

## **Section II**

# **Eco Construction Techniques**

## **Ch.5. Eco technologies**

### **5.1 Sustainable architecture, construction and planning**

Fortunately many design strategies such as energy efficiency can cut the costs of operating buildings, including industrial facilities, and reduce environmental impacts.

**Some principals of sustainable design and construction: -**

#### **1) Minimize resource and consumption. (Conserve)**

- Design for energy efficiency in building design, lighting, HVAC systems, etc.
- Use passive solar and day lighting features
- Select materials and design for durability. Maximize resource reuse.(reuse)
- Reuse construction materials, assemblies, and products
- Include grey water systems to reuse water

#### **2) Use renewable or recyclable resources (renew/recycle)**

- Use building materials with recycled content
- Specify woods from sustainable forests

#### **3) Protect the natural environment (protect nature)**

- Minimize disruption of the natural environment in site preparation and construction
- Select materials for low impact in their extraction and processing

#### **4) Create a healthy, non-toxic environment**

- Select non toxic materials and equipment
- Provide fresh air for all occupants
- Integrate building and infrastructure design into the natural and human environments
- Landscape the site using native plants of the region and ponds or wetlands to capture storm water run off
- Incorporate features to reduce impact of development on community transportation systems.

## **5.2 Water**

### **5.2.1 Aim of water management on site**

The main aim of the project would be to have zero runoff of water from the site which when allowed percolating into the ground will replenish the ground water sources while simultaneously solving the problem of site drainage.

Conservation of the ground water sources as far as possible.

Study the degree of cleanliness necessary for the varied uses of water in the specific industrial areas and residential areas, where ground water sources can be used judiciously and whenever possible replaced by other water sources such as harvested rain water from the roof and paved areas, and also from the waste water treatment plant.

### **5.2.2 Rain water harvesting**

Rain will be harvested from the different areas and processed and purified accordingly, to meet the required degree of cleanliness demanded by the specific purpose. These spaces could be divided into two main categories.

#### **a. Paved surfaces**

Like courtyards, pathways and roads where from the collected water would be relatively clean.

The drainage system for this purpose will be through open drains or perforated drainpipes under ground, through which water would be allowed to percolate uniformly throughout its length. This process would help in the increase of the surface area of percolation. The excess water from these surfaces will be led through these drains to a large central percolation pond.

#### **b. Roof of the buildings**

The water collected from the rooftops of buildings would be the cleanest among the harvested rainwater collected from different areas. The water from the roofs will be collected and stored in an underground tank (as it is more economical than overhead water tanks of this scale) through drainpipes. The water thus harvested from the roofs would cater to the various needs of the industry as well as residences.

