Low Cost, Energy Efficient & Environment-Friendly Housing Technologies for Developing Countries

12th September, 2007

R.K. Celly
Executive Director

Building Materials & Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation
Government of India

Housing in Developing Countries
– Areas of Concern

- Severe shortage of houses in developing countries especially for poor people.
- Severe problem of management of agro industrial waste in developing countries.
- Mounting pressure on non-renewable energy resources.
- Non-availability of energy efficient technologies for converting agro industrial waste and renewable local resources into alternative materials.
- Expensive & scarce building materials and components.

Major Causes of High Building Costs

- Expensive materials
- Lack of necessary building skills
- Lack of guidelines in selection of appropriate building packages
  - Designs
  - Materials
  - Methods
  - Equipment

Low Cost or Cost Effective Housing

Aims to reduce the cost of construction and at the same time not sacrifice any element of safety or serviceability of the house over the life cycle.

There is need for adoption of:
- strong,
- durable,
- functional,
- aesthetic,
- environment friendly,
- ecologically appropriate,
- energy efficient
- affordable and adaptable
- cost-effective materials
- appropriate technologies in construction.

Various aspects for cost reduction

- Optimisation of land use
- Functional design of buildings
- Optimum use of building materials
- Rationalisation of specifications
- New construction materials and techniques
Factors affecting Choice of Materials and Technologies

- Availability/suitability of raw materials
- Availability of skilled labour
- Scale of construction
- Cost variation with conventional materials
- Availability of adequate power for production of components
- Typology based on geo-climatic conditions
- Disaster-resistant requirements
- Environmental aspects
- Acceptability by people

Technology Selection Criteria

- Saving in cost, initial as well as recurring.
- Saving in consumption of imported or scarce materials, even if no saving in cost is achieved.
- Saving in time of construction.
- Utilization of waste materials even if no saving is achieved.
- Saving in quantum of skilled labour even if no saving in cost is achieved.
- Achieving better utilization of equipment but not necessary leading to optimum saving in cost.
- Better utilization of space.
- Better layout for economy in external services.

Promotion of Technology for Low Cost Housing Materials – the Collaborative Effort

Technology

- Employment Generation
- Environment Friendly
- Energy Efficient

- Simple Machines
- Small enterprises
- Local people involved
- Utilization of agro-industrial wastes
- Substitution of wood by composite materials made of waste and local natural resources
- Top soil preservation
- Simple Machines – Less energy consuming
- Products – Better thermal comfort

Technology for Alternative Materials for Low Cost Housing

- Energy Efficient
- Environment Friendly
- Employment Generating

- Simple machines – saves energy in production
- Raw Material – derived from agro-industrial wastes and natural fibres, requires less energy in production
- Products – when used in house, buildings provide better thermal comfort that results in conservation of operational energy.

- Converts agro-industrial waste into alternative material for low cost housing, thus improving waste management & environmental protection
- Utilizes local resources
- Substitutes wood – preserving forest cover
- Substitutes top soil – preserving soil for agriculture
Technology for Alternative Materials for Low Cost Housing

Employment Generating

- Simple machines – with manual handling, increases employment for unskilled and semi-skilled workers
- Small enterprises – can be set up at decentralized locations
- Production of components – involves local people after short training

Resource and Energy Saving through Use of Natural Fibres and Agro-Wastes in Building Materials

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Waste and source</th>
<th>Commercial product</th>
<th>Traditional resource</th>
<th>Energy saving %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>using natural fibre &amp; agro-waste</td>
<td>fully or partly saved</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Coir fibre (coir industry)</td>
<td>Coir fibre-reinforced roofing sheet &amp; panels</td>
<td>Asbestos</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>Rice husk (rice mill)</td>
<td>Rice husk-cement building board</td>
<td>Resin (PF or UF) bonded particle</td>
<td>20</td>
</tr>
<tr>
<td>3.</td>
<td>Ground nut shells (oil mills)</td>
<td>Ground nut hull-cement building board</td>
<td>Resin-bonded particle board</td>
<td>20</td>
</tr>
<tr>
<td>4.</td>
<td>Jute fibre (jute mills)</td>
<td>Jute fibre-reinforced bonded sheet, door &amp; window</td>
<td>Timber, metal</td>
<td>15</td>
</tr>
</tbody>
</table>

Waste and Commercial products coworkers are saving % of energy in primary and recycled product (MJ/kg).

