

## **SUSTAINABLE CONSTRUCTION**

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### **Introduction**

Its 8.00 am at the 13 storey building site of a leading developer in Gurgaon and the steady drone of the Gen-sets suggests that the work has started. Work resumed only yesterday after a construction worker died of a fall 3 days ago. The welders who need most of the power are not in yet since they put in a late night, but the supervisor incharge of the gen-set wants his boss to know that he is in . Dark plumes of smoke billowing out of the diesel generator indicate that it needs maintenance, however the site incharge can not afford a shutdown since he is already three weeks behind schedule.

A typical modern construction project has goals of meeting target costs, quality and time schedules. Designers as well as owners are however realizing that with due attention and meticulous planning buildings can be designed to save energy, decrease impact on the environment, be more people-friendly and reduce lifecycle costs.

*Sustainability in construction* is all about following suitable practices in terms of choice of materials, their sources, construction methodologies as well as design philosophy so as to be able to improve performance, decrease the environmental burden of the project, minimize waste and be ecologically friendlier.

The term 'ecologically friendlier' is an extension of the 'people friendly' concept, recognizing that mankind is only a part of the living creation and thus our activities should not disregard the welfare of the other species of the living world. Ecology signifies a totality of relationship with the living environment – a living harmonious with the natural order without making stark trespasses on natural systems. It implies a respect for the other members of the ecology around us.

### **Sustainable construction**

Sustainable construction means cities and buildings that respond to the emotional and psychological needs of people by providing stimulating environments, raising awareness of important values, inspiring the human spirit, and bonding societies, communities, and neighbourhoods. Sustainability in construction projects is generally achieved by :

- Defining clear goals sympathetic to sustainability issues.

- Concentrated effort at design stage to achieve these goals.
- Focussing on decisions like site selection, building layout, design etc.
- Choosing the right materials which are recyclable after their useful lives
- Choosing the right methods of construction in terms of energy and resource efficiency
- Creating an efficient and integrated building envelope harnessing the gifts of nature
- Integrating HVFAC and electrical systems.

The head office building of the Cement Giant – Holcim in Costa Rica<sup>1</sup> is an outstanding example of



a sustainable construction. It uses many passive design efficient mechanisms instead of wasteful conventional systems.

An intriguing piece of architecture it develops the environmental awareness of its occupants.

### **Trends / Attitudes**

Most development in the Construction Industry in the past has been in the direction of Cost Reduction, High tech (energy intensive) materials, Faster Construction and Mechanization (reduction in manpower ). Other than actions which make economic sense, ( like using demolition waste for filling), little has been done to make ecological sense. The imperative is a strong focus on the

environmental impact of materials as well as the construction methodology of the projects.

Only recently there is a sudden springing up of terms like Green Buildings, Eco Buildings, The Eco-house etc. signifying a conscious effort in recognizing the principles of sustainable construction. This is perhaps in response to other industries who have improved their environmental performance after realizing the unsustainable nature of current practice. There are also now certifications available by various organizations giving credits on the 'Greenness' of a Building. These include the USGBC<sup>2</sup> giving out a LEED Rating ( leadership in Energy and Environmental Design ), TERI<sup>3</sup> and IGBC<sup>4</sup>. The CII –Godrej Green Business Centre in Hyderabad<sup>5</sup> was the first LEED Platinum rated Green Building in India. Others buildings with LEED ratings that have followed suite are the ITC Green Centre - Gurgaon, Wipro Technologies - Gurgaon, Grundfos Pumps - Chennai and NEG Micon - Chennai. The 'green' features of the Godrej Building for example include

Zero water discharge ( 100% waste water recycling ), Rain water Harvesting, Minimum site disturbance (removal of trees), 55% reduction in energy consumption, 100% day Lighting, 15% Power – Solar PV, 60% recycled materials, Roof Garden – 60% area, Non Toxic paints and Fly ash Blocks.

Some people in the industry feel that such ratings are more of a fashion, an additional feather in the cap rather than a genuine concern to relieve mother nature. However it can not be denied that this is the desired direction. The intent may in some cases be superficial but combined with education and awareness training about the impending urgent environmental problems, this intent could be corrected to a more sincere concern .

The pursuit for Greenness in most of the above buildings has been owner driven, usually coupled with a similar interest and appropriate skill of the particular design team. Not in many projects though ! On ground, the construction teams seem to be oblivious of environmental matters.

Burdened with tight time schedules, and competitive cost considerations there is little time to learn about sustainability and ecology. In rare cases where the awareness of such issues is there, it is too lukewarm and gets easily washed out by unsympathetic contract specs or unaware owners or consultants.

