.

Green Building Materials for Sustainable Urban Housing

*Dr. R. K. Khandal**

It is an established fact that each anthropogenic activity has the risk of adversely affecting the environment. Such effects occurring at micro level over an extended period of time manifest themselves in the form of climate change at the macro level. In recent times, the climate change has been viewed as a much larger threat to the sustainability of society. That is why, research groups have been formed to undertake studies on climate change and to prepare plans to avert the catastrophies arising out of this, all over the world. Protection of environment has become a global issue because it has been realized that localized activities causing pollution would have a bearing effect at the global level. That is the reason that all the countries have started working to eliminate the possibilities of dangers of climate change.

It is true that the societal growth alongside the growth of economy is a criteria adopted to assess the development of a nation. The development and growth are accompanied by the large-scale industrialization and urbanization. Unless both these so-called parametersofgrowtharekeptunder check, the possible catastrophies of climate change would not be too far distant to destroy not only what is being created in the name of development but also the life on earth. Therefore, steps need to be initiated at all levels and in every sector to curb the trend that has already set in to result in climate change.

While everyone appears to be concerned with the climate change, there exists a huge difference in approach amongst nations as far as the policies and plans to go about it are concerned. On the one hand, the developed countries do not want to bring their energy consumption levels down, the developing countries have little options as they are keen to catch up with the developed world. If the developing countries attain the status of a developed country and start consuming the energy per capita at the same level, as for example of US, it will not be sustainable. How rising consumption per capita of China and India has caused such a steep rise in prices of crude oil during the last couple of years is good enough to understand the emerging economic scenario of future. The scenario of environment pollution would still be worse. The need of the hour, therefore, is to keep a check on energy consumption thereby, curbing the growth of emission of CO_2 in order to avoid the dangers of climate change.

The task of finding workable solutions to the problems of climate change is highly challenging. It involves development of clean and green technologies, on the one hand and search for alternative sources of energy and materials on the other hand. This would require multi-disciplinary research targeted to develop technologies adoptable at global levels but those based on the local inputs. International collaborations to achieve such objectives have already started to happen in different sectors of industries. The present paper would focus on the developments taking place in the construction sector.

In order to ensure that the humans have the basic right to shelter, developing projects for housing is the key. In cities these days, especially in developing countries like India, the major activity pertains to the construction for housing. Additionally, the construction for industries, establishments and other infrastructural facilities has

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also been taking place in a big way. All these constructions have the direct as well as indirect impact on the environment as they all leave their carbon footprints. For example, during construction, energy is consumed for the construction activities. Also, the materials used for constructions have their own embodied energy.

After the construction, the energy is consumed for both the operations as also for the maintenance of the buildings. The aim should be to keep a check on the energy input at every stage of the construction projects. One way of doing this is to have an appropriate design so that the requirement of energy for buildings and their operation is minimized. Another way deals with the use of materials that conserve energy by their inherent characteristics. These days, materials can be designed to meet the requirements of the construction industry in terms of saving the energy. For sustainable housing, therefore, use of suitable materials has become a focus area of research for the material scientists.

Building materials are basically composite materials of various types; rarely they are used in their pure form. For example, amongst the inorganic materials like cement, concrete, etc., are the combinations of different base materials. Likewise the alloys, glass and polymeric materials are all in the form of composites designed for special features. For sustainability, the energy consumption by construction sector can be kept under control by way of designing materials with following characteristics:

(i) Green Materials

(ii) High strength/weight ratio

(iii) Energy efficient (Green) materials

(iv) Materials with special features:

(a) Solar selectivity

(b) IR reflectivity

(c) Emissivity

All these aspects of green materials are discussed here.

(i) Green Materials

Materials can be called as green or not green depending upon the amount of energy required to produce them. With this criterion as the basis, the greenest material would be wood stock. This is not only green but also sustainable (renewable) material. Anything renewable and usable without further inputs of energy would certainly be the greenest material known to mankind.

The other way of classifying materials can be the process involved in making them. Depending upon the amount of energy needed to produce them, materials can be rated as more or less green; energy-intensive processes will produce a material lower in the order of greenness. There are several examples to elaborate this point. A polymer, for example, can be produced by different methods of polymerization i.e. thermal or irradiation; the former being more energy intensive than the latter. Similarly, the choice of base material used for production, keeping the process same would also be a measure of greenness, for example, manufacture of cements using different types of base materials. Using fly ash would easily make the cement greener than otherwise. Sometimes, the synergistic combinations of material may make the product green on relative basis. Various types of compositions are being developed to produce green materials. All these examples depict that the direct involvement of energy to produce the materials can be the basis to grade them for being green. Here, it may be noted that processes emitting hazardous gases would make the materials not so green!

The other important consideration used to decide the greenness of a material pertains to the life cycle of the materials used for a given purpose. A long-lasting material would be greener than the one lasting for a while, inspite of the fact that the former consumes more energy than the latter. Here, then, it will not be energy/ ton of material but energy/ton/year would be the basis. Rather than being energy-efficient, materials are graded as per their energy-effectiveness.

Keeping all the above mentioned criteria as a reference, one can go about designing green materials for desired applications. When it comes to base materials, it is always preferable to choose those derived from the renewable resources. The challenge is to convert such base materials into useful products so easily. Sometimes, the cost of the base materials derived from the renewable resources may make the developmental efforts prohibitive. For a chosen base material to be converted into green material, one will have to adopt a green process; energy-efficient and free from emission of hazardous substances. Here again, the challenge is in developing such a process. These days, attempts are being made to have a bio-route as an alternative to energy-intensive conventional processes to produce

materials. Green materials can also be designed by using waste from different sources. Options are many but the challenge is always to have the theoretical concepts work at the commercial scale.

(ii) High strength/weight ratio

Materials used for construction industry are required to have key features like a) desired strength b) desired strength for minimum weight c) long-lasting and d) free from maintenance. While all other attributes in a material can be acquired through surface modification, the properties like strength or strength/weight ratio can only be achieved through modifications at the bulk of the materials. There are several ways possible to do that but the most practical and successful ones relates to: a) modification of the bulk by incorporating the dispersed phase into the matrix, while designing composite materials with special characteristics. Most of the polymers and polymeric materials including compounds and composites are the prominent examples of such materials. Recent developments have led to the emergence of nano-engineered materials where the composites of unique strength are designed by incorporating nano materials into the continuous bulk matrix of both inorganic as well as organic type. b) Modifications of the basic structure (including of monomer) to obtain a material of completely different functionality. The second approach results in materials of new chemistries and such materials are also, at times, referred to as alternative materials with extraordinary strength as also high strength/weight ratio. In recent times, new materials are being developed using both these approaches.

Designing materials like nano-composites and nano-engineered concretes is also an approach to achieve materials with green character (Figure 1). Here, the challenge lies in not just making such materials in the first place but in fact it is in making them work over a period of their life cycle.

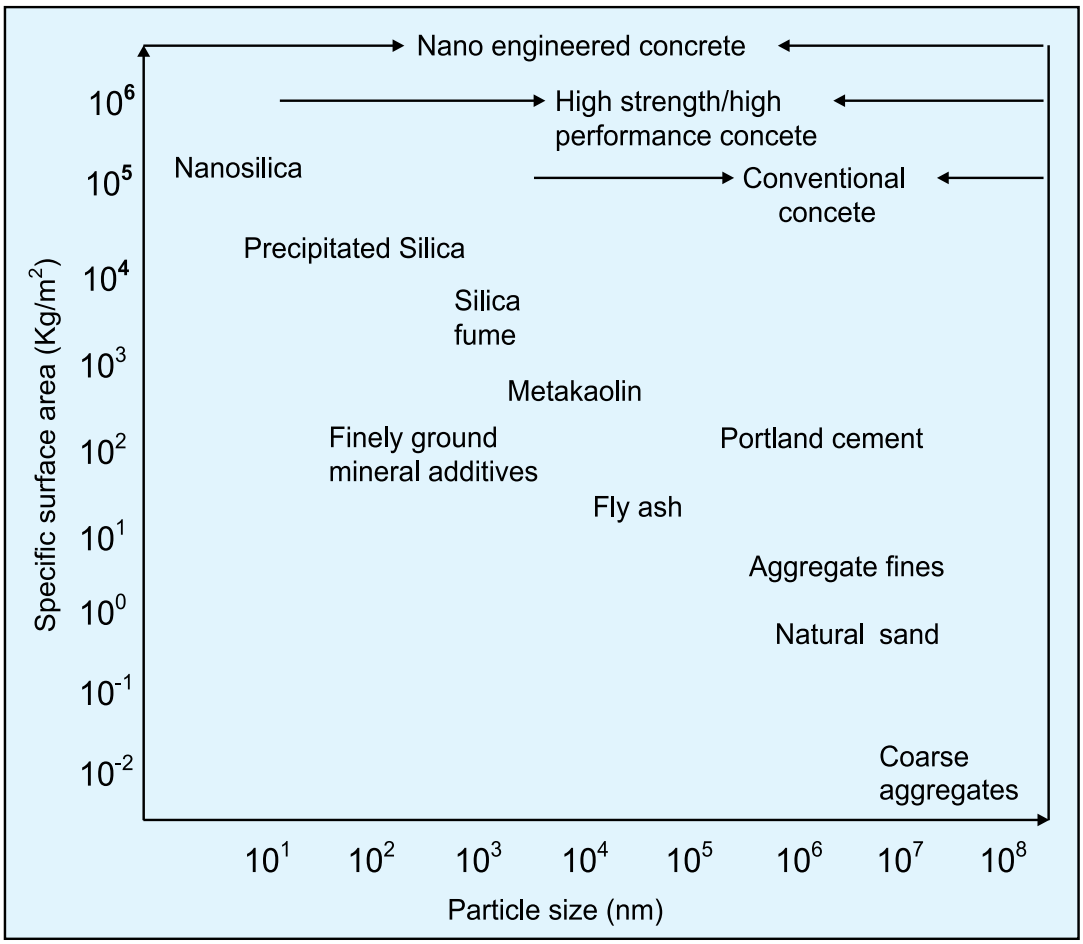

Figure 1: Nano engineered concrete impart high strength because of the presence of nanoparticles which allows better void filling, positive filler effects & improved bond between pastes aggregates. Nano-sized additives increase strength beyond what is attained with conventional materials

Thus, having the stable and compatible compositions delivering the desired characteristics of composite materials is the key. Already, several types of such materials exist for different applications. The properties of such composite materials are dependent on the particle size of the dispersed phase as also on the density of the final product. By reducing the size of the dispersed phase to increase the volume fraction of the dispersed phase, it is possible to have high strength materials even with lower density and hence exhibiting high strength/ weight ratio.

(iii) Energy Efficient Materials

Energy-efficient materials are called so because they consume energy in an efficient manner at different stages of their life cycle starting from production to their disposal. In the construction industry, the major materials being used are of the following types: a) metals and alloys b) polymers and polymeric materials c) composites d) cement e) concrete f) coatings and g) glass and h) ceramics.