<table>
<thead>
<tr>
<th>S. Material No.</th>
<th>Total energy in primary product (MJ/kg)</th>
<th>Total energy in recycled product (MJ/kg)</th>
<th>Saving %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>33.50</td>
<td>21.00</td>
<td>30.00</td>
</tr>
<tr>
<td>2.</td>
<td>235.00</td>
<td>11.00</td>
<td>94.00</td>
</tr>
<tr>
<td>3.</td>
<td>28.00</td>
<td>25.00</td>
<td>10.30</td>
</tr>
<tr>
<td>4.</td>
<td>100.00</td>
<td>56.00</td>
<td>44.00</td>
</tr>
<tr>
<td>5.</td>
<td>54.10</td>
<td>14.50</td>
<td>80.00</td>
</tr>
<tr>
<td>6.</td>
<td>23.00</td>
<td>17.00</td>
<td>26.00</td>
</tr>
<tr>
<td>7.</td>
<td>3.00</td>
<td>2.00</td>
<td>33.30</td>
</tr>
</tbody>
</table>

Low Cost Building Materials – Characteristics

- Easy to manufacture
- Easy affordability
- Easy Erection/commissioning
- Faster & cheaper construction
- Effective Waste utilization
- Energy efficient and Environment friendly
BMTPC was established to bridge the gap between lab & land and facilitate low cost and safer constructions.
**Low Cost Building Materials/Components/Technologies – Developed by BMTPC**

**BUILDING MATERIALS**
- Calcium Silicate Bricks
- Fly ash–Lime Bricks
- Clay–Fly ash Bricks
- Clay Flooring Tiles
- MCR Roofing Tiles
- Burnt Clay Flat Terracing Tiles
- Fibrous Gypsum Plaster Boards

**BUILDING COMPONENTS**
- Precast Solid Cement Concrete Blocks
- Precast Concrete Stone Masonry Blocks
- Hollow & Solid Light Weight Concrete Masonry Units
- Precast Reinforced Concrete Door and Window Frames
- Precast Door Shutters
- Precast Roofing Channels
- Precast Ferrocement Water Tanks
- Precast Concrete Manhole Covers & Frames
- Bamboo Mat Corrugated Roofing Sheets

**BUILDING TECHNOLOGIES**
- Precast Channel Unit for Flooring/Roofing
- Precast Reinforced Concrete Joint & Plank system for Flooring/Roofing
- Thin R.C. Ribbed Slab for Floors and Roofs
- Precast Concrete Waffle Units for Floors and Roofs
- Prefabricated Reinforced Concrete L Pans for Roofs
- Precast Doubly-Curved Shell Units for Floors and Roofs
- Precast Ribbed Concrete Slabs for Floors and Roofs
- Reinforced Brick and Reinforced Brick Concrete Slabs for Floors and Roofs
- Preformed Brick Slab for Floors/Roofs

BMTPC has developed and promoted more than 30 machines for producing cost-effective, energy-efficient, environment-friendly building components which are easy to operate. Employment generation varies from 4 to 14 per machine.

**Machines Developed/promoted by BMTPC**

- Alternate Station Hydraulic Brick Press
- Solid/Hollow Concrete Block Machine (Egg laying Type)
- RCC Plank Casting Machine (Rotating Type)
- Precast L-Panel Machine
- Precast RCC Plank Machine
- Precast Ferrocement Roofing Channel Machine
- Ferrocement Wall Panel Machine
- TNG Rural Housing Kit
- RCC Plank casting Machine (Egg-laying type)
- Precast concrete Door/ Window Frame Machine
- Ferrocement C-Beam Machine
- RCC Joist Casting Machine (Egg laying Type)
- Precast concrete Door Window Frame Machine
- Precast Double-Curved Shell Units for Floors and Roofs
- Precast Ribbed Concrete Slabs for Floors and Roofs
- Reinforced Brick and Reinforced Brick Concrete Slabs for Floors and Roofs
- Preformed Brick Slab for Floors/Roofs

**Machines Developed/promoted by BMTPC**

- Bi-Directional Vibro Press
- Compressed Earth Block Machine
- Bi-Directional Vibro Press
- Concrete Block Machine
- Bi-Directional Vibro Press
- C-Block Machine
- Compressed Earth Block (Balram) Machine
- Stationary Block Machine
- Multi-purpose Stone Processing Machine
- Micro Concrete Roofing Tile Machine
- StoneCut Drilling Machine
- Multi-concrete Roofing Tile Machine
## Disaster Mitigation & Management

- Digitised Vulnerability Atlas of India: State/UT wise
- Landslide Hazard Zonation Atlas of India
- Damage Assessment Studies and Technology Options
- Guidelines/Manuals on Disaster Resistant Construction
- Building Byelaws/ Regulations
- Capacity Building
- Repair, Reconstruction and Retrofitting

## Activities for Disaster Mitigation…contd.

### Building Byelaws:
- Regulations
  - Assisted MHA for preparing Model Building Bye-laws
  - Organising 1-day technical workshops on Model Building Bye-laws in 22 States including NE States

### Capacity Building
- Provided Training to 5000 masons and 50 engineers in J&K
- Involved in Training to 300 engineers in J&K

### Reconstruction / Retrofitting
- 478 model houses constructed in Gujarat
- 445 public buildings retrofitted
- Hospital Building at Kupwara
- School Building at New Delhi
Disaster Management & Mitigation

- Vulnerability Atlas of India brought out in 1997 have been revised on Digitised Format with latest Housing Census Data 2001 and information from GSI, CWC, IMD, SERC and BIS.