The Govt. buildings too are lagging behind. The 'other considerations' hog all the upper rows of the priority list, pushing 'sustainability' too down below. This is made worse with poor implementation of the already weak and meagre policy in this direction. Compared to ours, the case of UK is commendable where sustainable development is at the core of

policy and the govt. housing schemes strive for performance ratings of 'Excellent' , Like other 'Successful management' practices, the switch to a more sustainability-sensitive construction can happen most easily if it is Owner initiated. This intent shall then be suitably expressed in the choice of consultants and appropriate measures in Contract specifications.

### **Structural Materials**

Engineered Structures in India are mostly made of concrete and brick masonry. Two modern innovations – one in each category are briefly described which can add ecological value to the existing conventional materials.

#### **Fly ash Concrete:**

There is ample data now to prove that good quality fly ash when added to concrete enhances its performance in terms of strength as well as durability. All though the Indian code does not encourage a replacement of above 35% of flyash, it has been adequately demonstrated in projects spread out in different parts of the globe as well as in India ( no less prestigious than the Delhi Metro) that concrete mixes with 50% fly ash and cement contents lower than conventional have yielded far more superior performance. Such High Volume fly ash concretes consume nearly 40 % less cement and hence save heavily on GHG emissions. These concretes cost at par or less, are far more durable than conventional, and hence have a lower life cycle cost. By exploiting the pozzolonic nature of Fly ash , such concretes convert flyash into a resource which is otherwise a nuisance waste. The chemistry of this type of concrete is such that the beneficial engineering properties keep on improving with age for several months later. If all the concrete in the world became HVFAC<sup>6</sup>, it has the potential to remove emissions equivalent to 1/4<sup>th</sup> of all the world's automobiles. Hence HVFA concrete – a gift of CANMET as a material is one of the strongest sustainable technologies available.

#### **Cellular Lightweight Concrete Blocks**

CLC blocks<sup>7</sup> as they are better known, are masonry blocks cast out of cement-flyash-sand slurry. Foam produced separately is introduced during mixing so as to incorporate millions of tiny cells of air in the mix thereby reducing the block weight as well as enhancing its insulative value. Almost half the weight of conventional brick masonry, it is possible to make such blocks with adequate strengths for infill walls. Due to the lighter weight of the blocks they are easier to handle and consume masonry mortar far less than conventional brickwork. Due to the

reduced self weight of tall buildings the earthquake forces get reduced and it is possible to economize on the structural design requirements. By virtue of the air bubbles in the mix, the insulative value of this material is 3.5 to 4 times that of burnt clay bricks. Hence considerable savings on air-conditioning can be achieved by using these in the building envelope. Like HVFAC, this technology also uses a large fraction of Flyash and so relieves the ash mounds . CLC has already been successfully used in many high rises in different countries as well as in the NCR and continues to get more popular. It is an encouraging step towards a sustainable construction.

Other important technologies to be included in sustainable construction are :

- Use of Solar PV and Biomass for supplementary (renewable) sources of energy
- Maximizing Natural Light and Ventilation thru intelligent design
- Rain Water Harvesting
- *Sanitary fittings* WC suites with adjustable flush volume upto 6 ltrs.
- Taps and Shower heads with water saving design
- Waste Water treatment and recycling ( DEWATS )
- Segregated Recycling of dry waste materials

***What needs to be done***

Most of all, the need of the hour is to spread awareness about sustainability, amongst all members of the society – owners, users, occupants, professionals, workers - technical or non technical ,employers, employees, govt. establishments, private organizations, old as well as the young. Once the underlying issues are clearly understood, individuals and bodies shall come forward with voluntary targets of performance and resource/energy efficiency in their activities..

- Creating adequate forums for increasing awareness and exchange of knowledge/information. Awareness campaigns at different levels – Resident welfare associations, educational institutions, work establishments – any and everywhere where people lend their ears.
- Regular In-house training sessions or ‘toolbox meetings’ specifically for practicing professionals on construction sites - architects, Engineers subcontractors about materials – their characteristics including impacts on cost as well as environment.

- Monitoring and reporting of successfully designed and built ‘Green’ projects.
- Incentives / penalties (to ensure execution) for contractors to follow sound sustainable practices like reducing waste and improving performance. This would encourage innovative solutions in this direction.
- Selection of Contractors with “sustainable Construction’ experience.
- Contract Specifications at the tender stage requiring from the contractor :
- Detailed recycling plans for waste generated
- Detailed safety plan for Site personnel
- Detailed Training plan for the work force
- Govt. policies and strictly implemented Building regulations including fiscal benefits / Taxes or Penalties w.r.t : Energy Efficiency, Water Consumption, Waste management and Renewable Energy. For example the Landfill Tax in UK which keeps increasing every year.
- Corporates to take responsibility in making ‘Sustainability’ a priority issue.
- Practice principles of Sustainability in construction and maintenance of their buildings and thus set examples.
- Establish quantified goals for energy, water and waste.
- Involve employees and educate them regarding pressing environmental problems
- Make Socially responsible Investments ( SRI) to support the cause of environment.

