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Sustainable Construction Materials & Technology in Context with Sustainable Development.

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AbstractIn India tremendous environmental problems are arising in construction industry due to rapid urbanization. Increase in demand of residential dwelling units which leads to consume more energy, resources, raw materials which are responsible for the rise in the carbon footprint. All metros are already facing environmental impact issues such as change in weather pattern, destruction of ecology.The solution lies in the sustainable development use of sustainable materials & technologies. Sustainable development is the one which meets the needs of present without compromising the ability of future generations to meet their own needs.This paper elaborates the concept of sustainable development that has come to the fore front in the last twenty years. This development is achievable through use of sustainable construction materials & technology. The concept recognizes that human civilization is an integral part of natural world & that nature must be preserved, perpetuated if the human community itself is to survive.

Sustainable development articulates this idea through designs that exemplify the principals of conservation & encourages the application of those principals in our daily lives.Sustainable development must use an alternative approach to the traditional design. The new approach must recognize impacts of every material & technology choice on natural & cultural resources of the local regional & global environments.

KeywordsSustainable Development, Sustainable Materials, Sustainable Technologies, Embodied Energy, Recycle, Reuse, Bio-Degradable, Life Cycle Design , conservation.CO_2emission.

IntroductionThe pursuit of sustainable development brings the built environment and construction industryinto sharp relief. It is a well-known fact that the construction industry is a major contributor to socio-economic development in most of the countries (C.I.B, 1999) [1]. Statistics show thatthe construction industry normally constitutes more than half of the total national capitalinvestment, and represents as much as 10% of G.N.P. in every country (C.I.C.A.& U.N.E.P.2002) [2]. The building and construction industry makes a major contribution to the consumption of resource, for example, in the European Union, buildings are responsible for more than 40% of total energy consumption and the construction sector is estimated to generate approximately 40% of all manmade waste (C.I.B.,1999)[1].Sustainable construction development has become a major subject of policy, research and innovation, globally. Green building movements in India are Establishment ofinstitutions by Formation ofIGBC, TERI launch of LEED and TERI-GRIHA [3].

The sustainable development uses locally available building materials which are energy efficient and durable. It provides an opportunity to living inhabitants to live with healthy, comfortable conditions throughout the buildings full life cycle. The life cycle consists of material production, construction planning, design, construction, operation and maintenance processes. The objective of sustainability is to achieve efficient use of resources,viz. energies, water, and construction materials with minimum impact on the environment of buildings.However, because of the complexity of sustainability and the fragmentationof the construction industry, the level of implementation of sustainable construction practices isstill low.At a conceptual level, sustainable construction can be divided into four dimensions:[4], 1.Economical,2.Social3.Environmental and 4.Technical. Economic sustainability includes the use of full-cost accounting methods and real-costpricing

to set the prices and tariffs of goods and services to achieve a more efficient useof resource

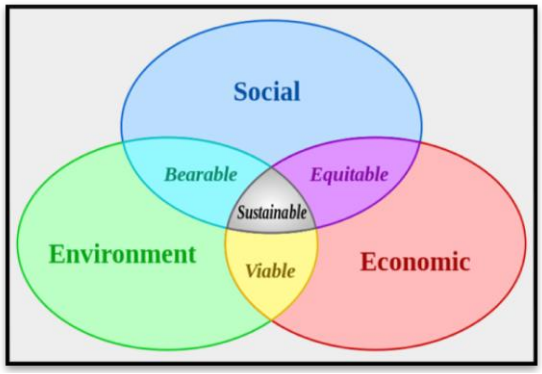

Figure 1: Conceptual level representation of sustainable development

Social sustainability highlights improvement in the quality of human life, and the humanliving environment, which includes culture, health, education, and intergenerationalequity.Environmental sustainability includes the notion that sustainable construction needs to protectthe natural environment rather than pollute it by encouraging the use of renewable resource and reducing the use of water, energy, materials and land at each stage of project.Technical sustainability requires high performance, durability, quality and mixed use of a building.This paper examines the concepts of sustainable development by adoption of sustainable construction materials and technologies. To be more particular we have shortlisted five sustainable materials.

Defining Sustainability

Buildings areby far the greatest producers of harmful gases such as CO2and this 'eco footprint can only increase with the largepopulation growth predicted to occur by 2050 [5].