Demonstration of Retrofitting Techniques

- Initiated retrofitting of 12 MCD Schools at New Delhi
- Retrofitted Five MCD Schools at New Delhi.

Demonstration of Retrofitting Techniques

- Retrofitted Sub-District Hospital Building at Kupwara, J&K
- Prepared 10 Posters and a booklet in Urdu & English on safe construction practices

Standardization and Product Evaluation

- The Government has authorised BMTPC to operate the Performance Appraisal Certification Scheme for the benefit of building materials and product manufacturers and user agencies and professionals. Six certificates issued. A number of applications are under various stages of processing.
- Providing technical inputs to various Sectional Committees of BIS, for formulation of Indian Standards on various subjects related to Civil Engineering.

Promoting Indian Technologies in Developing countries

Exhibitions held

- Thailand 1995
- Turkey 1996
- Trinidad & Tobago 1997
- Kenya 1997
- Uganda 1998
- Trinidad & Tobago 1999
- Tanzania 2000
- Venezuela 2002
- Bhutan 2005

Construction Expo-2005, Bhutan
Seminar on “Technology Options for Cost Effective and Earthquake Resistant Construction in Housing” in Bhutan

Capacity Building Programmes
Realising the need of capacity building of professionals, BMTPC has continued its efforts in organizing structured training programmes on various themes for working professionals on regular basis:

- Earthquake Resistant Buildings;
- Concrete Mix - Design and Quality Control;
- Water Proofing and Damp Proofing;
- Quality Assurance in Construction;
- Use of Chemical and Mineral Admixtures for Concrete Construction;
- Seismic Retrofitting & Repair of Buildings;
- Repair, Maintenance & Rehabilitation of Buildings.

Organised 26 training programmes during last year and trained more than 700 professionals from leading organisations like CPWD, PWDs, Railways, NTPC, MES, GAIL, etc.

Field Level Application of Cost effective technologies

Field Level Application of cost effective technologies

<table>
<thead>
<tr>
<th>Demo Houses under VAMBAY</th>
<th>252 demo units in Karnataka</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constructing 540 demo houses under VAMBAY in Bilaspur (Chhattisgarh), Nagpur (Maharashtra), Jodhpur (Rajasthan), Trichy (Tamil Nadu), Kodoli (Karnataka), Dehradun (Uttrakhand)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demo Structures in NE Region</th>
<th>10 structures using bamboo based technologies in Mizoram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 structures using bamboo based technologies in Tripura</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other structures/public housing</th>
<th>3164 units in Bawana (Technical Assistance)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Few buildings in Andhra Pradesh, Haryana, Rajasthan, Punjab, Karnataka, Orissa, New Delhi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demonstration Houses under VAMBAY in BANGALORE</th>
<th>252 demo units in Karnataka</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Dwelling Units</td>
<td>252</td>
</tr>
<tr>
<td>Unit covered area</td>
<td>275 sq.ft.</td>
</tr>
<tr>
<td>Cost per Unit</td>
<td>Rs. 60,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technologies Used</th>
<th>Concrete Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Filler Slab Roof</td>
</tr>
<tr>
<td></td>
<td>Wood alternate Doors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demonstration Houses under VAMBAY in NAGPUR, Maharashtra</th>
<th>70 demo units in NAGPUR, Maharashtra</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Dwelling Units</td>
<td>70</td>
</tr>
<tr>
<td>Unit covered area</td>
<td>194 sq.ft.</td>
</tr>
<tr>
<td>Cost per Unit</td>
<td>Rs. 50,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technologies used</th>
<th>Fly Ash Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Filler slab Roof</td>
</tr>
<tr>
<td></td>
<td>Ferro Cement and Fly Ash Polymer Doors</td>
</tr>
</tbody>
</table>
Demonstration Houses under VAMBAY in Dehradun, Uttarakhand

- No. of Dwelling Units: 100
- Unit covered area: 194 sq.ft
- Cost per Unit: Rs.45,000
- Technologies used:
  - Solid/Hollow Concrete Blocks
  - Pre cast Plank & Joint Roof
  - RCC Door frame
  - Wood substitute Doors

