

# SUSTAINABLE DEVELOPMENT THROUGH APPROPRIATE TECHNOLOGIES IN CIVIL ENGINEERING

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## 1. Introduction

Appropriate technology is small-scale technology which is simple enough that people can manage it directly and on a local level. Appropriate technology makes use of skills and technology that are available in a local community to supply basic human needs such as gas and electricity, water, food, and waste disposal. Although the technology involves simple, easy-to use and repair designs, it is based on sophisticated, 20th-century technologies. Appropriate technology may involve judicious use of high energy materials to improve the properties of resulting composite materials. It will also involve development of eco-friendly processes to solve environmental problems. The development of appropriate technology in materials, products and services may demand simple cost effective equipments, machineries and process. Therefore, this technology may involve other disciplines like mechanical, chemical and electronics. This technology will help to set up medium to small scale industries, transfer of technology from lab to land, up-gradation of local skill, proper use of agricultural waste, waste materials and bi-products from industries, local development of people through participation in it directly or indirectly. This technology will sensitize the common people to understand about the alternate materials & technologies which will go a long way in achieving goal of sustainable development towards affordable housing. This technology will improve the scope for self development, practical experience, interaction with industries and entrepreneurship development opportunities. Thus, appropriate technologies will help sustainable development of the region through use of local materials and skills and hence reduce the pressure on conventional costly materials and process. The paper presents areas in civil engineering where appropriate technologies can be successfully used where cost reduction in construction and energy is of prime importance. Some experimental works have been carried out in order to develop cost effective products. The paper also presents some test results of cost effective materials and structural elements suitable for low cost construction. The role of various agencies associated with these appropriate technologies and their interaction is presented in the paper.

## 2. Challenges to the Environment and Sustainable Development<sup>3</sup>

Environmental and developmental challenges facing the nations today are complex but well known. One side of problem is like the situation in regions such as South Asia where high population levels, rapid population growth and unbalanced population distribution are already overloading the capacities of various natural systems. The increasing inability of these systems to provide for basic needs is resulting in increased poverty. Countries are caught in a vicious cycle of poverty, rapid population growth, environmental deterioration and more poverty. The other side of problem is well exemplified in the pacific-rim region where rapid industrialization is taking place. Number of negative environmental impacts due to industrialization is rapidly affecting the human life and benefits received from the growth of industries. Haphazardly planned industrialization could lead to rapid natural resources depletion, air, water and noise pollution, accumulation of hazardous wastes, deadly industrial accidents, urban congestion and damage to human health.

Environmental trends and projects are generally used as the bases for anticipating changes in the region and to identify challenges that must be faced if the region is to sustain the long term needs of both present and future generations. This has triggered the concept of sustainable development. <sup>2</sup>Sustainable development meets the needs at present generations without compromising the ability of future generations to meet their own requirements. It involves wise use of nature and its resources to promote the greatest sustainable benefits to the present generation while maintaining the potential to meet the needs and aspirations of future generations. Sustainable development is an inter-generational

concept, seeking equity over time and minimization of disparities between generations. Even now only a very small fraction of humanity enjoying the good life even within developed countries and there are wide disparities in the less developed countries. Since present standard of living is low in most of the low developed countries, people aspire for a higher standard. Sustainable development cautions that there are limits to such growths due to finite stocks of natural resources and energy available on other side pollution of environment, exploding population is escalating aspirations and conflicting interests.

### **3. Role of Civil Engineering for development and its effect on environment**

Civil Engineering is responsible for multidimensional growth in economic, social, environmental, industrial and business areas. Civil engineering is backbone of for the development of any country due to its characteristics which supports directly developmental activities like infrastructure facilities irrigation system, water supply and sanitary system, transportation systems like roads, railways, airports, docks and harbours, building construction systems and indirectly to all disciplines. Civil engineering provides largest scope for employment next to agriculture. Research and developmental activities different branches of civil engineering have benefited to mankind in proper utilization of natural resources and every efforts are being taken to achieve objectives of sustainable development. With the increase in population, demands for buildings, roads, transportation and other infrastructure facilities are increasing. The cost of important construction materials such as cement, steel, bricks is increasing due to high pressure on demands, high processing and transportation cost and limited availability of resources. The over exploitation of natural resources such as stone, sand, wood, clay and other materials results in environmental deterioration.

To reduce the cost of constructions, research works related to low cost materials, utilization of waste materials for value added products and cost effective techniques to solve the problems related to water shortage and environmental problems, are being carried out by scientists and engineers. There is need to develop appropriate technologies in the area of development of cost effective materials using locally available suitable natural materials or waste materials and the area of cost effective processes to solve the need based or environmental related problems through participation of local people and their skills.