Sustainability in construction is all about followingsuitable practices in terms of choosing materials, theirsources and construction methodologies as well as designphilosophy, so as to be able to improve performance,decrease the environmental burden of the project, minimizewaste and be ecologically friendlier, taking into consideration environmental, socio-economic and cultural values.All materials are ultimately derived from thebio-geo-sphere. They are everything between the take andwaste and are the key to sustainability. The choice ofmaterials for construction controls whole of life cycle impacts such as emissions, gross take, properties of wastesreturned to the bio-geo-sphere, use of recycled wastes andtheir own recyclability. Materials also strongly influencelifetime energies, user comfort and durability [6].

Countries with mature economies are in the position of beingable to devote greater attention to creating more sustainablebuildings by upgrading the existing building stock throughthe application of new developments or the invention and useof innovative technologies for energy and material savings.While developing countries are more likely to focus on socialequality and economic sustainability, [7].

Material selection profoundly affects manyvalue properties relevant to sustainability including weight,embodied energies, fuel related and chemical emissions,lifetime energies, user comfort and health, use of cycledwastes, durability, recyclability and the properties of wastesreturned to the geosphere-biosphere.

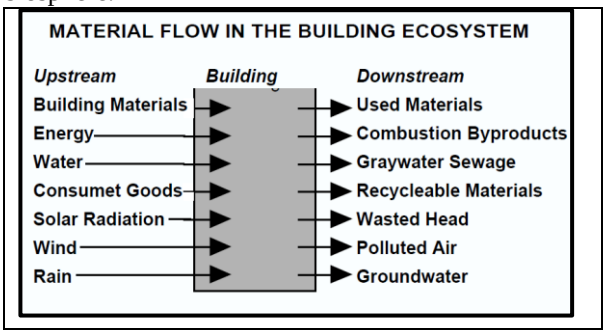

Figure 2: Schematic representation of upstream to downstream flow of products, energy in the building eco-system

Technology can make it possible to achieve after greater measure of sustainability, to economically reduce,re-use and recycle. The potential multipliers from spendingon research and development are huge [6].Identifies technologies which can be used during construction to improve efficiency and reduce waste [8].As long as sustainability in construction projects is considered it is generally achieved by, [8]:1) Defining clear goals sympathetic to sustainability issues.

2) Concentrated effort at design stage to achieve thesegoals.3) Focusing on decisions like site selection, building layout,design etc.4) Choosing the right materials which are recyclable aftertheir useful lives.

5) Choosing the right methods of construction in terms ofenergy and resource efficiency.6) Creating an efficient and integrated building envelopeharnessing the gifts of nature.

Methodology

Careful selection of environmentally sustainable buildingmaterials is the easiest way for architects to begin incorporatingsustainable design principles in buildings. Traditionally,price has been the foremost consideration when comparingsimilar materials or materials designated for the same function.

However, the “off-the-shelf” price of a building componentrepresents only the manufacturing and transportation costs,not social or environmental costs.

The three principles of sustainability in architecture.

1) Economy of Resources: It is concerned with the reduction, reuse,and recycling of the natural resources that are input to abuilding.

2) Life Cycle Design: Itprovides a methodology foranalyzing the building process and its impact on the environment.

3) Humane Design: Itfocuses on the interactions between humans and the natural world. These principles can provide a broad awareness of the environmental impact, both local and global, of architectural consumption.

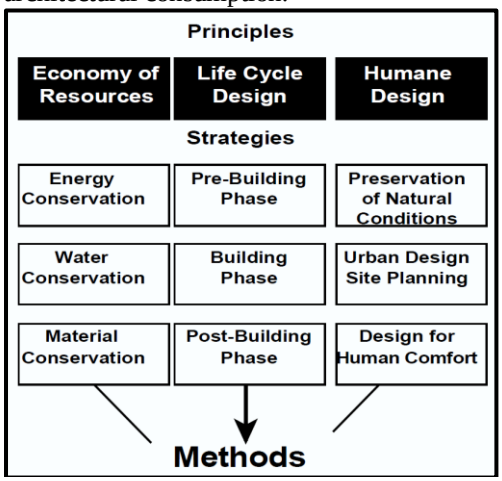

Figure 3: The three principals of sustainability

Each of these principles embodies a unique set of strategies.Studying these strategies leads to more thoroughunderstanding of architecture's interaction with the greaterenvironment. This allows further disaggregating and analyzing specific methods architects can apply to reduce theenvironmental impact of the buildings they design. [9]

Life Cycle Design

A "cradle-to-grave" analysis of building products, from thegathering of raw materials to their ultimate disposal, providesa better understanding of the long-term costs of materials. These costs are paid not only by the client, but also by theowner, the occupants, and the environment.

The principles of Life Cycle Design provide important guidelinesfor the selection of building materials..