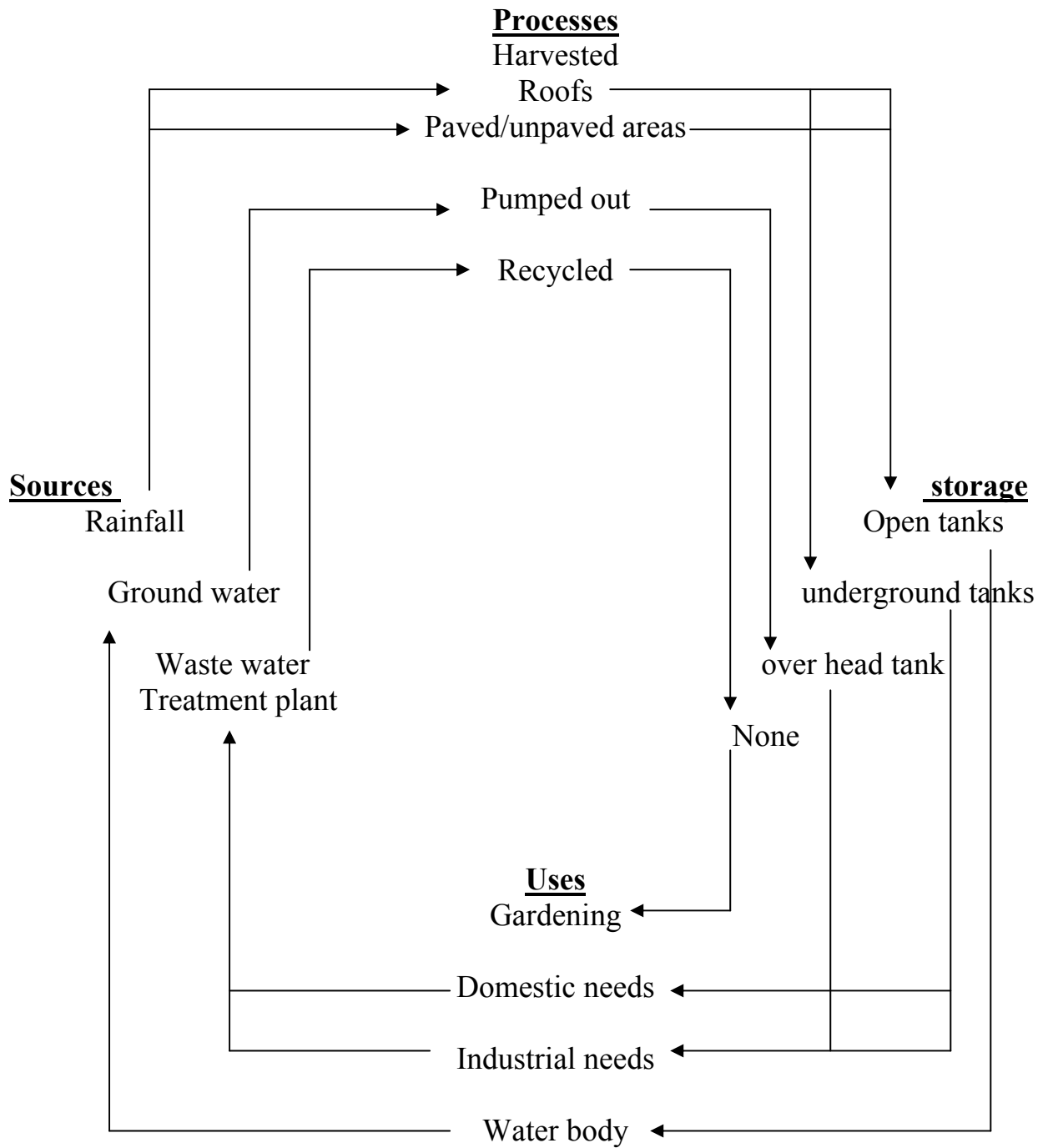
### **5.2.3 Open tanks for the storage of harvested rainwater**

Open tanks act as large reservoirs for the storage of water, which allow slow percolation during the drier months. However the disadvantages emerging from its application have to be taken into consideration and solved accordingly.

### **5.2.4 Expected Problems and their solutions;**

1. Breeding of mosquitoes-the first problem of this system will be the breeding of mosquitoes, which if not checked can lead to the spreading of many diseases. This can be countered by introducing fish in the tank.
2. Dry tank during driest months(steady water reduction in water level)  
As one cannot rely on having a minimum water level even in the drier months, the fish face a threat of dying out periodically. And if one does not immediately introduce the new fish immediately after the rain begin, mosquitoes will begin to breed at once. In order to sustain the fish during the dry months the design of the tank can be modified to accommodate a sealed portion at the bottom of the tank to prevent percolation after it reaches a minimum water level.
3. Visual aspect of a fluctuating water level-since the water would not be taken to maintain the visual aspect of the tank so that it does not prove to be an eye sore during the drier months.
4. Pathogen bacteria- these develop in open tanks. Up to the depth of 90 cms the ultra violet rays in the sun are known to be able to kill the germs. This solution of restricting the tanks calls for a huge surface area, which is not only more expensive but also, blocks a lot of land.
5. Invasion of tank surface by greenery-if one wants to save the water body being filled from being filled with greenery; it should have a minimum depth of 3m.