Metals, alloys and polymers are known for having a fixed amount of energy involved in their manufacture, and the developments so far have already achieved the most possible levels of energy-efficiency in these cases. However, for the other materials, there exists a lot of scope to bring down the consumption of energy during their manufacture. Let us discuss some of the prominent ones here for the purpose of listing out the gap areas that needs to be filled by using unconventional but novel methodologies for the purpose. It will also help figure out the existing state-of-the-art vis-ã-vis the future requirements of applications of these materials.

(iv) Materials with special features

As stated above, for designing of materials with special features, it is essential to first short-list the design criteria in terms of properties both of the bulk and its performance. This would determine the design basis. A thorough understanding of different types of options available in terms of the base materials and the process technologies developed so far has to be in place. The prospective base materials are selected for this purpose. For the purpose of transforming the basic inputs into novel materials, the candidate process technologies would be adopted. For the construction industry, the focus for designing materials with special features for green buildings is centered around the following main objectives:

(i) Materials with a value of Young's modulus, Yield strength, Tensile strength, etc. at least matching if not higher than the conventionally used metallic materials but with densities significantly lower than the metals.

(ii) Materials having high degree of insulation so that the temperature inside the building can be maintained for long duration with minimum energy consumption.

(iii) Materials with high resistance to weathering conditions.

(iv) Coatings that can reflect the sunlight mainly of the IR region for the tropical climates. This way the buildings would have the visible region of the light entering inside the building without letting the indoors get heated up by the IR radiation.

(v) Coatings that absorb maximum solar radiation including the IR regions for applications in temperate regions.

(vi) Coatings with fluorescent effect for the indoor applications.

(vii) The materials should have a smart character in terms of changing weather conditions. For example, for temperature requirements inside the building, the materials should have the ability to change their behaviour towards sunlight falling on it.

a) Materials active in visible region

It is an established fact that materials for future are bound to be very different than the materials, which are being used today. In the area of buildings and infrastructure which is one of the most energy consuming sectors, the prime focus so far, of course, has been on designing energy-efficient buildings. The need for use of energy-efficient materials for sustainability of buildings has also been there even earlier but it has received focussed attention in recent times. The ability of certain materials to selectively absorb/ reflect/ emit/ transmit solar light can be used to develop energy-efficient coatings, windows, roofing, etc. Such materials can be used to design buildings, which can provide interiors, which are cool in summers and warm in winters. There are several approaches that can be adopted to design such materials. One of the concepts pertains to the modification of band gap of candidate materials for building construction. Modification of band gap energies of certain materials like TiO_2, WO_3, etc. from the UV range to the visible range results in the designing of materials with special features such as self-cleaning, solar selectivity, etc.

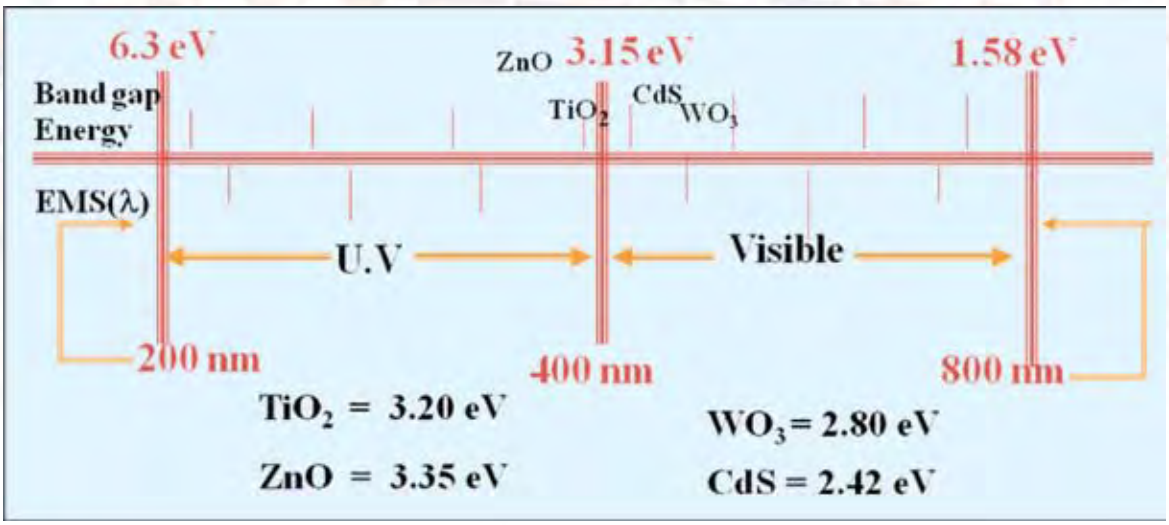

Figure 2: Alteration of band gap energy of materials active in UV region. For example, if by doping, the band gap of TiO_2 or ZnO is brought down to less than 3.15 eV, they would become active in visible region.

Looking at Figure 2, one may note that the materials with a band gap value less than 3.15 eV will be active in visible region while those with a band gap value more than 3.15 eV would be active in UV region. Materials active in visible region means that such materials can absorb solar radiations of wavelength 400-800 nm and can undergo photochemical conversion. This means that the building materials designed using materials active in visible region would be capable of capturing solar radiations during the day for a desired purpose. Most of the available materials are active in UV region, but by modification, example through doping, their band gap can be brought down to the visible region. Such developments are going to transform the whole scenario of green buildings.

Optical properties include parameters such as reflection, refraction, absorption, transmission, diffusion, etc. Light waves interact with the atoms and molecules present in a material. By varying the internal structure of materials, materials with selective absorption, reflection and transmission properties can be designed. By suitable alteration of properties such as refractive index, the behaviour of the materials towards light can be designed accordingly. Nanocomposites are suitable materials whereby the incorporation of inorganic materials in organic or polymeric matrices helps in the development of materials with varying refractive index. Such compositions would be highly useful as IR absorbing, reflective and transparent coatings for energy efficient buildings.

b) Solar selective materials

Before describing the solar selective materials, it will be worthwhile having a look at the solar spectrum from the point of view of the changes that radiations of different wavelengths bring to the materials exposed to them (Figure 3). It may be noted that the radiations of the wavelength region 780 nm to 10^6 nm can cause vibration to the molecules of any material resulting in the rise of temperature. The other wavelengths cause changes that are not very significant from the point of view of changes in materials and thus, the only purpose served of such radiations relates to the availability of light to the area.

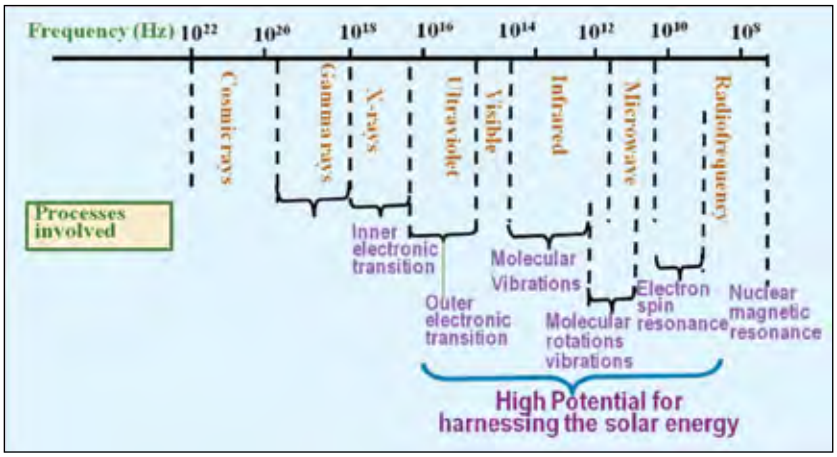

Figure 3: Figure depicting material's response towards solar selectivity. Solar sensitive materials undergo specific region transition leading to solar energy conversion. The changes at atomic and molecular level become the via media for harnessing solar energy.

Solar selective materials are those that selectively absorb/ transmit/ reflect/ emit various radiations of solar spectrum. Depending upon the purpose, the solar selective materials can be designed. Such materials are often meant for exterior applications. For windows and skylights, it is preferred that incident sunlight is reflected rather than absorbed so that it does not become a heat load for the building. Light absorption is a problem with photochromic glass, and photochromic, electrochromic, and thermochromic coatings, which all turn dark. Materials which turns from transmissive to reflective upon heating and then turns transmissive again upon cooling are a new class of materials. Such materials can be used in building apertures.

Materials, which can be activated by ambient light intensity instead of local temperature, are preferred. Materials can be so designed that they remain opaque for extended periods, and resistant to shear, creep, puncture and freezing. The transition temperature and light absorption can be varied continuously over a wide range. Polymers are used where they precipitate reversibly from solution above its transition temperature, thereby reflecting light. The polymer and solvent form separate phases, which are finely divided. One of the phases is solvent rich, while the other phase is polymer rich. In some cases, the polymer rich phase is continuous, while in some other cases the solvent rich phase is continuous. Let us look at Table-1 describing different types of materials.

Table 1: Criteria and requirements for designing materials with special features for solar selective materials

Criteria	Requirement	Design	Materials
Admit light, reject solar heat	Transmit: 400-700 nm	Dielectric/ metal/ dielectric layer	TiO_2, Bi_2O_3/ Zn, Cu, Ag, Au/TiO_2
Solar heating	Transmit/ absorb< 2500 nm Reflect > 2500 nm	Oxides, Semiconductors	Al_2O_3/ MO/ Al_2O_3
Radiative cooling	Emit > 5000 nm	Cermet coating	SiO_2, oxynitride

Most solar selective coatings used for energy-efficient buildings employ metals and dielectric materials also known as cermets, as they absorb solar energy, admit light and reject heat. Certain composites having three layers of dielectric-metal-dielectric (Figure 4) are known to transmit light of wavelength between 400-700 nm. Materials used for preparation of such composites are TiO_2, Bi_2O_3, etc.

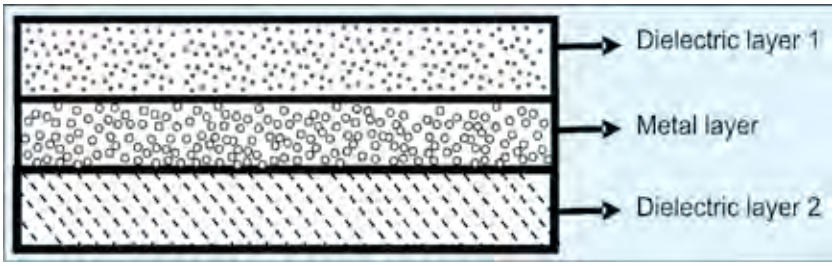

Figure 4: Structure of layered metal-dielectric composites (cermets) used as solar selective materials; based on the material used, properties such as absorption/ reflection of solar light/ solar heat can be imparted.