### **4. Appropriate Technology and its Characteristics**

Appropriate technology is small-scale technology. It is simple enough that people can manage it directly and on a local level. Appropriate technology makes use of skills and technology that are available in a local community to supply basic human needs, such as gas and electricity, water, food, and waste disposal. It is important to realize that use of appropriate technology does not mean turning the clock back to the 18th or 19th century. Although the technology involves simple, easy-to use and repair designs, it is based on sophisticated, 20th-century technologies. Appropriate Technology involves a search for technologies that have, for example, beneficial effects on income distribution, human development, environmental quality, and the distribution of political power as well as productivity in the context of particular communities and nations.

The appropriate technology movement in the rich countries such as the United States got started due to the convergence of a variety of concerns. These included the need to find a more harmonious and sustainable relationship with the environment, identify a way out of the accelerating energy and resource crises, reduce alienating work disconnected from its products and goals, develop more democratic workplaces, bring local economies back to health with diverse locally owned and operated enterprises, and revitalize local communities and cultural traditions. Thoughtful, careful social choices are needed to correct the excesses and imbalances of an industrial culture driven by materialism. An essential quality of the appropriate technology movement in the United States can therefore be expressed by the word "restraint".

The appropriate technology movement in poor countries has, on the other hand developed in a very different fashion. In the poor countries the small amounts of capital available have usually been concentrated in the small industrial sector, creating very few jobs due to the high investment required per workplace. The appropriate technology movement in poor countries has come out of the

recognition that industrialization strategies have not been successfully solving the problems of poverty and inequality. Indeed, in many cases "modernization" efforts have been massive assaults on local culture. The result for hundreds of millions of people has been the modernization of poverty—the neglect or construction of traditional craft occupations, the consolidation of farmlands into fewer and fewer hands, and the division of communities, leaving these people to eke out an existence on the fringe of economic activity. The appropriate technology movement in the developing world has developed as "the art of the possible" among the world's poor, seeking ways to solve pressing basic problems and create jobs with resources consisting of local skills and materials but little surplus cash.

From these different origins, the appropriate technology movements in rich and poor countries have been moving towards each other. The development of renewable energy technologies has long been a chief area of activity among U.S. appropriate technology groups. It moved high on the list of priorities in oil-importing poor countries in the late 1970's, as they faced high prices and scarcity of fuel for buses, tractors, and irrigation pumps. Similarly, environmental protection has gained increased attention in poor countries as pesticides have created major health risks for farmers and farm workers, and deforestation has reached a critical level.

### Appropriate Technology

1. requires only small amounts of capital;
2. emphasizes the use of locally available materials, in order to lower costs and reduce supply problems;
3. would be relatively labor-intensive but more productive than many traditional technologies;
4. would be small enough in scale to be affordable to individual families or small groups of families;
5. can be understood, controlled and maintained by villagers whenever possible, without a high level of specific training;
6. can be produced in villages or small workshops;
7. supposes that people can and will work together to bring improvements to communities;
8. offers opportunities for local people to become involved in the modification and innovation process;
9. would be flexible, can be adapted to different places and changing circumstances;
10. can be used in productive ways without doing harm to the environment.

Some of the reasoning that underlies the concept of appropriate technology may be summarized as follows:

1. it permits local needs to be met more effectively because local people are involved in identifying and working to address these needs; for the same reasons, it is likely to be in harmony with local traditions and values;
2. it means the development of tools that extend human labor and skills, rather than machines that replace human labor and eliminate human skills;
3. it represents a comprehensible and controllable scale of activities, organization and mistakes, at which people without management training can work together and understand what they are doing;
4. it allows more economical operation by minimizing the transport of goods in an era of expensive energy, allowing greater interaction of local industry and permitting greater use of local resources—both human and material;
5. it makes unnecessary many expensive or unavailable finance, transportation, education, advertising, management, and energy services; avoids the loss of local control that use of such outside services implies;
6. it helps to establish a self-sustaining and expanding reservoir of skills in the community which begins from already existing skills;
7. it provides a region with a cushion against the effects of outside economic changes (e.g., the collapse of the world sugar market or the sudden unavailability of fertilizer);

8. it helps to reduce economic, social, and political dependency between individuals, between regions, and between nations, by recognizing that people can and will do things for themselves if they can find a way.

Appropriate technology emphasizes the use of renewable resources, like the energy from the sun, wind, or water. Appropriate technology makes it possible to satisfy our basic human needs while minimizing our impact on the environment. We are running out of the natural resources necessary to sustain ourselves. In addition we are limited in our ability to deal with the social and environmental problems that result from continuous growth. There seems to be a growing dissatisfaction with the complexity and hectic lifestyle of 20th-century society. Many people would prefer to return to a simpler way of life. Appropriate technology is attractive because it makes households and industries more self-sufficient, and most things can be managed at a local level. We may have to do more hand labor instead of depending on automation to satisfy our basic needs. However, there are many advantages to simplifying our lives. By growing more of our own food and producing and buying goods in our own communities, we spend less time and money on transportation, produce less waste and consume fewer environmental resources.