### 5.2.5 Water recycling concept



## **5.3 Waste**

### **5.3.1 Sewage water**

There is a growing recognition now globally that water, a very precious primary resource that sustains all life is not only limited but also rapidly being polluted. Apart from conservation of water where it falls, a sustainable and Eco-friendly development could include the treatment of used wastewater as a reliable and secondary source of water, while simultaneously ensuring that only clean water is finally released back into the environment. Conventional treatment cleans wastewater physically, biologically and chemically, while natural systems such as root zone system rely on the cleaning power of microbes, plants and fish alone. Auroville is situated on a large plateau, about 65 meters above sea level, sloping gently towards the Bay of Bengal. The absence of rivers or major lakes makes it necessary to draw water needs from underground for its present population of 1500 people. If the projected growth rate towards a small city of 50,000 people is to be achieved and sustained, wastewater treatment will be an essential part of the overall city water use.

During the nineties the preferred choice for recycling domestic wastewater shifted towards treatment systems called planted filters. With such natural functioning systems one could obtain a high quality effluent. The large space requirement for this kind of system was not viewed as a disadvantage since the treatment systems can be beautifully landscaped into any environment, even urban.

### **5.3.2 Aim of wastewater treatment systems**

1. Be able to remove the chemical toxins as well as disease organisms.
2. Be capable of producing secondary, tertiary and advanced tertiary effluents.
3. Be reliable in producing safe, reusable water everyday all year round.
4. Be ecologically sound, capable of improving rather than harming the local environment.
5. Not add harmful chemicals or create toxic sludge during the treatment process.
6. Produce valuable by-products from the waste nutrients to reduce net operating costs.
7. Be cost effective, with low construction and operational costs, and the potential to achieve profitability from resale of water and products.

## **5.4 LOMWATS (low maintenance waste water treatment systems)**

Low maintenance waste water treatment systems are based on the assumption that the polluter

- has no genuine interests necessarily in waste water treatment
- does not know much about waste water treatment
- Does not want or is not able to have professional staff for wastewater treatment/management.

### **5.4.1 Characteristics of LOMWATS**

- Does not need control of waste water flow
- Cannot be switched off.

### **5.4.2 Principles of waste water treatment applied in LOMWATS.**

1. **Sedimentation**-involves anaerobic sludge stabilization, sludge disposal, aerobic composting.

Systems based on this are: -

- septic tank
- Imhoff tank
- sedimentation pond

2. **Anaerobic digestion of liquid via contact processes**-all anaerobic systems are biogas producing systems.(executed underground)

Systems based on this are: -

- fixed bed filter
- baffled reactor
- anaerobic ponds

3. **Aerobic decomposition of liquid via natural oxidation (on the surface of the land)**

Systems based on this are: -

- aerobic ponds
- horizontal sub flow systems
- overland treatment

### **5.4.3 Choosing the appropriate system**

The choice of the system can be made according to the follows: -

- kind of waste water
- amount of waste water
- required discharge quality
- use/reuse of by-products

## **5.5 Biogas**

Biogas is the methane and carbon dioxide gaseous mix generated through biological decomposition of organic matter in the absence of air. Biogas production is a microbial process. All microbes involved in biogas production grow in the absence of air. The most important organisms are tiny bacteria. Different groups of bacteria act upon complex organic materials in the absence of air to produce biogas rich in methane.

## **5.6 Biocoal**

Biocoal is produced by the compaction of all solid, dry organic waste by feeding the waste directly into a simple compaction machine. This machine converts the waste in the form of heavy, compacted chunks of solid mass which when burned give out smokeless and residue less combustion fuel used for various industrial as well as domestic purposes.