Similarly, for designing semiconductor materials which transmit/ absorb solar heat at wavelength< 2500 nm and reflect at wavelength > 2500 nm, composites consisting of Al_2O_3 and metal oxides have been shown as a viable option. Radiative cooling coatings made up of SiO_2 and oxynitrides can also be used for the purpose that the coating emits heat at wavelength > 5000 nm (Table 1).

C) Nano-engineered composites

To meet the growing demands, there has to be the development of novel materials. Materials developed so far could deliver to a certain extent what we all have today but for future demands, they are not going to be good enough and hence we need novel materials. Novelty lies in the fact of bringing out extraordinary materials out of the ones, which are present today. Even though there have been enough developments from high purity materials to composites, creation of nanostructured materials would pave way to solve the present day challenges. Preparation of nanocomposites by combining the unique features of inorganic materials, say metals and minerals with organic materials, say polymers, synergistic effects can be acquired. As the size of a particle decreases in the order of one millionth of a millimeter, the number of particles increases extraordinarily. As a result of this, the volume fraction of the dispersed phase increases as one goes from macro to micro to nanocomposites. The dimensions of inter-particle interactions become so huge and meaningful that the complete physico-mechanics of the

structure gets transformed when a nano-engineered composite is designed.

Nano-engineered composites, these days, have been gaining popularity. Even the concretes and design mixes are being developed using the concepts of nanosciences and nanotechnology. Such composites are termed as green because of the fact that they exhibit extraordinary properties out of the inputs with similar level of embodied energy as used for conventional building materials (Figure 5).

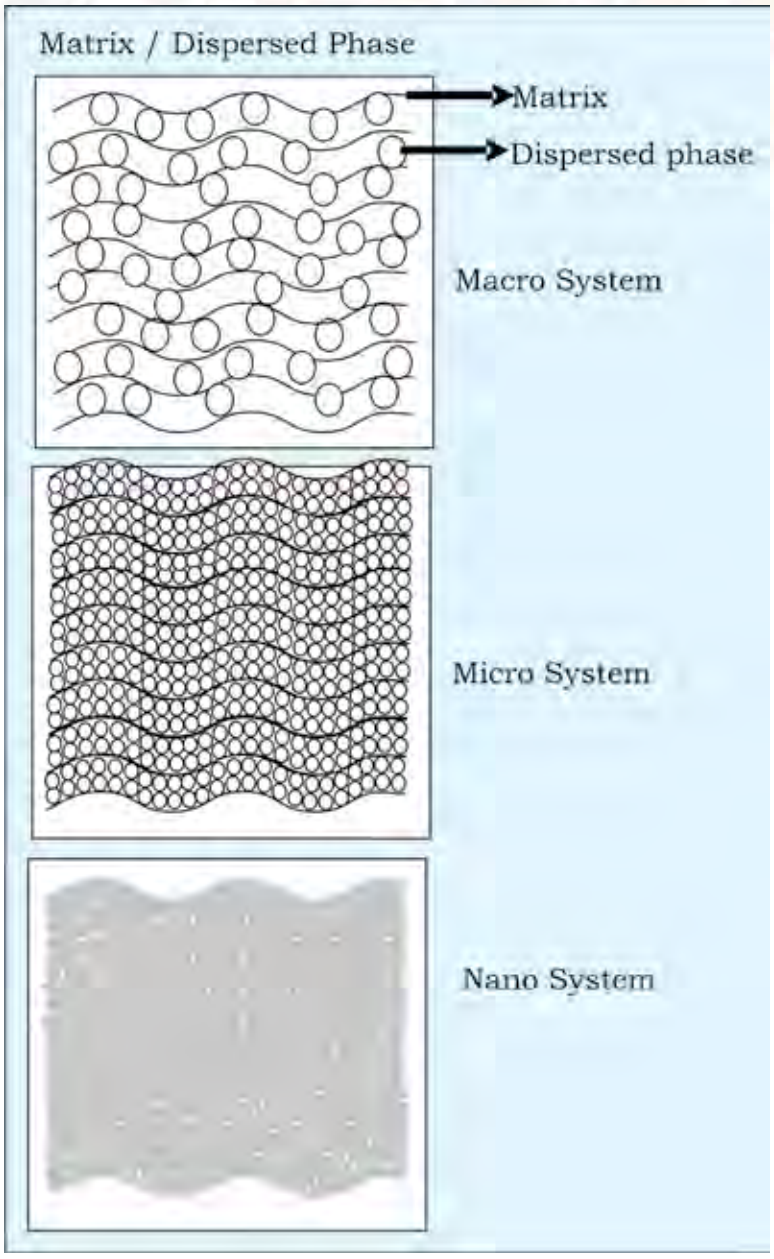

Figure 5: Depiction of structure of composites having the dispersed phase material of macro to micro to nano size. The number of particles increase extraordinarily when the size of the particles of dispersed phase is reduced while moving from macro to micro to nano scale. As a result, volume fraction ratio of dispersed phase/ matrix is the highest in the case of nano-engineered composites

When we consider two phase systems, macro phase is best described when the volume fraction of the dispersed phase is less than the volume fraction of the matrix (Figure 5). As the particle size of the dispersed phase is micronized, the number of particles increases leading to a state where the volume fraction of the dispersed phase increases and gradually leads to a homogeneous system where the volume fraction of the dispersed phase is equal to the volume fraction of the matrix. Further reduction in particle size of the dispersed phase leads to the nano system where due to reduced particle size, the volume fraction of the dispersed phase becomes more than the matrix (Table 2). It has been found that the materials at nanoscale exhibit extraordinary properties. Nanomaterials, therefore have been the target for various applications especially when the special effects like optical properties and magnetic properties are desired alongside the mechanical strength. In this direction, the development of carbon nanofibers has been a boon for the development of composite materials. Similarly, efforts are being made to develop ceramic nanofibers.

Table 2: Size effects of particles from macro to micro to nano structures
Symbols↓,~ and ↑ indicate high, medium and low respectively

	Volume fraction of dispersed phase	Volume fraction of matrix
Macro	↓	↑
Micro	~	~
Nano	↑	~

As per the requirements, the materials of varying rigidity, flexibility and resilience are

designed. Various types of foams have been developed for applications where low-density materials with adequate mechanical strength alongwith flexibility are required. At the same time, low-density materials with little flexibility and high strength are also known. In many cases, different types of materials are mixed together to achieve the desired mechanical properties. In the recent times, there have been efforts to design composite materials, which exhibit synergistic effect. The properties of the continuous phase are enhanced by the incorporation of the dispersed phase with special effects. Today, in almost all applications, composite materials of various kinds are being designed to suit the needs.

Polymeric composite materials are very desirable for use in building materials, such as roofing materials, decorative or architectural products, outdoor products, insulation panels, etc. because of their excellent mechanical properties, weathering stability and environmental friendliness. These materials can be of relatively low density, due to their foaming or high density when unfoamed, but are extremely strong, due to the reinforcing particles or fibers used throughout. The polymer content contributes to the good toughness or resistance to brittle fracture and good resistance to degradation from weathering when they are exposed to the environment. An advantage of polymer composites is that the filler materials could desirably be recycled fibers or particulates formed as waste or by-product from industrial processes. Polymeric composites allow these materials to be advantageously reused, rather than present disposal problems. A highly filled, foamed or unfoamed composite polymeric material having good mechanical properties can be obtained which results in a substantial decrease in cost, because of decreased materials cost, and because of decreased complexity of the process chemistry, leads to decreased capital investment in process equipment. Homopolymers of polyacrylates, polyolefins, polycarbonates, polyesters, polyamides, natural rubbers and synthetic rubbers are promising materials.

In order to bring down the density of the material, it is utmost essential that the light materials of organic type, for example polymers, etc. are used extensively in designing materials. The combination of various types of polymers with high density (metallic) materials could be considered to meet the requirements. Already, a series of such nanocomposite materials also termed as hybrid nanomaterials are being exploited for the purpose. Here, the challenge lies in the compatibilization of the materials of completely different nature, example given inorganic and organic.

D) Inorganic Hybrid Polymer Systems (HIPS)

Designing composite materials is not always as easy as it appears to be mainly because of the fact that one has to deal with completely different materials to bring them into one cohesive structure to deliver the desired performance from a cohesive composite material. To create compatibility amongst the materials of totally different nature becomes complex as in the case of polymeric materials. The polymer blends and polymeric composites are physical mixtures of two polymers held together by secondary physical forces, which can either be Vander Waals forces, dipole- dipole interactions or H-bonding. Polymer composites offer tremendous versatility by combining two or more materials on a nano, micro and even at macro level to obtain properties, which are not available for the individual component. As a result, composites are always in demand for a much greater variety of applications. Epoxies, polyesters, phenolics, silicones and polyimides have been the most widely developed composites for green buildings.

Inorganic Hybrid Polymer Systems (IHPS) are a class of materials, which can be used as binders, coatings, adhesives, and cements for structural applications. Exploiting IHPS for high temperature stability and flame/fire resistance widens the scope of their utilization in the area of building and construction. IHPS are formulated with the intention of exploiting the beneficial properties of both organic and inorganic polymer systems. Properties such as toughness, elasticity, Young's modulus, adhesion, water-resistance, acid resistance, surface hardness/impact resistance, thermal resistance and flame resistance can be influenced and controlled by incorporation within the polymer structure of one or more types of organic functional groups.

The inorganic polymers include Si--O--Al bonds and may be classified depending upon the three dimensional silico-aluminate structures generated. Fly ash is a good source of such aluminosilicates. These types of inorganic polymers

exhibit characteristic properties, which can be manipulated with specific end uses in mind. A number of different classes of hybrid inorganic polymers may be prepared depending upon the nature of the organic functional groups, which are incorporated within the structure of the polymer. The type and concentration of the organic functional group introduced influences the properties of the resultant hybrid polymer. This in turn enables the properties of the polymer to be tailored to a targeted functionality. Phenolic resins, polyamides such as nylon-6 and nylon-6,6, acrylates such as polymethyl methacrylate, polyimides, epoxy cresol-novolak resins (ECN), bisphenol F resin and cycloaliphatic epoxy resins are used. Polymeric compounds such as polyurethanes, styrene butadiene/nitrile rubbers and poly(vinyl chloride) may also be blended with the inorganic polymer. The polymer compounds tend to act as a matrix material between the polymer chains of the inorganic polymer. This leads to enhanced properties, such as flexibility, due to the presence of the polymeric compound at inter-chain locations. The hybrid polymer systems can be cast, extruded, molded and coated (dipping, spraying, brushing). Such novel polymeric compositions may be applied to produce fire-proof ducting and in walling applications.

Use of various types of natural fibers such as bamboo, banana, palm, coconut, etc. with different types of synthetic polymeric materials has been on the rise. Certain attributes of natural fiber help create novel composite material consisting of natural fiber reinforced plastics. Taking cue from this type of developmental studies, attempts are being made to design composites using waste materials from various industries, example given tyre industry, thermal power plants (fly ash), ceramic industry, agriculture, etc. Here again, the fiber from agri source is also being tried. One interesting example here is that of the pavement tiles made out of the crumb rubber (a waste from tyre industry) and fly ash (a waste from thermal power plants). Such composite materials would exhibit the mechanical behaviour similar to a ceramic tile but would also perform just like an elastomer. Creation of such composite materials is a challenge in itself but it is worth it considering the potential applications for such a product.