Appropriate technology may involve judicious use of high energy materials to improve the properties of resulting composite materials. It will also involve development of eco-friendly processes to solve environmental problems. The development of appropriate technology in materials, products and services may demand simple cost effective equipments, machineries and process. Therefore, this technology may involve other disciplines like mechanical, chemical and electronics. This technology will help to set up medium to small scale industries, transfer of technology from lab to land, up-gradation of local skill, proper use of agricultural waste, waste materials and bi-products from industries, local development of people through participation in it directly or indirectly. This technology will sensitize the common people to understand about the alternate materials & technologies which will go a long way in achieving goal of sustainable development towards affordable housing. This technology will improve the scope for self development, practical experience, interaction with industries and entrepreneurship development opportunities. Thus appropriate technologies will help sustainable development of the region through use of local materials and skills and hence reduce the pressure on conventional costly materials and process.

#### **4.1 Obstacles in Appropriate Technology<sup>1</sup>**

The emphasis on self-reliance and local production for local needs, no need of well-developed infrastructure and of highly trained human power may be the reasons for that the concept of appropriate technology is so popular. The elements of self-reliance, local initiative, and local control that are essential parts of this approach present a challenge to conventional thinking in the development institutions. Up to 80% or more of the population in most developing countries lives in rural villages. Many of the people in urban areas fled the stifling lack of opportunities that tends to characterize rural areas. Thus successful rural appropriate technologies might concern some 90% of the population. An important voice in the dialogue about village technology can and should be provided by educated people working in rural areas in small projects. However, many of these people seem hesitant to get involved in experiments with technology, perhaps because this is seen as the work of engineers and scientists, and therefore as too difficult for others to undertake. Yet, the development of appropriate technology is not solely or even primarily a question of engineering design it involves a wide range of considerations. Appropriate technology work cuts across traditional lines of expertise, and benefits from the insights of local farmers, technologists, educated generalists and business people.

### **5.0 Appropriate Technology in Civil Engineering**

In today's context when India is heading towards economic growth and entering into an era of overall development, it is more than essential that we create an enabling environment for affordable housing for one and all. Over the years, we have realized that the technology exists but it

does not reach to the common people. Most of the time, we are either not aware of these innovative interventions or do not know how to proceed. It is now widely recognized that the cost of housing can be reduced and speed and quality of construction stepped up through the use of emerging innovative building materials and technologies. Despite a number of innovative cost-effective building materials, components and construction techniques developed through research the housing and building agencies have not adopted them in their construction practices. The extent to which lack of standards and specifications has been instrumental in hindering the adoption of homegrown innovative building material technologies has long been a matter of concern. Since non-listing of these new techniques in Indian Standards and Codes is quoted as one of the foremost reasons by construction agencies for non- adoption in their practice, the Bureau of Indian Standards (BIS) has been constantly striving to cover new technologies within the fold of standardization. While quite a few of new materials and techniques have attracted attention of the building industry and several housing agencies and have also been gradually identified in Codes of Practices, these have not percolated to the practices of organizations like CPWD, MES, State PWDs and others in public and private sectors. This indicates that there is wide scope for research and development of new cost effective, durable materials .

By and large, conventional building technologies like burnt bricks, steel and cement are high in cost, utilize large amount of non-renewable natural resources like energy, minerals, top-soil, forest cover etc. These increase dependence on external materials and manpower, harm the local economy and are generally polluting in nature. The materials and technologies chosen for construction must, in addition to functional efficiency, fulfill some or more of the following criterion, for the cause of sustainability and a better quality environment

- non endanger bio-reserves and be non-polluting;
- be self-sustaining and promote self-reliance.
- recycle polluting waste into usable materials
- utilize locally available materials
- utilize local skills, manpower and management systems
- benefit local economy by being income generating
- utilize renewable energy sources
- be accessible to the people
- be low in monetary cost

Details of some Environment-Friendly, Energy Efficient, Cost-Effective Composite Materials/Products for Low Cost Housing are summarized in the Table 1

Table 1: *Environment-Friendly, Energy Efficient, Cost-Effective Composite Materials/ Products for Low Cost Housing*<sup>4</sup>

Product	Basic Raw materials	Materials for production	Applications
BAMBOO MAT BOARD	Bamboo Plantation wood veneer	polymeric resin, chlorinated hydrocarbons and boron and cashew nut shell liquid	Flooring, walling, structural membrane, false ceiling, door/window frames.
BAMBOO MAT VENEER COMPOSITE	Bamboo Plantation wood veneer	polymeric resin, chlorinated hydrocarbons and boron and cashew nut shell liquid	Door skin in flush doors, structural use as roofing, web construction, prefab and portable shelters, packing, modular partitions, furniture.
BAMBOO LAMINATED COMPOSITE	Bamboo plant, wood Bamboo mat,	waste wood chips, polymeric resin	Flooring, walling and partitions.