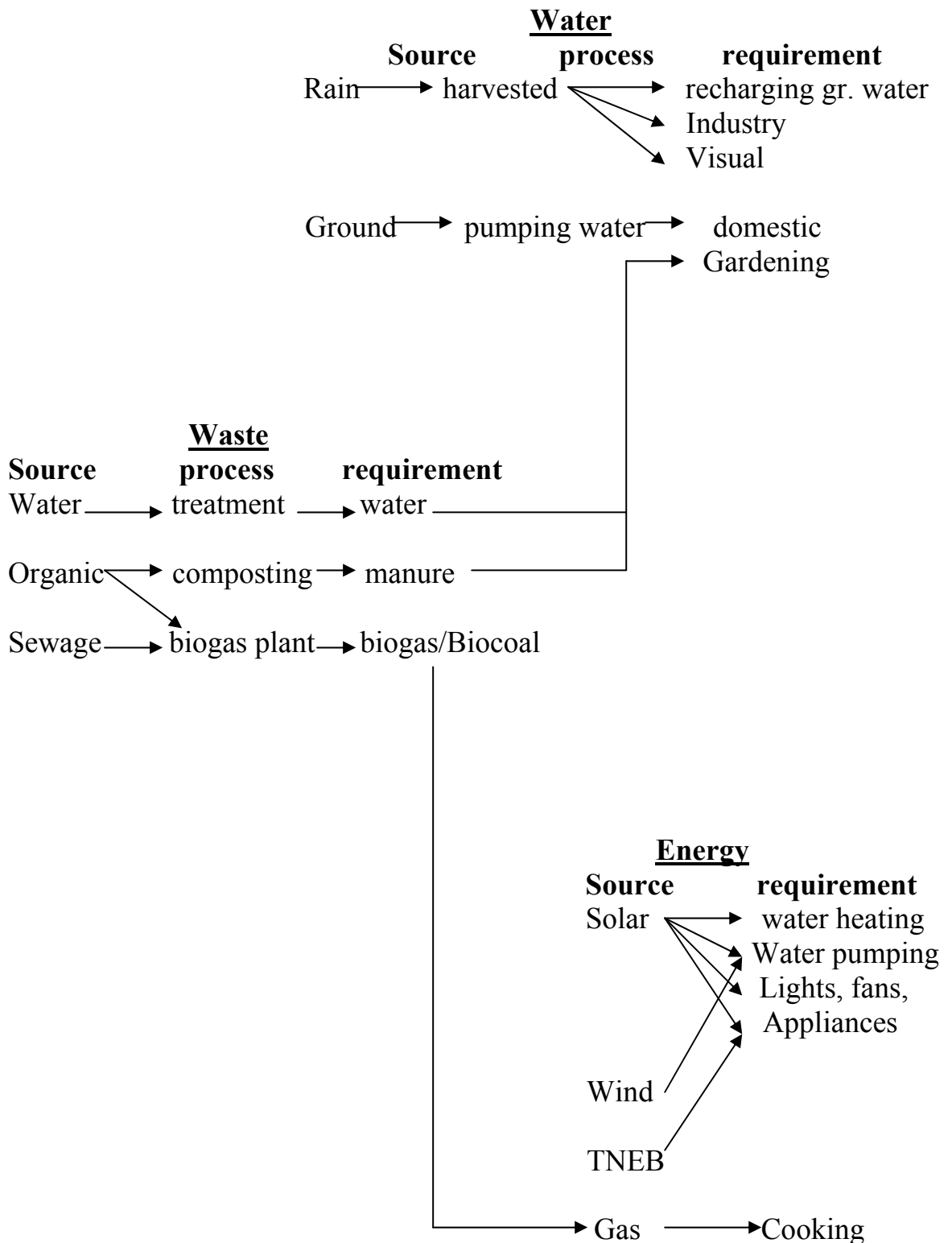
## **5.7 Solid wastes**

Solid wastes like any other wastes are a result of human activities. With rapid urbanization, industrialization, increase in population and increase in standard of living the collection, handling and disposal of waste has become a problem of world wide concern.

On an average, about 0.4 to 0.5 kg. Per person per day of refuse is generated in most of the cities in India.

Indiscriminate dumping in low lying areas on the outskirts of the city, in notified areas, with very little concern for public health, pollution consequences or aesthetics, has been going on for years. In many cases, the waste is left uncovered and outspread. The dump sites provide a fertile ground for rodents, flies and insects and during rainy season the run-off from the dumps can affect nearby streams and canals, bore wells and even the city drinking water supply.

## 5.8 Interrelationship between waste, water and energy



## **Ch.6. Energy**

### **6.1 Energy-its implications on architecture and environment**

Unlike vernacular architecture which provided more or less climatically comfortable living spaces with a minimum use of external energy, conventional modern architecture with all its achievements is however heavily dependent on commercial energy sources for providing lighting, heating and cooling in buildings. In fact, conventional habitats today absorb the sun energy to first heat the then fall back on artificial means to let off the heat, which gets further compounded by the groupings of the buildings themselves.