Path Forward

Green building materials are needed not only for urban housing but for all sorts of housing in times to come. The emphasis these days is given to the urban housing simply because of the reason that large scale housing activities are being undertaken mainly in the urban areas. Here, it may also be noted that even though research and development work resulting in the designing of green building materials has been done in the developed world, the requirement for such materials would be more in the developing world including countries like India.

For sustainable growth all over the world, new materials will have to be designed to ensure the following objectives:

(i) To have devices that can be used for tapping the renewable resource of energy, example given solar, winds, geothermal, etc.

(ii) To build establishments which are energy efficient

(iii) To have the structures with inherent smartness so that the per capita energy consumption can be reduced

(iv) To eliminate the Green House Gas emissions for the protection of environment and ecology in addition to the safety of consumers

To achieve the above objectives, following novel approaches will have to be adopted:

(i) Development of nanomaterials and nanocomposite materials

(ii) Materials based on the wastes from different industries

(iii) Exploitation of renewable resources and biomass

(iv) To minimize the dependence on fossil fuels

The research and development efforts would have to be directed towards achieving the sustainability of growth.

Acknowledgements

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Demonstration Construction using Cost Effective and Disaster Resistant Technologies

The Council made visible strides towards demonstration housing projects undertaken at various locations so as to showcase the effective use of cost effective building materials and disaster resistant technologies and sensitise the masons in the region.

Using alternate building materials and techniques such as rat-trap bond in bricks instead of flemish bond for walling, filler slabs against RCC cast in situ slab for roofing, RCC doors/ window frames, precast sunshades, staircases, lintel etc; BMTPC constructed 24 dwelling units at Amethi, Sultanpur, U.P. having carpet Area – 27.15 sqm. with separate kitchen, bathroom, toilet including 15% open spaces within developed land.

The housing units and the infrastructure work have been completed. The demonstration project focussed at promoting innovative technologies in the region. Documentation of the project is also being done. The cost saving compared to conventional construction is about 15%.

The handing over ceremony of demonstration houses using cost effective technologies in Amethi was organized on 8th February, 2011 by the Council. The programme was graced among other persons by Shri Rahul Gandhi, Hon'ble M.P. Amethi, Smt. Anita Singh, Hon'ble MLA and Chairperson, Nagar Panchayat. About 200 people including family members of the beneficiaries were present. Beneficiaries, identified by local Panchayat were handed over the keys by Hon'ble M.P., Amethi through draw system.

The project has been appreciated for its planning and quality of construction by general public and dignitaries. BMTPC's technical support for cost effective technologies has been sought by local MLA for assistance in future projects in the region. For the benefit of general public, an exhibition on the activities of BMTPC was also organized.

The Council is also constructing 24 demonstration houses with community centre & multi-purpose meditation room at Bitna Road, Pinjore, Distt.Panchkula,

Demonstration Housing Project at Amethi, Sultanpur, UP

Handing over ceremony of demonstration houses at Amethi on 8th February, 2011

Demonstration Housing Project at Bitna Road, Pinjore, Haryana

Haryana. The construction work of the housing units are at different stages of completion. The technology being used are rat-trap bond in bricks, RCC filler slab, precast concrete door/window frames, etc. In the Community Centre and Multi-Purpose Meditation Room, the technology being used are concrete blocks for walling, filler slab for roofing, micro concrete roofing tiles, precast concrete door/window frames etc. The work on Community Centre has also reached upto plinth level.

In order to showcase all the possible technology at one place, BMTPC has recently completed construction of the Community Centre with facilities of a Community hall, dispensary, cretch, library, green room, office etc., initiated on the request of the Haryana State Government, at Village Khojkipur-Naggal, Ambala.

In this Centre, varieties of alternate cost effective technologies like rat trap bond in bricks; interlocking type compressed earth blocks; flyash bricks; perforated bricks for walling; RCC planks and joists; prefabricated brick panels; prefab brick arch panels; RCC filler slab; doubly curved shell for roofing; MCR roofing tiles; precast concrete door/window frames; precast sunshades, lintels, staircases, etc. have been used so that local community visiting the Centre have exposure to such technologies.

Demonstration Community Centre at Village Khojkipur-Naggal, Ambala, Haryana

The project also includes plinth protection, boundary wall, rainwater harvesting and external development work. A few training programmes were organised at the site for the prospective architects and engineers of nearby colleges. Also several interactive meetings with State Engineers of Haryana were held at the site. The project is being documented for its cost effectiveness and other features.

Demonstration Community Centre at Village Khojkipur-Naggal, Ambala, Haryana

Disaster Mitigation and Management – Recent Initiatives by BMTPC

Demonstration of Retrofitting Techniques for Seismic Strengthening in MCD School Buildings

After completion of retrofitting of five MCD schools, the Council initiated retrofitting of two more MCD school buildings namely MCD school at Vivek Vihar and MCD school at Lajpat Nagar, based on the provisions of latest Indian Standard IS 13935 (Guidelines for Repair and Seismic Strengthening of Buildings). Retrofitting plan and estimates were prepared. Necessary soil testing were also done. The seismic features recommended and carried out in the retrofit solution encompasses:

1. Seismic belt at lintel level in all walls on both sides
2. Seismic belt at sill level on one face of the walls
3. Connections between seismic belts
4. Door and window encasement through jamb steel
5. Masonry pier encasement
6. Vertical single bars at wall corners and T junction
7. Vertical seismic strap
8. Strengthening of parapet

Being school building an additional door have been provided in each of the class rooms for the safety of children in the event of future earthquakes. The retrofitting work in both the schools has been completed.

Guidelines on Earthquake, Flood and Cyclone resistance of Housing

With the recurrent disaster striking Indian sub-continent, it has been realized that disaster resistant construction should be amalgamated with any conventional or innovative construction methodology or technology. Also there has been series of Indian Standards available such as earthquakes and cyclone resistant construction. BMTPC has been publishing a sort of running commentary along with detailed explanation on various Indian Standards so as to make them simple and easy to implement.

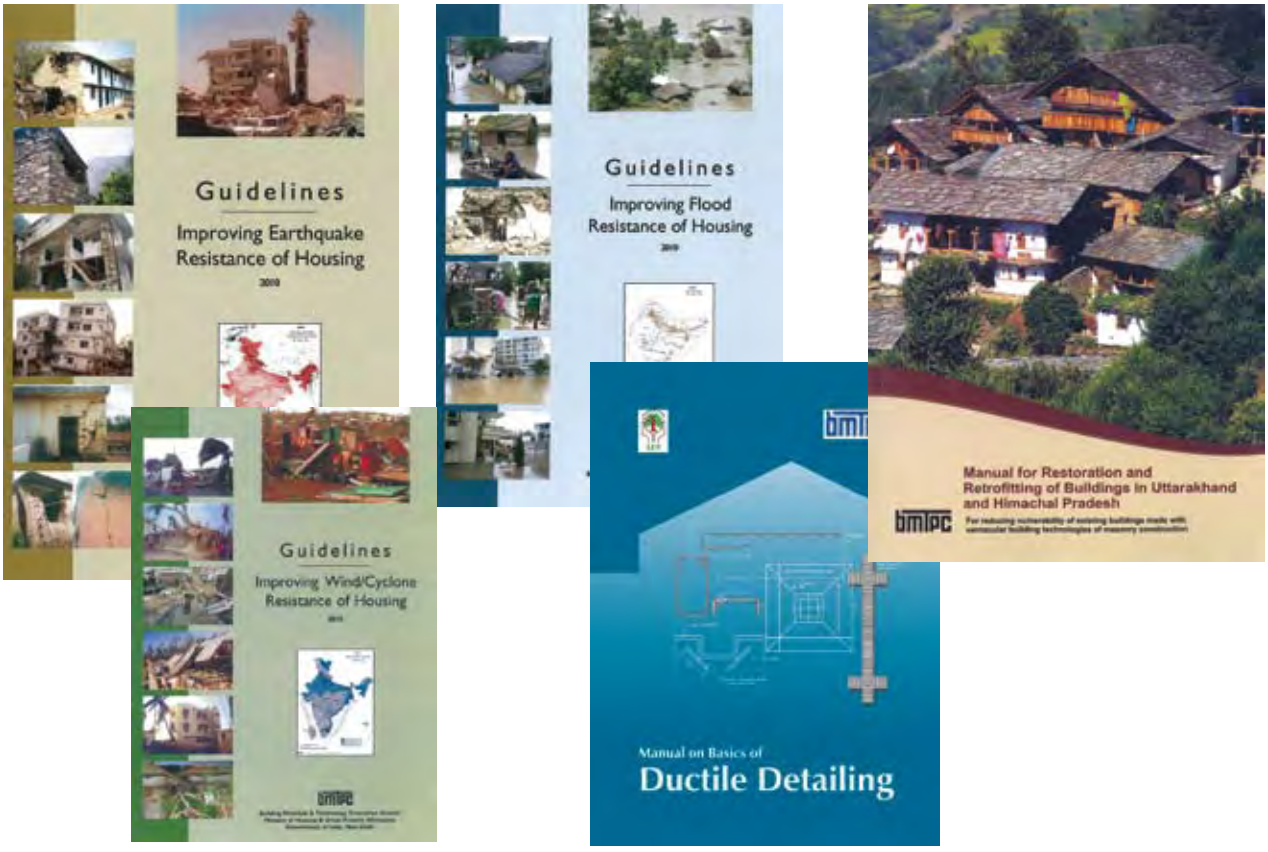
With this background, BMTPC published its first Guidelines on Earthquake and Cyclones in 2000. However, since the publication of these guidelines, there have been radical changes in relevant IS Codes and also much experience have been gained during recent past disaster failures. This necessitated the revision of the guidelines. In view of this, the Council has brought out following publications relating to disaster mitigation and management recently:

- Guidelines on Improving Earthquake Resistance of Buildings
- Guidelines on Improving Flood Resistance of Buildings
- Guidelines on Improving Wind/Cyclone Resistance of Buildings
- Training Manual for Ductile Detailing
- Manual for Restoration and Retrofitting of Buildings in Uttarakhand and Himachal Pradesh

The Council has published these guidelines after the peer review. BMTPC has the distinction of publishing first ever guidelines on flood resistant housing construction in light of disaster caused by Kosi floods.

Study and Retrofitting of Bara Hindu Rao Hospital in Delhi

A request was received from Municipal Corporation of Delhi for retrofitting of existing hospital building of Hindu Rao Hospital. In this connection, several meetings were held with MCD and Medical Superintendent of the hospital. Based on the priority of the hospital authorities, study of 250 bedded ward was taken up in association with Earthquake Engineering Department of IIT Roorkee. The necessary study including non-destructive tests have been performed in the building. The Retrofitting Plan has been prepared and is being discussed with MCD officials for further action.