BAMBOO CORRUGATED ROOFING SHEET	Bamboo grass (Plant), Species (Meleannca baccifera)	Bamboo, polymeric resin, chlorinated hydrocarbons, boron, cashew nut shell liquid, coating for UV protection and to improve impermeability to water.	Roofing sheets as substitute to corrugated Asbestos Cement sheets, Galvanized Iron sheets, Aluminum sheets and Fiber-reinforced Plastic (FRP) sheets.
BAGASSE COMPOSITE PANEL/BOARD	Waste from Sugar industry	General purpose, polyester resin, methyl ethyl ketene and cobalt naphthenate	For variety of building and furniture applications. Properties closely resemble with the wood but lighter in weight. Stackable and can be easily chiseled and sawed.
JUTE POLYESTER COMPOSITE	Jute industry (Jute plant is grown in several developing countries)	Woven jute fibbers, and polyester amide polyol as interfacing agent	Chip boards, roofing sheets, door shutters, partition panels and door/window frames.
COIR COMPOSITE BOARD	Coconut – Plantation in Coastal Regions	Core fibers, mineralized water, cashew nut shell liquid, para-formaldehyde	Medium Density Fiber boards, can be used as wood substitute for paneling, cladding, surfacing and partitioning and door/window shutters
CELLULAR LIGHT WEIGHT CONCRETE BLOCK	Fly Ash from coal based power generating plants	Fly Ash, cement, sand, water and foaming agent	Concrete blocks, densities ranging from 400 kg/m <sup>3</sup> to 1800 kg/m <sup>3</sup> . Filler walls. In-situ cellular walls & partitions. Very good insulation at roof tops for reduction of heat load in buildings.

Appropriate Technology will play important role in the development of base for research and development of cost effective and eco-friendly technology in various areas related to civil Engineering are suggested below.

1. Indigenous Material Technology : Use of different natural materials such as bamboo, coconut coir, jute fibers, banana fibers, sisal , sugar baggase, etc; in efficient way, application of bio-technology in development of required properties in these natural material.
2. Energy Efficient Technology: It includes cost effective technology applicable to green building, energy saving system ( natural ventilation ) , use of local materials in construction, use of solar, wind energy , bio gas energy etc.
3. Disaster resistance Structures : It includes earthquake resistance structures using light weight materials, portable structures, Temporary sheds in disaster affected areas, floating structures near coastal areas
4. Rain water harvesting techniques : Water conservation through roof top water collection and utilization system , Collection of rainwater from open spaces, parks, roads and using it for storage and ground water recharge. Reuse of water through recycle systems in processing units and factories like sugar, clothes, paper mill etc and service industries like automobile, washing hotels etc.
5. Waste Material Technology : conversion of waste materials into value added products.

Waste may be solid waste from treatment plants industries, sewage, processing units, wastes from construction sectors like recycled aggregates, road materials, waste from pipe, tile and other precast factories, waste from furniture, plastic wastes agricultural wastes, bio-composting etc.

6. Cost effective Transportation systems: Low cost roads in rural and remote areas, Temporary and emergency bridges, use of rope way systems in remote hilly areas, Use of Inland water ways for transportation of goods and persons with water cleaning techniques.
7. Bamboo and other useful tree plantation in open land.

With this in mind, it becomes essential to introduce a subject related to appropriate Technology and low cost technology in civil Engineering discipline in Engineering and research institutes so that short term research projects can be taken. This will create awareness about need and importance of sustainable development and they will come forward to develop the technology for common people and technology for our nation to reduce the pressure on demands on energy intensive materials. Role of government and local authorities in this area will be very important. Participation of local people, non-government organizations, and industries with vision of sustainable development with appropriate training will gear up the movement of appropriate technology. This technology will help to set up medium to small scale industries, transfer of technology from lab to land, up-gradation of skill, proper use of agricultural waste, waste materials and bi-products from industries, local development of people through participation in it directly or indirectly.

## 6.0 Conclusions

The vicious cycle of poverty, rapid population growth, environmental deterioration and more poverty and negative environmental impacts due to industrialization have triggered the concept of sustainable development. Civil Engineering is responsible for multidimensional growth in economic, social, environmental, industrial and business areas. Civil engineering is backbone of for the development of any country due to its characteristics which supports directly developmental activities infrastructure. Deterioration of environment due to over exploitation of natural resource materials and increasing cost construction , have created awareness in development of cost effective materials and processes related to civil engineering and hence appropriate technologies suggested in this paper will help the sustainable development of the region. There is vast scope of research in the area of development of appropriate technology in various area which is possible through interaction of various agencies and participation in projects related to appropriate technology.

## References

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