This puts tremendous strain on conventional energy – which is easy to hook onto – thus aiding and abetting the release of energy into the atmosphere, related manifestations like green house effects, and further and sustained damage to the environment.

According to estimates, during last 100 years or so of industrial revolution, this civilization of ours has released almost same amount of energy into the atmosphere as has been done by our ancestors in the last 5000 years.

### **6.2 Conservation of energy**

The aim of reducing the strain on conventional energy is achieved through conservation of energy by:

1. **Low energy buildings** - efficient structural design, reducing the quantities of high-energy building material and transportation energy.
2. **Solar passive architecture** - climate responsive architecture that conserves energy otherwise used for heating, cooling and interior lighting by taking into account solar radiation and other ambient conditions in the area and by incorporating features such appropriate building materials, appropriate shape, orientation, insulation, shading devices etc.
3. **Creating low energy demands of energy** - through efficiency.

### **6.3 Renewable energy sources**

To meet energy demands for water pumping, street lighting and housing appliances such as: -

#### **1. sun**

- a. solar photovoltaic
- b. solar water heating
- c. solar pumping
- d. solar cooking
- e. solar refrigeration

#### **2. wind**

- a. wind mill for water pumping
- b. wind power generation

#### **3. biogas**

- a. cooking
- b. refrigeration

### **6.4 Solar passive architecture**

There are two basic approaches to solar passive architecture (solar energy systems), active and passive. In an active system, the sun is the heat source and there are various components such as thermostats, fans, pumps and valves to move heat wherever needed.

In passive approach, a building is designed to allow the sun to warm or not warm the interiors without any intermediary machinery. In short, the building serves as its own heating or cooling systems.

Solar passive architecture

Providing comfortable buildings, while reducing the use of conventional fuels and electricity, can be obtained through solar passive architecture. The benefit of solar energy is utilized through designing energy efficient buildings.

### **6.5 Climatically responsive, energy efficient architecture**

Auroville is situated in the hot humid zone, a zone where solar passive measures are the least effective. Natural lighting and proper ventilation, shading of the walls and good insulation of the roof are important features for creating comfort zones within buildings.

## **6.6 Low energy content building materials**

Appropriate building technologies are an overall part of passive solar architecture. Auroville Building Centre has gained expertise in two low energy content technologies: compressed earth blocks and ferrocement. Both technologies use in their category substantially less energy than the more traditional applications of fired bricks and RCC structures.

## **6.7 Advantages of passive systems**

Passive systems have several distinct advantages over active systems. Passive systems require little or no maintenance; with no or hardly any machinery to breakdown there are rarely any costly repairs. Most importantly, both the initial costs as well as the operating costs are much lower than active systems, so passive systems can pay for themselves in much shorter time.

## **Ch.7. Building Materials and Construction**

### **7.1 Building materials**

The assessment of building materials can be divided into five different categories: -

#### **7.1.1 Building materials - accessibility and availability**

Auroville is in rural Tamilnadu, India, which means:

- Often poor transportation links
- Lack of sufficient energy supply
- Lack of building machinery such as shuttering, mixers, cranes, power tools
- Conventional building materials are of poor quality and of unreliable supply

Given these constraints, the most obvious materials are ferrocement and earth. The domestic architecture of the poor was/is earth, which makes the acceptability an important aspect of consideration. The strategies adopted were to build demonstration buildings within Auroville to prove the suitability of the said materials and technologies.

Due to the geographical location and absence of sufficient capital, the technology:

- Had to have low economic input, eliminating materials and technologies which need heavy machinery or infrastructure
- Had to be accessible for use, which means people had to be able to learn and apply with minimum of training
- The maintenance aspect of the finished structure had to be minimal as the earning level of the people was insufficient to replace or repair on a regular basis.

#### **7.1.2 Human resources and skill**

The Auroville area being a seasonal agriculture zone, craftsmanship was not developed in this area, as there is no agricultural surplus.

- Constructional work force is semi- or unskilled, so the training required should be minimal and easy
- Education level being insufficient, the building industry should lend itself to the use of the unorganized sector.