Demonstration Houses under VAMBAY in Bilaspur, Chhattisgarh

- No. of Dwelling Units: 100
- Unit covered area: 194 sq.ft
- Cost per Unit: Rs.40,000
- Technologies Used:
  - Fly Ash Bricks
  - Pre cast Plank & Joint Roof
  - RCC Door frame

Demonstration Houses under VAMBAY in Kudalu, Bangalore

- No. of Dwelling Units: 70
- Unit covered area: 194 sq.ft
- Cost per Unit: Rs.60,000
- Technologies Used:
  - Solid/Hollow Concrete Blocks
  - Filler slab Roof
  - Ferro Cement and Fly Ash Polymer Doors

Demonstration cum Production Units

- Technology Demonstration-cum-Production Centre at Greater Noida, U.P. (producing cost-effective environment-friendly building components using agro-industrial wastes like flyash, gypsum, and hydrated lime)

- Production Unit at Village Sikri, Faridabad, Haryana (Solid and hollow concrete blocks and pavers using flyash)
BMTPC is promoting Bamboo

'A material for cost effective and disaster resistant housing used for construction of demonstration buildings and structures'

Construction of demonstration structures using bamboo materials in Mizoram and Tripura

**Salient Features of the Structures**
- Bamboo posts
- Bamboo grid ferrocement walls
- Bamboo trusses and purlins
- Bamboo Mat Corrugated Sheet Roofing

Demonstration Structures using Bamboo Technology in Mizoram

Construction of Demonstration Buildings using Bamboo Based Technologies in Mizoram

Construction of Demonstration Buildings using Bamboo Based Technologies in Tripura

Type II house at Circuit House Agartala - COMPLETED
Type II house at Rajbhawan Agartala - COMPLETED
Picnic Hut at Nehru Park, Agartala - COMPLETED
Type II house at Circuit House Udaipur - COMPLETED
Eight Bamboo Mat Production Centres in Assam, Mizoram, Meghalaya and Tripura (2 each) are being established.

**Ongoing India UNIDO Initiative**

*Interregional Programme on Capacity Building for Transfer of Energy–Efficient and Eco–Friendly Technologies and Promotion of Local Investments in the Area of Materials based on Local Resources for Low Cost Housing in Africa, Asia and Latin America*

**Main Objective**

To establish appropriate mechanisms for promoting investment and technology transfer in the area of innovative and cost effective building materials based on agro-industrial wastes in the African, Asian and Latin American regions.

**India UNIDO Programme – Implementation Mechanism**

- The Ministry of Housing & Urban Poverty Alleviation, Government of India and its organisations BMTPC and HUDCO is providing support to UNIDO in the implementation of the project.
- Making available its expertise, technologies, know-how for transfer to the recipient countries, and assisting them in building up local capacity for sustained growth of housing sector.
- The Advisory Council of ICAMT is providing the advice on means and ways of successful implementation of the project.
- UNIDO facilitating the networking and knowledge transfer between the various partnering countries.

**Regional Cooperation Framework – Focuses on**

- Environmental Protection
- Energy Efficiency in Manufacturing Processes
- Reducing Poverty through Employment Generation
- Modernization of Manufacturing Process of Composite Materials by recycling Agro – Industrial Wastes
- Technology Transfer & Capacity Building
- South South Cooperation

**Regional Cooperation Framework – Demand Driven**

- Sharing of experience, expertise and technologies for manufacturing of building materials using agro-industrial wastes and employment generation potential of machines through micro and small enterprises
- Regions to facilitate and promote technology sharing
- Procurement of technical know–how and machines

**Regional Cooperation Framework – deliverables**

- Building up capacities at institutional and enterprise levels for productive employment and technology transfer and adoption.
- Protecting environment by utilisation of renewable resources rather than fast depleting non-renewable ones.
- Promoting energy saving technologies, and thus, making very significant contribution to gaseous emissions, especially of carbon dioxide.
- Encouraging competitive enterprises to gain access to profitable markets, especially in the alternative materials sector.
Tools for Strengthening Regional Cooperation

- “Working Group” with BMTPC - Ministry and ICAMT-UNIDO
- Identification of the Universities, R&D institutions, local enterprises in the area of innovative building materials and construction technologies.
- Establishing linkages for technical cooperation at UNIDO supported centres of developing countries of Asian and African regions.

Targeted Product and Technologies

- Waste and local Secondary Resource material based Building Products.
- Pre-fabricated building components.
- Cost-effective and alternative building materials based housing technologies
- Technologies for Natural Disaster Mitigation & Management

Expected Outcome of Regional Cooperation Programme

- Identification of local resource based new Technologies.
- Skill development through demonstration & training.
- Saving in energy & material by adoption of pre-fabricated building components.
- Skill upgradation of local workers for implementation of disaster resistant housing technologies.

Thank you for your kind attention

Strengthening the Technological base of Housing and Human Settlements Sector