An impressive beginning has already been made in this direction by companies like ITC and HCC but the awareness has to permeate further among the masses for a quantum change to happen.

***Nature-friendly ?***

And while we have looked at ‘Construction’ – connoting building materials and methodologies, let us not miss out the more important aspect of the word – meaning ‘The built environment’. The following paragraphs are a jumble of ideas, concepts, technologies and sketches of individual personalities & groups who have association with the topic under discussion.

In a very personal sense, ‘sustainable construction’ means staying close to mother nature – enjoying the butterflies, birds and the bees instead of the ‘controlled environment’ of a ‘glass box’.

The gentle intermittent whiffs of the natural breeze carrying the scent of freshly mown grass or the beautiful smell of wet-earth after a sudden shower are precious gifts offering a pleasant relief from the

mundaneness of sitting before a computer screen in a perpetually artificial office environment.

Many individuals and groups all over the world share such ideas and have explored technologies and materials which are ecologically friendlier than the conventional ones. Many have actually showcased buildings incorporating those principles. The groups include *Development alternatives* – a Delhi based NGO and Auroville<sup>8</sup> in Pondicherry.

Auroville, - an experiment in human unity and living in progressive harmony has been exploring sustainable building technologies since it was born in 1968. The community has some remarkable achievements in the areas of Reforestation, Renewable energy, Appropriate building technologies<sup>1</sup> like ferrocement and building with earth blocks, Waste water recycling etc. It is now trying to incorporate these into a systematic design practice.

### **Earth Construction :**



*The award winning visitor's Centre at Auroville made with compressed earth blocks is one of the most attractive and comfortable buildings in south India.*

Building with earth is definitely a cost & energy efficient technology that has a great future.

Today, *Compressed Earth Block technology* is widely used worldwide, because it represents a synthesis of traditional practice and modern technology. It is also benefitting constantly from scientific input. Many organizations all over the world have come up with their own versions of Mud Block presses which can be used to compress stabilized earth and made into building blocks. *Hydraform*<sup>9</sup> of South Africa for example sells machines which can make high quality, dry stacking interlocking blocks from earth stabilized with 5% cement.



**USA, California - Project by Rammed Earth Works**

*Rammed earth* is another age old technique being revived in which earth is rammed in forms either

manually or pneumatically. This technology was used traditionally in countries like France, Morocco, northern India and Tibet, and is today used with stabilisers in USA and Australia.

Obviously, one has to master the disadvantages of this abundant material, learn the techniques so as to obtain the optimum possibilities with a harmonious, durable, agreeable and efficient architecture! With awareness, education and training earth construction is a strong candidate for 'sustainable construction.

### **Ferrocement**

Ferrocement – a variation of reinforced concrete is another appropriate technology for certain types of constructions. It uses the commonly available, energy intensive materials like cement and steel but in a highly efficient manner thus saving scarce material resources. With an ability to be cast into thin shell elements, Ferrocement opens possibilities which are not possible in conventional brick and concrete.

Steve Kohner of *flyingconcrete*<sup>10</sup> has done some exciting construction in this material exploiting the age old, structurally efficient vault shapes. Below are two examples:



Ferrocement can be used in exciting ways to make durable, light weight buildings



A vaulted residence designed and built by Steve Kohner, Mexico

Ferrocement which was explored well by Nervi of Italy 70 yrs ago lends itself remarkably to shell structures and domes. It is also used to prefabricate roofing channels ( DA ), door shutters, prefab toilets, soak pits and water tanks. A labour intensive technique, it can be mastered quickly with some training. By combining modern concrete technology with the art of ferrocement some very durable, lightweight, disaster resistant structures can be made.

Some of the big names that have been successful in the direction of sustainable construction are Nader Khalili of Iran / U.S , Laurie Baker of South India and Chitra Vishwanath team in Bangalore.