### **7.1.3 Climate and comfort**

Auroville is in the hot-humid zone with extreme temperatures in the summer, which implies:

- Comfort with maximum ventilation, which means larger openings
- Humidity and erosion control
- Time lag in the building materials has to be low as the difference between the day and night temperatures are not much: lower building mass, high material to strength ratio.

### **7.1.4 Environmental impact**

More accountable and sustainable practices of development are called for in view of the Indian crisis of high population growth and natural resource crunch:

- Solutions must grow from the place itself, which requires information on the local conditions and people
- Ecological accounting
- Renewable energy usage
- Recycling of waste
- Integrated site developmental approach.

### **7.1.5 Cost effectiveness**

Economics are dependent on very diverse factors, some of which are not within local control. But the local area for the enhancement of the local economy can control certain factors.

- Less outflow of money and other resources by the adoption of certain technologies and materials
- Creation of employment by up-gradation of local skills
- Innovative use of the available building materials
- Direct market and supply connection - elimination of the middleman
- Labor intensive approaches

- 1. effect on the macro-environment**
  - a. Atmospheric impact
  - b. Resource depletion
  - c. Bio diversity
  - d. Habitat loss
- 2. energy**
  - a. Production energy
  - b. Transportation energy
  - c. Energy required for the use
  - d. Energy saving potential of different materials
- 3. waste**
  - a. Recycled content
  - b. Durability
  - c. Recyclability
  - d. Wastes that are a byproduct of its production or use.
- 4. health and welfare**
  - a. Indoor air quality
  - b. Toxic byproducts
  - c. Socio economic impact e.g. locally available products generate jobs while avoiding the use of transportation energy.
- 5. transportation energy**
  - a. Someone has defined local material as all that is available within the bullock cart radius.

## **7.2 Criteria for identification**

Criteria used to identify the most appropriate building materials and technology:

- Building material : availability and accessibility
- Technology: processing and assembly
- Human resources: skill and equity
- Climate and comfort
- Environmental impact
- Cost effectiveness

## **Ch.8. Building technologies**

### **8.1 Appropriate building technology**

The term 'appropriate building technology' refers to building processes and tools that are appropriate to the climate, socio-economic conditions and natural resources of an area, and which contribute to sustainable development. In the Auroville context we have two examples of appropriate building technology, earth construction and ferrocement.

### **8.2 Appropriate architecture**

The term 'appropriate architecture' is used for the integration into construction of all the separate technologies and disciplines involved in the research and promotion of sustainable solutions. 'Green Architecture' is another name used for this approach.

#### **1. Insulating terracotta roofing elements**

Roofs vaults are built of hollow burnt clay tubes stacked along a catenary curve requiring no steel for reinforcement. The system allows quick clean assembly. The shape guided by g.i. Pipes along the vault length held at either end in metal arches. No shuttering or demolding is required. a) Tubes, b) Pots

#### **2. Ferro cement technology**

Definition of ferrocement reported by ACI Committee 549, 1988  
Ferrocement is a form of reinforced concrete using closely spaced multiple layers of mesh and/or small diameter rods completely infiltrated with, or encapsulated in, mortar. The most common type of reinforcement is steel mesh. Other materials such as selected organic, natural or synthetic fibers may be combined with metallic mesh. Ferrocement is a type of thin wall reinforced cement concrete construction where usually a cement mix is reinforced with layers of continuous and relatively small diameter mesh. Mesh may be made of metallic or other suitable materials. Ferrocement uses far less cement and steel than concrete. This technology lends itself perfectly for the casting of prefabricated elements as well as in-situ applications. Although ferrocement is not strictly a 'sustainable' technology as it uses cement and steel, it nevertheless employs them in a highly efficient and cost-effective manner. Ferrocement is a thin cement mortar laid over wire mesh, which acts as reinforcement. It is relatively cheap, strong and durable, and the basic technique is easily acquired. Ferrocement in Auroville is used, among other things, in the construction of roof channels, doors, water tanks, latrines, slabs, various form works and biogas plants.

### **3. Rammed earth walls and foundations**

Raw soil from the site is rammed into forms manually. Can be stabilized with 5% (or approx. proportion) of cement and used as foundations or walls.