Design Packages on Alternate House Building Technologies for various regions of the country

There is an imperative need to find ways by which housing can be made affordable for the various stakeholder groups. Affordable housing, within the socio-economic context, would need major interventions to reduce the cost of construction using conventional technologies and construction practices, by using appropriate and cost effective technologies. These alternate options should also lead to safe, strong, durable, functional, acceptable housing. However, due to various reasons, there is a major gap between the availability of these technology options and the accessibility of the same in the housing delivery process.

In last two to three decades, cost effective appropriate technologies have crossed the borders of laboratory and research organizations and have reached real construction sites. Many experimental and demonstrative projects have been constructed across the country proving the strength and feasibility of these technologies. Realizing the fact, Ministry of Housing and Urban Poverty Alleviation when formulated National Urban Housing and Habitat policy 2007 for realizing the goal of affordable housing for all; greater emphasis was given on the use of cost effective technology.

A number of cost effective appropriate materials and technologies have been developed, standardized and are being used in the field with success over the years. Many of them have even proved themselves in the test of time. The Bureau of Indian Standards (BIS) has included many of these technologies under their umbrella.

Housing, next to food and clothing is the most important need of a human being. Besides giving shelter from natural calamities and man-made hazards, the house reflects his socio-economic status in society. For most families, housing is perhaps a major goal of family saving effort. It must be durable, as it is an outcome of a long drawn process of saving and aspiration. It must at least respond to some extent, to the changing family needs and at times of a family emergency or need, be utilized as an economic asset in the market.

Housing is a bundle of goods and services. It is not the product of uni-sectoral efforts. Housing production includes a multitude of tasks like land acquisition, development, laying infrastructure, site planning and architectural design on pre-conceived concepts of affordable densities, to provide for shelter, social and physical infrastructure, project finance and finally construction and delivery of the same.

It is within this context that a need was felt to look at ways of optimizing shelter cost. The usual practice involved in this area till the recent past by architects has been:

1. Reduce area of the house to the minimum possible level
2. Reduce the finishing specification of flooring, external and internal walls, fittings etc.

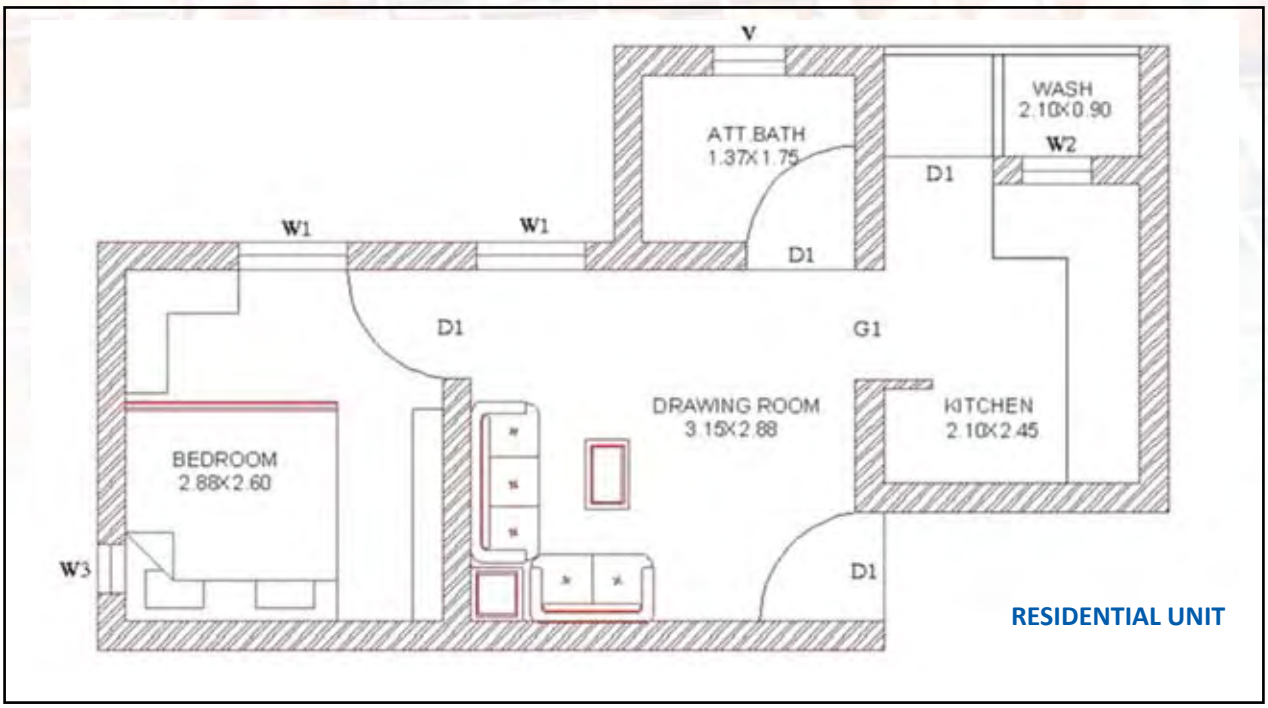
The cost of shelter can be broken up as building element costs as shown in table below. These are indicative and based on single storied structure with a particular set of specifications.

Cost break up of a shelter:

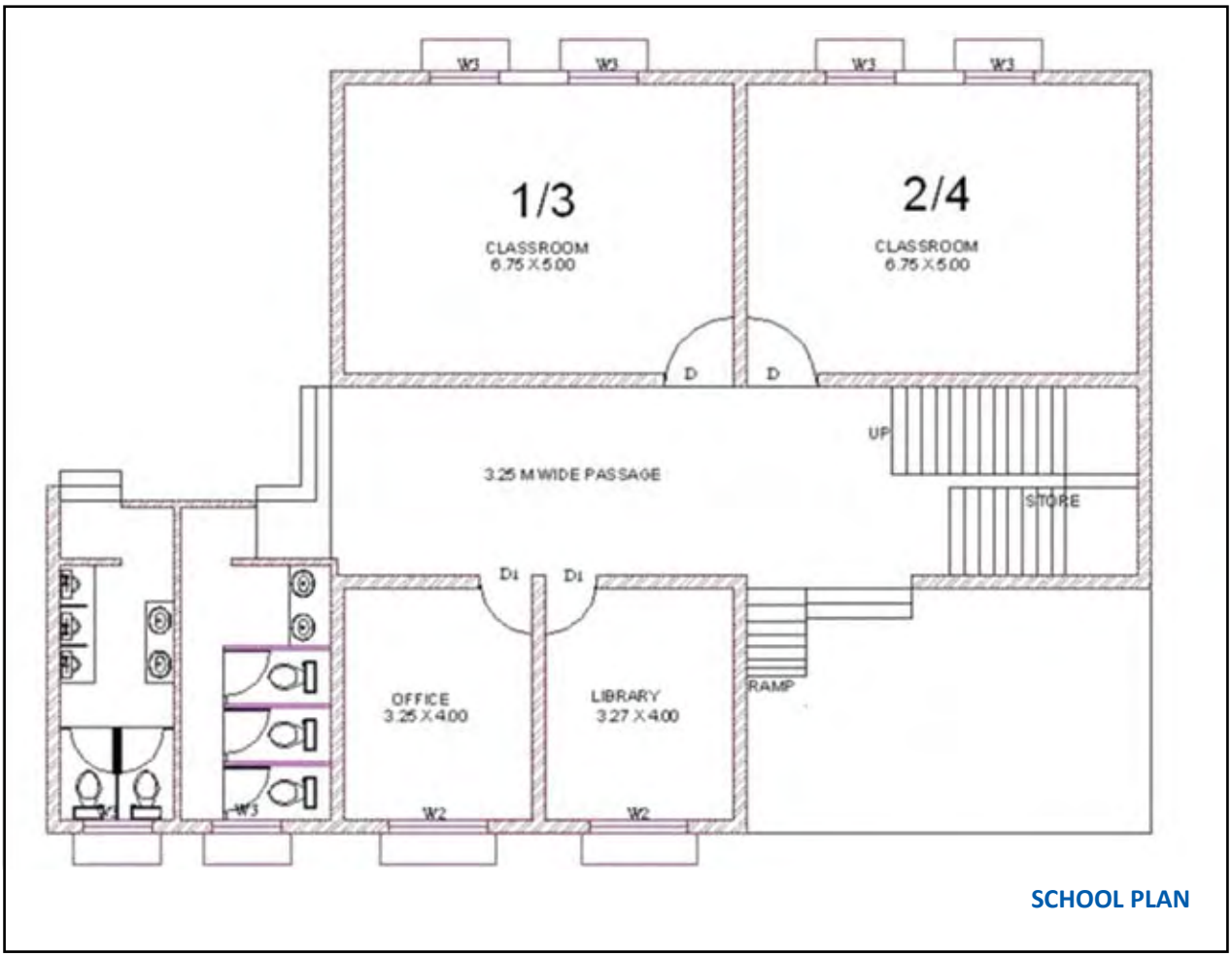
Foundation	10%
Walling	30%
Roofing	25%
Door and window	15%
Flooring	10%
Finishing	10%

It is apparent that there are several other ways of optimizing shelter cost such as:

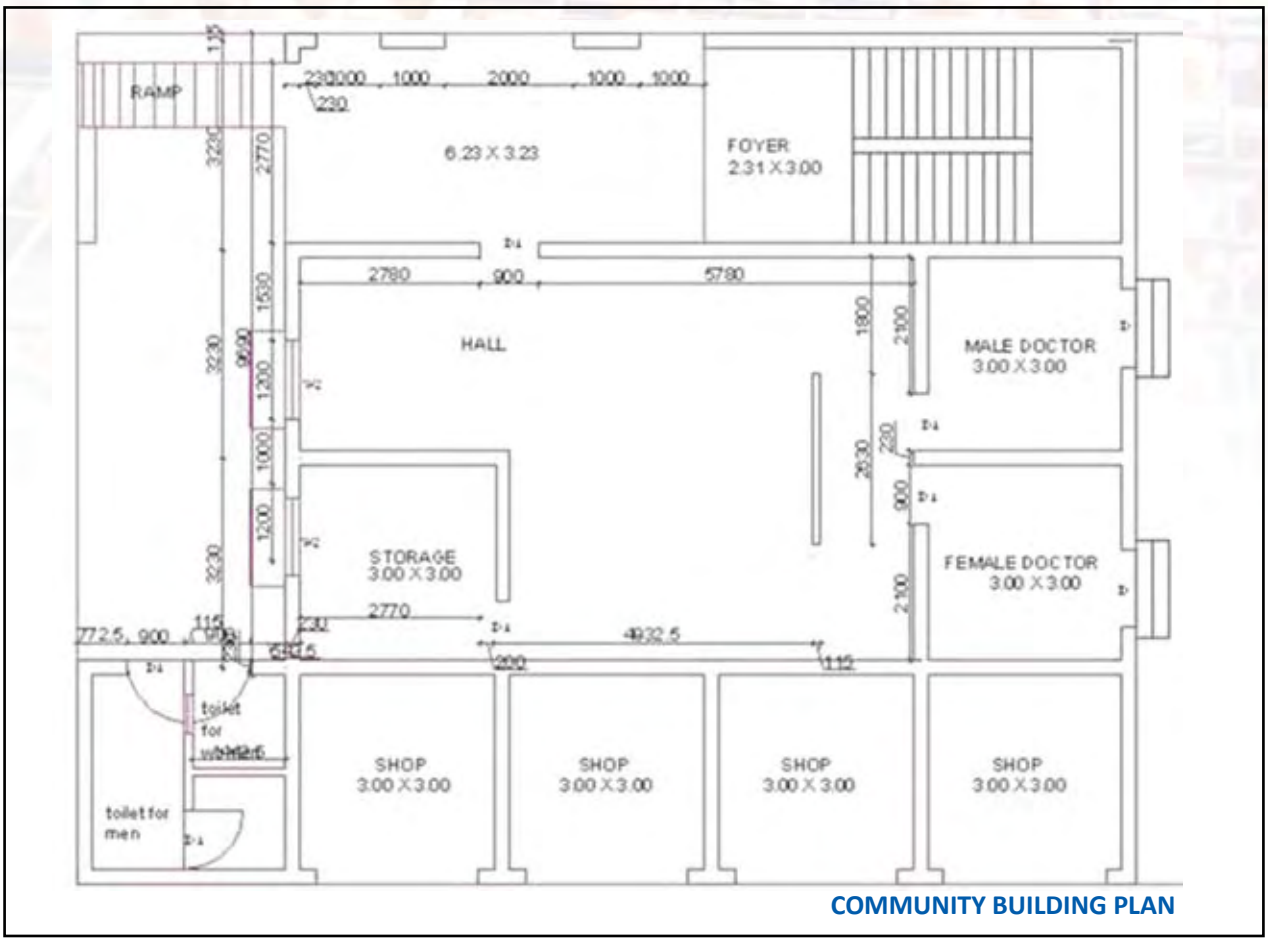
- By optimal architectural design in the form of cluster layout, cluster and unit plan, to achieve maximum sharing of walls and common areas.
- By optimal unit design with respect to optimized shape of rooms, minimizing circulation and maximizing shared walls.
- By using alternative, cost effective construction systems for building elements like foundation, wall, roof, opening, door, window, flooring and finishing.
- By adopting green technologies in terms of natural lighting, rain water harvesting etc.



RESIDENTIAL UNIT



SCHOOL PLAN



COMMUNITY BUILDING PLAN

LAYOUR PLAN WITH RESIDENTIAL, SCHOOL, COMMUNITY BUILDING AND COMON SPACES

There is lot to be done to actually transfer these time tested, proven technology into the real field. As a one more process so as to help main stream the time proven technologies, The BMTPC initiated development of Design Packages which are customized to the local needs and includes regional specific appropriate technologies. The packages which include a cluster of 60 houses about 25 sq. m each, school, community hall and commercial spaces specifically designed so as to include cost effective technology in the same. The most important aspect is that it is not been considered as a demonstration project but does include only those technologies which are local and have are proven over time. Also, the technology should compete by being financially feasibility with respect to conventional technologies.

While developing the present design package a specific care has been taken so as to choose only those Cost effective technologies which are appropriate in context and are proven over time. While developing the entire design package, apart from economy, regional context, disaster resistant features, gender context, disable friendly features, etc has also been considered. The Design Packages also attempts to compare the cost of construction with conventional technology so as to clearly reflect the advantages of using cost effective technologies. Further, the Design Packages also provide, detailed quantities, actual Rate analysis of cost effective technologies, etc. so as to impart all the basic information help in adopting the package directly.

The design packages for different geo-climatic regions prepared have broadly the following salient features:

North Zone

Load bearing structural frame with following technologies:

- Flyash bricks
- RCC Planks and Joists for roof
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

Western/Central Zone

Option – 01

Load bearing structural frame with following technologies:

- Rat trap bonds in clay bricks
- Filler slabs for roof
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

Option – 02

Structural scheme with RCC Frame having following technologies:

- Interlocking type compressed earth blocks
- RCC planks and joists
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

Option – 03

Load bearing structural frame with following technologies:

- Random rubble masonry foundation
- Cast-in-situ stone filler concrete blocks
- RCC rafters and purlins with tiles
- RCC Door & window frames

East Zone

Structural scheme with RCC Frame having following technologies:

- Rat trap bond in bricks
- Filler slab for roof
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

South Zone

Option – 01

Load bearing structural frame with following technologies:

- Rat trap bond in flyash bricks
- Precast joist and prefab brick panels
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

Option – 02

Load bearing structural frame with following technologies:

- Random rubble masonry foundation
- Stabilized mud blocks for walling
- Wooden rafters and purlins using locall available wood with mangalore pattern tiles
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

North Zone (Hilly)

Load bearing structural frame with following technologies:

- Bricks/precast PCC blocks/Stone faced blocks
- RCC planks and joists for intermediate floors
- GI Sheet for roof
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

North-Eastern Zone

Option – 01

Load bearing structural frame with following technologies:

- Bamboo posts and bamboo crete walls
- Bamboo Mat Corrugated Roofing Sheets with Ridge Cap
- Door & window frames with locally available wood.

Option – 02

Structural scheme with RCC Frame having following technologies:

- Ferrocement walling panels
- Filler slab for roofing
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls

Option – 03

Load bearing structural frame with following technologies:

- Compressed earth blocks
- Filler slab for roofing in slope
- RCC door & window frames
- Precast lintels, sunshades and staircases
- Plastering on internal and external walls
- RCC plinth bands, lintel bands, roof bands and gable bands for earthquake resistance.

Regional Sensitization Programmes on Confidence Building in Appropriate Housing Technologies

The Council has initiated the Pilot Project on "Confidence Building in Alternate Housing Technologies through Demonstration Construction & Training". The Pilot Project on Confidence Building in Alternate Housing Technologies aims to facilitate wide spread dissemination and adoption of both existing proven and emerging cost-effective and sustainable building materials and construction technologies as an alternate to the conventional, in a manner and by a strategy that will promote knowledge, confidence and create enabling environment for the large scale adoption of such materials & technologies in different geo-climatic parts of the country, thus making housing cost-effective, accessible and sustainable. The implementation of the Pilot Project will be through demonstration construction based on the Design Package developed by BMTPC using cost effective, eco-friendly construction technologies for a cluster of 60 houses with carpet area of 25 sqm. each, community centre (built-up area 300 sqm.), primary school (built-up area 250 sqm.), shops/kiosks ((built-up area 100 sqm.) including on-site infrastructure development for the various regions of the country having different geo-climatic condition and topography.

In order to spread awareness about the alternate housing technologies and study the mindsets of the stakeholders in various States, the Regional Sensitization Programmes were organised at following places. These programmes were attended by the State officials from various States. The participants shown keen interest in the alternate housing technologies.

Sr. No.	Zones	Dates	Venue	States covered
1	West/ Central Zone	23 July, 2011	Ahmedabad	Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Daman & Diu and Dadra & Nagar Haveli
2	North Eastern Zone	5 August, 2011	Guwahati	Assam, Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh, Mizoram and Sikkim
3	East Zone	16 August, 2011	Kolkata	West Bengal, Bihar, Orissa and Jharkhand

The Council at present is preparing design package for Haryana Housing Development Board and Porbandar Municipal Coproration . There have been indications from Maharashtra, Tripura and Mizoram to take these design packages forward.

Performance Appraisal Certification Scheme (PACS)

Performance Appraisal Certification Scheme (PACS), being operated by BMTPC, is a third party voluntary scheme for providing Performance Appraisal Certificate (PAC) to manufacturers or installers of building materials, products, components, elements and systems etc. on which, there is no Indian Standards after due process of assessment.

Brief description of the products/ system on which PACS have been issued recently are given below:

1. Glass Fibre Reinforced Gypsum Panel System

Brief Description: Glass Fibre Reinforced Gypsum (GFRG) Panel branded as Rapid wall is a building panel product, made of calcined gypsum plaster reinforced with glass fibres, for Mass-scale building construction, was originally developed and used since 1990 in Australia.

The panel, manufactured to a thickness of 124mm under carefully controlled conditions to a length of 12m and height of 3m, contains cavities that may be unfilled, partially filled or fully filled with reinforced concrete as per structural requirement. Experimental studies and research in Australia, China and India have shown that GFRG panels suitably filled with plain reinforced concrete possesses substantial strength to act not only as load bearing elements but also as shear wall capable of resisting lateral loads due to earthquake and wind. GFRG panel can also be used advantageously as in-fills (non-load bearing) in combination with RCC columns and beams (conventional framed construction of multi-storey building) without any restriction on number of stories. Micro-beam and RCC screed (acting on T-beam) can be used as floor / roof slab.

Grade and Type: GFRF panel may be supplied in any of the following three grades:

1) **Class 1:** Water Resistant grade - panels that my be used for external walls, in wet areas and / or as floor and wall formwork for concrete filling;

2) **Class 2:** General grade - panels that may be used structurally or non-structurally in dry areas. These panels are generally unsuitable for use as wall or floor formwork; and

3) **Class 3:** Partition grade - panels that may only be used as non-structural internal partition walls in dry areas only.

2. Marble Slurry Based Binder

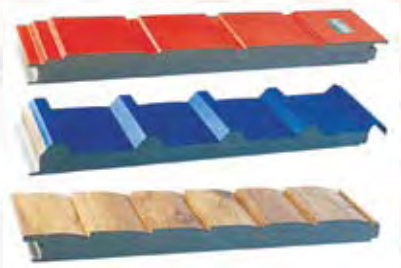
Brief Description: Marble Slurry Binder is a mixer of waster marble slurry, hydrated lime and fly ash. Waste marble slurry is obtained after cutting of marbles and is available in fluid form in dumping yards. It constitutes of various

chemicals in varied quantities. The marble slurry in the fluid form is left for drying. After drying, it is broken in to small pieces in the power form. The powder plastic in nature has got water retaining properties & is capable to retain it for considerable period of time.

Scope of Assessment: Suitability of Marble Slurry Binder for use as mortar in place of cement mortar for masonry and plaster in rural and low cost housing for non-load bearing walls.

3. Continuous Sandwich Panel

Brief Description: Continuous sandwich panels are of lightweight modular design for easy & quick assembly. These insulated walls along with proper air conditioning and proper thermal management system are able to bring about direct savings on opex. Sandwich composite panels have emerged as viable alternatives to the traditional construction materials



in the building primarily due to their strength & stiffness, low thermal conductivity & adequate durability. The major advantages of such layered construction are their structural rigidity in relation to its weight, quick & easy installation and low labour cost. Sandwich panels are generally layered construction composed of thin facing bonded to a core. This facing carry most of the applied load and provides the panel with its stiffness & strength characteristics. The core acts to separate the facing & transmit shear forces between them.