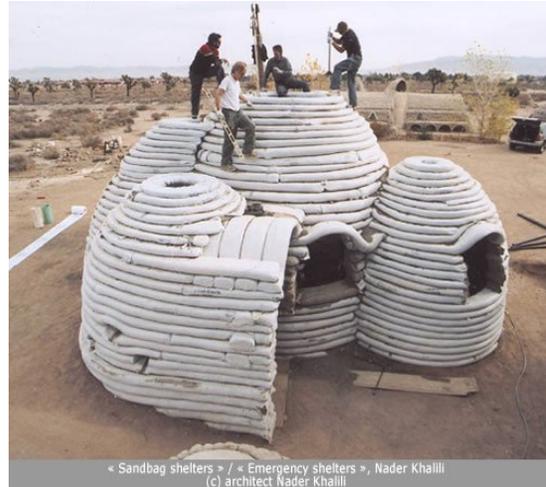
**Nader Khalili**<sup>11</sup> - an Iranian born, US based architect of world renown is famous for his innovations in earth architecture. His philosophy is based on the equilibrium of the natural elements of earth, water, air, and fire, and their unity at the service of the arts and humanity

“There is a Sustainable Solution to Human Shelter, based on Timeless Materials (earth, water, air and fire) and Timeless Principles (arches, vaults and domes). Every man and woman should be able to build a shelter for his or her family with these universal elements, almost anywhere on the earth and other planets..... The only missing link is to educate humans how to use these timeless techniques to fit their own culture and environment.”

Khalili's methods are now used all over the world to bring low-cost, self-help, eco-friendly, disaster resistant and affordable housing to people with otherwise very limited resources.. Not only is the potential cost of his homes cheap, but they are

beautiful to look at and live in, as well as being very environmentally friendly and energy efficient.

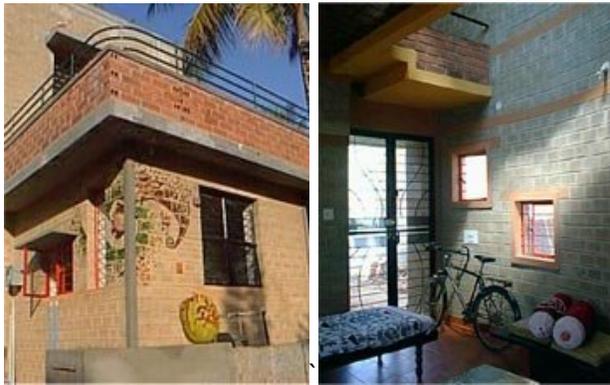
Below are pictures of a structure made by earth bag construction.



Khalili's greatest hope is that new space technology and architecture will influence people to open their minds to the concept of sustainable earthen homes. In his words -"Humans will gain spiritually and environmentally from these natural construction projects .....and begin to look within themselves for answers again."

**Chitra Vishwanath**<sup>12</sup> is a sensitive eco friendly architect practicing in Bangalore. Her design philosophy treats spaces as ecological spaces, not just physical spaces. Response to climate, conservation and judicious use of natural resources, and elimination of waste are consciously built into each project. The buildings are usually built with earth, harvest rain, sun and wind, encourage recycling and

reuse, attract local plants and birds and be unique but comfortable spaces.



Residences designed by Chitra exploit the bounties of nature – natural light, ventilation and the honest naked beauty of earthy materials.

**Laurie Baker**<sup>13</sup> – another shining star in the field of sustainable construction devoted his active career to the construction of low cost, low waste buildings in south India. Baker did not reject Modernism and technology but used it sensibly and sparingly, to build economic and



A stairwell in a residence in trivandrum has a perforated brick wall creating

affordable buildings which work with rather than against, local skills, materials, culture and climate. Through his buildings he was constantly refreshing local traditions of construction, reducing cost, providing service and minimizing waste – the basic principles of sustainable construction.



Creatively used local materials in the form of curves create interest in a public building

Architecture that encourages the folk-traditions closely related to the culture and life of the people as it is really lived, rather than the alienation of styles borrowed from elite houses or foreign cultures in the name of fashion, is sustainable.

### **The reality**

The developing countries, specially our own is on a path of rapid economic growth. This could stress our already emaciated natural resources beyond acceptable limits. Though India houses nearly one fifth of the world's population, it has only 2.4% of the land mass. Only 4% of the world's water resources are found in India and only 1% of the world forest cover. Water is already on the threshold of crisis in most metropolitan cities of India and many other parts of the country. Forests are being depleted in favour of expansion in mining operations as well as poor management practices. These facts should be a wake-up call for all of us in quest for sustainability. Rapid economic growth at the cost of our fragile environment will be a blunder that will not be forgiven by the next generations .

**- T.P. Singh** is the director of Construction Research Centre. His research interests include Environment, Climate Change, Sustainable development, High Performance Concretes, Non Destructive testing, Fire resistant materials, Ferrocement and Appropriate technologies.

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