This technology was used traditionally in countries like France, Morocco, northern India and Tibet, and is today used with stabilizers in USA and Australia. Is rammed in forms either manually or pneumatically. Until 1995, Auroville had only one house in raw rammed earth. AV-BC / Earth Unit designed slipping forms adapted to Indian conditions for the 600m<sup>2</sup> of School building with stabilized rammed earth. Since then, the demand has risen for houses, workshops and other developments using this technique.

### **4. Stabilized Earth Blocks**

Raw soil from the site is mixed with a little water to become just humid, and then is compressed in a press. This can be used like common masonry but in a stabilized earth mortar mix.

Compressed Earth Blocks (CEBs) are made in a manual press (produced in Auroville) using a mixture of earth with 3-5% cement. The advantages of using CEBs for construction are that they can be made on site and the manufacture of them doesn't pollute the environment. A CEB uses between 3-5 times less energy to make than a fired brick.

Today, Compressed Earth Block technology is the widest one used worldwide, as well as in Auroville, because it represents a synthesis of traditional practice and modern technology. It is also benefiting from scientific input.

In Auroville, the average results obtained with CEB at 5% cement are ( $\pm$ ) 50 kg/cm<sup>2</sup> (5 Mpa) for the dry compressive strength, and ( $\pm$ ) 9% for the water absorption. Local fired country bricks are at ( $\pm$ ) 35kg/cm<sup>2</sup> and ( $\pm$ ) 12%). The Auroville Building Centre has designed a press for CEBs, which is sold in India, Africa and even Europe.

Over the years, various techniques and equipment have been researched, developed and implemented: presses for CEB with 15 different moulds, stabilized rammed earth foundations, composite beams (RCC with U shape CEB), composite pillars (RCC with round hollow CEB), alternative soil stabilization with homeopathic milk of lime & alum and cement, etc.

## **5. Surkhi and Lime**

Surkhi and lime can be used in various proportions to reduce or eliminate the use of cement in masonry mortar and plaster.

The Auroville Building Centre / Earth Unit lays emphasis on the management of resources, where the quarry is planned first, so as to be integrated in the processing of every development. First of all, one should scrape away and put aside the topsoil, which can be re-used later for agriculture or gardens. Two types of quarries may be developed: deep ones which can be used later on for water harvesting, pools, percolation systems, or shallow ones which can be used for landscape design, work or play areas, gardens and also percolation features, etc.

The diversity and quality of techniques and know-how has increased; and thus the demand for and general recognition of the value of this natural building material has risen. Its economic advantage, comfort quality and flexibility are now well established. The Auroville red soil makes for aesthetically pleasing buildings. It gets its color from iron oxides, the properties of which enhance the already rich composition of this remarkable building material.

Some may say, "Using soils for building will lead to the destruction of nature..." True, if it is done unconsciously, without knowledge; but wrong if one is alert to proper management of resources and the natural balance thereof.

### **8.3 A material for the future**

Building with earth is definitely an appropriate and cost & energy efficient technology that has a great future. However, one has to master the disadvantages of the material. These are usually caused by variations in the soil quality, and hence the block quality may suffer. Bad quality soil can give relatively poor characteristics (when compared to concrete) and shrinkage cracks may occur.

Among the advantages of earth as a building material, one observes:

- Earth is a local material, contributing to sustainable development.
- Production of the building components utilizes a lot of semi-skilled manpower.
- The technology is easily adaptable and transferable.
- The energy & monetary costs are much lower than with most other materials.
- The thermal comfort and 'vibratory' atmosphere are very positive.

Obviously, one has to master the materials and techniques so as to obtain the optimum possibilities with a harmonious, durable, agreeable and efficient architecture!

Nevertheless, the following drawbacks have to be considered:

- Mechanical qualities less regular.
- Sensible building details.
- Constraint to organize and manage the production of one's own building material on the site.

### **8.4 Challenge**

Building with earth has a great past, but also a promising future, especially in Auroville. It is a true challenge to realize architecture full of light, suppleness, simplicity, imagination and beauty with dark, heavy and formless mud. In Auroville we're working on it.