Scope of Assessment: Suitability of Continuous sandwich panels for construction of Cold storages, Official complexes, Schools, Laboratories & Industries sheds etc. and for construction sites where the access is difficult.

4. Marshal Door

Brief Description: Marshal Doors are made out of GI Pre-coated sheet with an average wall thickness of 0.25mm on both sides. M.S. 'C" block having dimensions of 20x10mm is inserted along the hinge side of the door at three places at equal distance. Core of the door shutter is filled with high density Polyurethane Foam (PUF) injected with the help of hydraulic injection method. All four sides of the door are covered with same GI Pre-coasted sheet. The polyester pre-coating on the GI sheets is provided for protection from corrosion. The hardware locations are reinforced with suitable wooden blocks for taking up necessary hardware. Stickers indicating the locations for fixing of hardware & accessories are pasted on the door at appropriate places. Marshal Doors are made out of Continuous Sandwich Panels only.

Scope of Assessment: Suitability of these doors for built environment structures like offices, telecom shelter, schools etc. made of Continuous Sandwich Panels.

Shades: Off white and other customizes colours as per requirement.

Sizes: These doors are available in sizes of 1.98mx0.76m (6'6"x2'6"), 1.98m x 0.84m (6'6" x 2'9") & 2.13m x 0.91m (7' x 3') & other customize sizes as per requirement of the customers and thickness of 25mm/30mm.

5. uPVC Window

Brief Description: uPVC Window are made out from different types of uPVC extruded hollow multi chamber profile sections. These are designed to provide the fabricator with total manufacturing flexibility for complete choice of window style & sizes. The window system consists of three basic profiles i.e. Outer frame, Shutter frame & Beading profiles. Corners are heat welded in the conventional manner.

Scope of Assessment: Suitability of uPVC Windows for internal & external applications in residential, commercial, schools, hospitals and factory buildings etc.

Types: These windows may be of following types:

i) Suprima Series Openable Single Glazing Windows
ii) Suprima Series Sliding Single Glazing Windows
iii) Suprima Series Openable double Glazing Windows
iv) Suprima Series Sliding double Glazing Windows
v) Ultima Series Openable Windows
vi) Ultima Series Sliding Windows
vii) Energy saving Windows with Elastomeric Gaskets

Sizes: These windows are available in sizes of 0.91mx1.82m (3.0ft to 6.0 ft) x 0.61m x 1.82/2.31m (2.0ft to 6.0/7.0ft)

6. FRP Manhole

Brief Description: FRP Manholes are made of Polyester resin, Fiber glass and fillers. These are ideal for use in underground sewer, storm water and water tpile lines. These manholes are factory made. They do not corrode, have no joints,

hence leak proof and prevents ingress in the manholes. These are easy & fast to erect.

Scope of Assessment: Suitability of FRP Manholes for underground applications only.

Sizes: FRP Manholes are available in sizes of 1.22mm (4ft), 1.52m (5ft), 1.8m (6ft) & 2.44m (8ft) in diameter and 0.91m (3ft) to 12.80m (42ft) in height.

7. Polyethylene Underground Septic Tank

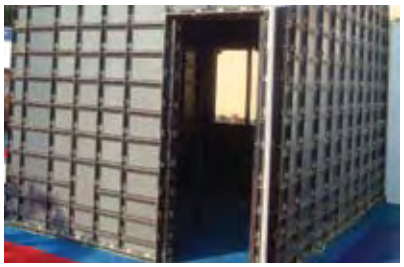
Brief Description: Disposal of waste which is anaerobic type of waste water treatment designed for treating waste water from toilet bowl, sink, kitchen and other waste water outlets in a house. Septic tank is an onsite system designed for disposal of biological sanitary waste etc, influent from all domestic activities enters the septic chamber where natural

bacterial action decomposes human waste into acceptable level of discharge. It involves decomposition of organic substances present in waste water in the absence of molecular oxygen. Under such conditions, the facultative bacteria comment the complex organic matter into short chain low molecular weight volatile acid along with other products.

Scope of Assessment: Suitability of Polyethylene septic tanks as an alternate solution to the concrete or brick water storage tanks. These underground septic tanks are suitable for houses, schools, hospitals etc.

8. Formwork for Monolithic Construction

Brief Description: Hardware used in the Formwork for Monolithic Concrete Construction consists of various Aluminium and PVC sections of consistent dimensions. Majority of the equipment consists



of panel sections while the rest includes vertical & horizontal corner sections, bulkheads & special floor, slab & beams that can be dismantled without disturbing the props supporting the slab & beams.

This system is externally adaptable to any building design. Based on the architectural & structural design of the buildings, a process of computer modulation is carried out. It involves iteration and optimization techniques which select the most economical components. Major differences of Monolithic formwork over conventional formwork system are its (i) modular size, (ii) faster erection, (iii) smooth finish, (iv) light weight and (v) lesser work force

Scope of Assessment: Suitability of Formwork for Monolithic Concrete Construction for construction of Mass housing wherein large number of units of similar configuration are needed.

Since the scheme is operated for the product/system where no relevant Indian Standard is available, it is required to first work out the desired specifications for Performance Appraisal. For the items under considerations, International practices have been modified based on international practices. One such item is Underground Septic Tank, where specification & performance criteria have been modified based on Australian/New Zealand Standard.

One of the constraints faced for evaluation is lack of proper testing facilities in Accredited independent laboratories. For this, facilities available with the firms are being utilized. Third party agencies having adequate exposure & experience are also being involved for in-house testing wherever laboratory testing is not possible.

Other PACS issued earlier covers:

- Endura Doors
- Fomura Doors
- PVC Profile Doors
- PVS Flush Doors
- Frontura Doors
- Plastocrete Panels
- Insulated Roof Panels
- Underground Tank (Sump)
- Gypcrete wall panel
- Block making machine
- Pan mixture
- Recron fibre
- Plastocrete/Insulated panel
- Underground storage tank

These PACS with independent evaluation of the performance parameters would be useful in further standardization at National level. It is expected that these PACS will provide confidence to construction industry in making decisions regarding the use of new materials/system.

JNNURM : Activities undertaken by BMTPC

Jawaharlal Nehru National Urban Renewal Mission (JNNURM), a flagship program of Govt. of India was launched on December 03, 2005 and is being primarily implemented in 65 mission cities of the country. Under it's two Sub components namely Urban Infrastructure & Governance (UIG) and Basic Services to Urban poor (BSUP), it mainly focuses on improving quality of infrastructure in urban areas while making provision for basic services to urban slum dwellers in terms of affordable housing and basic infrastructure . It need not be emphasized that improvement in quality of infrastructure while taking into environmental considerations results in better and safer cities and also contributes to it's sustainable development. The mission is now at advanced stage of implementation. As on mid September, 2010, under the BSUP Sub component, 1501 projects including 15, 62, 211 dwelling units have been sanctioned. Out of this, 4,78,843 dwelling units stand completed as on date while dwelling units in progress are 3,66,895. BMTPC has been involved in the implementation of BSUP Sub-component of JNNURM in various ways which are detailed below:

Appraisal of Detailed Project Reports (DPRs)

Under BSUP, total 144 Detailed Project Reports (DPRs) from 22 numbers of States/UTs with total project cost of 8102.75 crores have been appraised by the Council and sanctioned by Central Sanctioning & Monitoring Committee (CSMC) of M/o Housing & Urban Poverty Alleviation (HUPA), GoI. Further, 50 DPRs under Integrated

Housing and Slum Development Programme (IHSDP- part of BSUP Sub component to be implemented in small & medium towns) have been appraised with a total cost of 612.73 crores and sanctioned by the central sanctioning committee of M/o HUPA, GoI. Under appraisal, the scope of activities includes; adherence of proposal to 7 point charter (security of tenure at affordable prices, improved housing, water supply, sanitation and ensuring delivery through convergence of other already existing universal services of the Government for education, health and social security), Project implementation, quality assurance, sustainability details etc.

Monitoring of BSUP and IHSDP Projects

Monitoring on sample visit basis:

The Council has also been designated as one of the monitoring agencies for monitoring of BSUP and IHSDP projects being implemented all over the country by Mission Directorate of the Ministry. In addition to BMTPC's technical representative, the monitoring team comprises of expert from reputed Technical Institution/ R&D Organizations, representative from HUDCO, Official from JNNURM Directorate of Ministry as per the availability. The monitorable parameters include the various project aspects as Physical progress, financial progress, quality control, deviations w.r.t. sanctioned parameters, cost overrun, time overrun, etc. Subsequent to visits, the monitoring reports are submitted to Mission Directorate. About 160 projects from 35 mission cities (BSUP) and 130 projects from 112 towns (IHSDP) have been inspected by the Council so far.

Review of TPIMA reports

As an important tier of the Quality Control Structure, Third Party Inspection and Monitoring (TPIM) agencies have been appointed by various States in line with requirement of GoI. The TPIM agencies scope of work encompasses evaluation of projects in various stages as Pre-construction stage, Construction stage, Project completion stage & Post construction Stage. After visiting the projects, TPIMA submits report to the States & Mission Directorate. The Mission Directorate has entrusted the council to review these reports. So far 364 TPIM reports have been reviewed & observations have been submitted to JNNURM Directorate.

Capacity Building Programme

In order to build capacities with States, the council has conducted a number of programmes/workshops focusing on interaction with the officials of State Govt./ ULBs/ Implementing agencies on issues related to preparation of DPRs, project implementation issues, monitoring of projects. The related toolkits are circulated among participants during the workshop. During the last one year, seven programmes on Quality assurance and Third Party Inspection & Monitoring were conducted in Agra, Hyderabad, Chennai, Bhopal, Thiruvananthpuram, Delhi & Faridabad for TPIM & Project implementing agencies.

Further, BMTPC in consultation with reputed scientific/ technical institutions has also prepared a Quality Control Guideline which includes well defined procedures for achieving, desired quality of Projects (primarily housing) complying with the requirements of projects specification and design as per contract document.

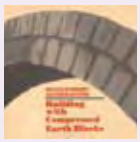
Priced Publications of BMTPC

DIRECTORY OF INDIAN BUILDING MATERIALS & PRODUCTS (with information on Nepal, Bhutan & Pakistan) 2009
550 pages, Rs. 1000 + 200 postage

BUILDING MATERIALS IN INDIA : 50 YEARS - 560 pages, Rs.1500 + 200 postage

HOUSING AND KEY BUILDING MATERIALS IN INDIA - A LONG TERM PERSPECTIVE - 98 pages, Rs. 700 + 75 postage

INSTRUCTION MANUAL FOR APPROPRIATE BUILDING SYSTEMS
64 pages, Rs. 150 + 75 postage



BUILDING WITH COMPRESSED EARTH BLOCKS
28 pages, Rs. 60 + 30 postage

STANDARDS AND SPECIFICATIONS FOR COST EFFECTIVE INNOVATIVE BUILDING MATERIALS AND TECHNIQUES INCLUDING RATE ANALYSIS (SECOND EDITION)
200 pages, Rs. 250 + 75 postage

DIRECTORY OF CONSTRUCTION EQUIPMENT AND MACHINERY MANUFACTURED IN INDIA - 684 pages, Rs. 1500 + 200 postage

USER'S MANUAL on Production of Cost-Effective, Environment-Friendly and Energy-Efficient Building Components - 116 Pages, Rs. 250 + 50 postage

MANUAL ON BASICS OF DUCTILE DETAILING -
27 pages, Rs. 100+50 postage

VULNERABILITY ATLAS OF INDIA (First Revision – 2006) - Earthquake, Windstorm and Flood Hazard Maps and Damage Risk to Housing - 900 pages, Rs. 5000 + 200 postage

LANDSLIDE HAZARD ZONATION ATLAS OF INDIA - Landslide Hazard Maps and Cases Studies - 125 pages, Rs.2500 + 200 postage

BUILDING A HAZARD- RESISTANT HOUSE:
A COMMON MAN'S GUIDE-
88pages, Rs. 350+75 postage

MANUAL FOR RESTORATION AND RETROFITTING OF BUILDINGS IN UTTRAKHAND AND HIMACHAL PRADESH -
134 pages, Rs.250+ 75 postage

GUIDELINES FOR IMPROVING EARTHQUAKE RESISTANCE OF HOUSING -
84 pages, Rs. 350 + 75 postage

GUIDELINES FOR IMPROVING FLOOD RESISTANCE OF HOUSING -
36 pages, Rs. 200 + 50 postage

GUIDELINES FOR IMPROVING WIND/CYCLONE RESISTANCE OF HOUSING - 50 pages, Rs. 350 + 75 postage

EARTHQUAKE TIPS – LEARNING EARTHQUAKE DESIGN & CONSTRUCTION
58 pages, Rs.200 + 50 postage

Publications/Video Films may be obtained by sending Demand Draft, drawn in favour of BMTPC payable at New Delhi

Promotional Publications of BMTPC

1. Corporate Brochure - in English and Hindi
2. BMTPC Newsletters
3. Environment Friendly Building Materials & Construction Technologies
5. Grah Nirman Mein Vishesh Savdhaniyan
6. Reconstruction of Earthquake Resistant Houses in Garhwal Region - Guidelines in Hindi
7. Retrofitting of Stone Houses in Marathwada Area of Maharashtra
8. Saste Makan: Vibhinn Vikalp Avam Suvidhain - in Hindi
9. Useful tips for House Builders
10. Local Vegetable Fibres + Industrial & Mineral Waste for Composite materials
11. Machines developed by BMTPC
12. An Introduction to the Vulnerability Atlas of India
13. Performance Appraisal Certification Scheme
14. Catalogue for Machines
15. Green Houses for ITBP at Leh
16. Bamboo - A Material for cost-effective and disaster resistant housing
17. Retrofitting of Hospital in Kupwara, Kashmir, J&K for Safety Against Earthquakes
18. Simple Ways to Earthquake Safety for Jammu & Kashmir - in English and Urdu
19. Bamboo in Housing & Building Construction - Initiatives of BMTPC
20. Disaster Prevention & Mitigation - Major Initiatives by BMTPC.
21. Aam Aadmi Series - House Building Digest (Series 1 to 12)
22. Brochure on Dissemination of Information, Demonstration Construction using Cost Effective and Disaster Resistant Technologies".

Films Produced by BMTPC

1. **MAKAN HO TO AISA** *15 min.*
Film on improving buildings in earthquake prone areas of Garhwal. This is an instructional documentary film in Hindi for imparting training in repair and reconstruction of damaged houses using local materials and earthquake proof structures.

2. **ABHIVARDHAN** *30 min.*
Film on nature of damages and what needs to be done for making houses disaster resistant in the Uttarkashi region. The film focuses directly on the needs of households and artisans to reconstruct their houses using traditional techniques with a catalytic input of modern materials and design techniques

3. **A BETTER WAY TO BUILD** *25 min.*
This film focuses on technology delivery system for cost-effective housing. It highlights the activities of Building Centres as technology transfer agents for improving housing delivery system at grass-root level. Building Centres are being set up in different parts of the country under a Central Scheme of the Ministry of Urban Affairs and Employment. Nearly 250 Centres have already been set up in different states and these are making useful contribution to promoting cost-effective innovative building materials and construction technology for house construction.

4. **AASHRAY** *28 min.*
Film depicts the application of low cost building materials and technologies. It also gives guidance to common man to procure financial support and a house.

5. **LESSONS FROM LATUR** *20 min.*
Film is a rapid survey of causes, nature and extent of damage due to the earthquake in Latur and Osmanabad districts of Maharashtra and Gulbarga district of Karnataka in September 1993. The film is available in Hindi, English and Marathi. The direct relationship between housing structure and materials used in affected areas and the enormity of the impact of the disaster have been reflected through illustration and interviews with affected people. Rescue, immediate relief and temporary rehabilitation have also been shown in the film. The film also discusses measures for constructing earthquake resistant buildings. Alternate layout plans for reconstruction of villages, retrofitting of existing structures which are disaster prone, different technological options and social tensions arising out of the process of resettlement/relocation, etc., are covered.

6. **HOMEWARD BOUND** *16 min.*
This film was produced on World Habitat Day, October, 1993 on the UNCHS (United Nations Commission on Human Settlements) theme Women and Shelter Developments. The film covers significant contributions and achievements made by India by encouraging participation of women in shelter process in different parts of the country.

7. **FLYASH UTILISATION** *20 min.*
Nearly 40 to 45 million tonnes of flyash is being generated annually as waste by 70 thermal power stations in the country. Apart from covering large areas of useable land it leads to environmental problems by contributing to air-borne and sub-soil water pollution. The film shows various methods of utilising flyash to manufacture building materials. This can convert waste to wealth as country is facing severe shortages of building materials, especially for housing. The film covers various ongoing activities of flyash utilisation through small, medium and large scale production of flyash-based building materials in different states.

8. **SEISMIC RETROFITTING** *20 min.*
This film, in four parts, is a series of training films on the techniques of strengthening of houses in the earthquake affected regions of Marathwada in Maharashtra. This film was produced under guidance and direction of Dr AS Arya, Professor Emeritus (Earthquake Engg.),University of Roorkee.

Part 1 Installation of headers
Part 2 Reduction of weight on the roof
Part 3 Installation of knee braces
Part 4 Installation of seismic bands

9. **A STITCH IN TIME** *15 min.*
This film is a capsule on the techniques of strengthening partially damaged houses in the earthquake affected Marathwada district of Maharashtra, India. The programme is an illustrated lecture by Dr AS Arya (Professor Emeritus, Earthquake Engineering and UGC Emeritus Fellow, University of Roorkee)

10. **PHOSPHOGYPSUM-BASED BUILDING MATERIALS** *14 min.*
Phosphogypsum is generated as a by-product of the phosphoric acid based fertiliser industry. The interaction of ground phosphate rock with sulphuric acid produces 10- to 40 per cent free moisture along with phosphogypsum. Nearly 4.5 million tonnes is generated per year. Over 10 million tonnes has accumulated at plant sites. The fluoride contents of phosphogypsum causes land and water pollution. This film shows the various methods of utilisation of phosphogypsum in production of building materials for ceiling, partition walling, etc.

11. **BUILDING THE FUTURE BLOCK BY BLOCK** *28 min.*
Film on the activities of various Building Centres located in southern India and the ways they are helping in promoting cost-effective technologies.

12. **BUILDING CENTERS: DELIVERING TECHNOLOGIES TO THE MASSES** *15 min.*
A brief film on the Rajasthan Building Centre, and the manner in which they are helping to develop and promote innovative building materials and cost effective technologies ehich have been adopted by the Centre in their construction.

13. **IN SEARCH OF HOME** *28 min.*
A film on the theme of 'Home and the Family' on the occasion of World Habitat Day, 1994. It shows the poor civic amenities in substandard shelters and outlines the possibilities for improvement by using alternate cost-effective and eco-friendly building materials and technologies to convert a shelter into a home.

14. **SHANKER BALRAM SEPTIC TANK** *21 min.*
This film in Hindi describes the method of constructing the maintenance free Shanker Balram Septic Tank for low cost sanitation. It also explains the advantages of this tank over the conventional septic tanks available in India. This was based on a rapid survey carried out by WordSmithy on behalf of BMTPC.

15. **A SUCCESS STORY OF PLASTICS WASTE MANAGEMENT** *25 min.*
Plastics are being used in every walk of life and in the end results in wastes. This films shows various aspects of plastics waste management and the ways to recycle it.

16. **ROOF FOR THE ROOFLESS** *18 min.*
A film on Gram-awas 95 held during the India International Trade Fair 1995. The film shows shortage of housing in the country, various housing schemes launched by the Government of India and the cost-effective innovative building material and technologies for the rural poor.

17. **TARA CRETE — A ROOF FOR MILLIONS** *18 min*
The film details the introduction, the manufacturing technology of Micro Concrete Roofing Tiles (MCR), the benefits of Tara Crete Roof, how to build with it and how much it would cost.

18. **HOUSING AND INFRASTRUCTURE** *18 min.*
The films shows the various aspects of housing and cost-effective innovative building materials and technologies developed in India.

19. **BUILD A SAFER TOMORROW** *12 min.*
The film covers the natural disaster prepardness and mitigation strategies covered in the Vulnerability Atlas of India prepared by the Council.

20. **BUILD A SAFER TOMORROW ON CD ROM** *12 min.*

21. **REKINDLING HOPE** *12 min.*
The film shows the activities of BMTPC in the rehabilitation after Gujarat earthquake.

22. **MICRO ENTERPRISES THROUGH BUILDING COMPONENTS PRODUCTION** *15 min.*
The film covers the activitiesof demonstration cum production units set up by the Council at various locations for generating employment and micro enterprises.

23. **BMTPC - PROTECTING HOME AND LIVES** *15 min.*
A film on multifarious activities of BMTPC.

24. **ASHA AUR ASHRAY** *11 min.*
The film covers BMTPC's efforts in dissemination of information through construction of demonstration houses under VAMBAY.

RS. 1000 EACH FILM + PACKING AND POSTAGE CHARGES RS. 100. TO PURCHASE ANY OF THESE FILMS, PLEASE WRITE TO BMTPC.

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The Building Materials & Technology Promotion Council (BMTPC) was setup in 1990 as an inter-ministerial organisation under the Ministry of Housing & Urban Poverty Alleviation to bridge the gap between laboratory research and field level application.

Vision

"BMTPC to be world class knowledge and demonstration hub for providing solutions to all with special focus on common man in the area of sustainable building materials, appropriate construction technologies & systems including disaster resistant construction."

Mission

"To work towards a comprehensive and integrated approach for promotion and transfer of potential, cost-effective, environment-friendly, disaster resistant building materials and technologies including locally available materials from lab to land for sustainable development of housing."

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