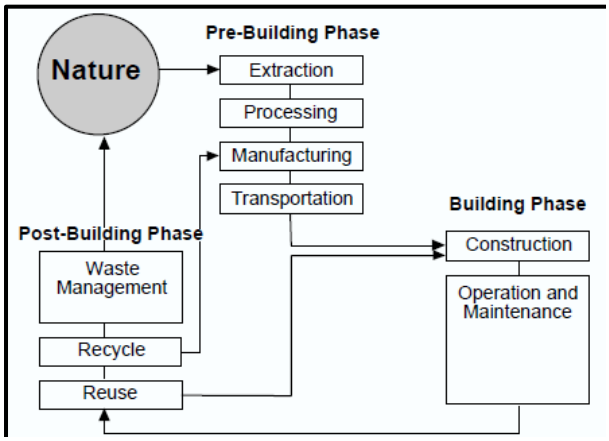

Figure 4: The sustainable building life cycle

A material's life cycle can be organized into three phases:Pre-Building; Building; and Post-Building.

Humane Design Strategies:

An essential role of architecture is to provide builtenvironments that sustain occupant'ssafety, health, physiologicalcomfort, psychological well-being, and productivity.The following three strategies for humane design focus onenhancing the coexistence between buildings and the greaterenvironment, and between buildings and their occupants,

1) Preservation of Natural Conditions
2) Urban Design and Site Planning
3) Human Comfort

Sustainable Building Material

Sustainable building materials can be defined as materials with overall superior performance in terms of specified criteria. For Selection of Sustainable building materials the following criteria are commonly used:

1.Locally produced and sourced materials 2.Transport costs and environmental impact 3.Thermal efficiency 4.Occupant needs and health considerations 5. Financial viability 6. Recyclability of building materials and the demolished building 7. Waste and pollution generated in the manufacturing process 8. Energy required in the manufacturing process 9. Use of renewable resources 10.Toxic emissions generated by the product 11.Maintenance costs

Few of the materials are described below

1) Lime:

Lime is our chief material which replaces the cement in building construction. It gives the good air quality by absorbingthe carbon and emitting oxygen in the atmosphere. The cost of lime is comparatively less than that of Cement. Life span of lime building is much more as comparedto cement building. [10]Depending on the mix of aggregate and water hydrated lime can be used to manufacture a lime Concrete, mortar, plaster or stuccoColor Lime Plaster.

Figure 5: Lime Plaster

The Volatile Organic Compounds (paints) are available by using coloured lime plaster as paint. It reduces the painting for whole structural life. It is maintenance free, washable and water proof. Its shine and glossiness increases as the time passes. It gives better aesthetics look than conventional painting work.

2) Fly Ash Bricks: Fly ash is one of the naturally-occurring by products from the coal combustion process and is a material that is nearly the same as volcanic ash.

There are following types of fly ash bricks :

1. Fly ash Lime/Gypsum Bricks
2. Clay Fly Ash Bricks
3. Sand Fly Ash Bricks
4.Red Mud- Fly ash bricks

Figure 6: Fly Ash Blocks

Environmental and Social Benefits Of Using Fly AshBricks:

The environmental and social benefits of using Fly ash bricks and its positive environmental effects are:1. Eliminate carbon emissions. 2. Saves top soil**.**
3. Source of all the year round employment.
4. Prevention of dumping of fly ash in ponds.

3)Eco-Friendly Tiles:

An Eco-friendly tile replaces the conventional flooring and uses less energy in their production. It is cheap as compared to the conventional tile. They are available as per the client requirement in various patterns and also easy to place. Thistile improves performance of indoor environment quality.Eco-friendly tiles are cheap in cost as compared to regular tiles; these tilesare manufactured on the construction site so that its transportation charges are reduced.

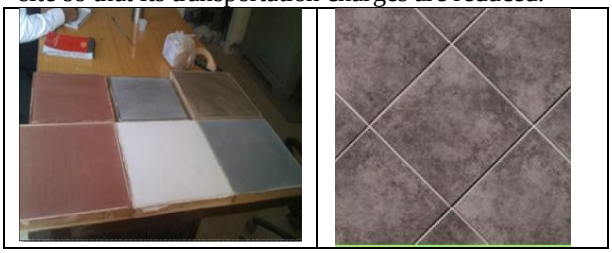

Figure 7: Eco-friendly tiles

4) Bamboo:

Bamboo is the fastest growing plant on earth.It is a member of the grass family and can be found in many regions throughout the world in a diverse range of climates from cold mountains to hot tropical regions [(11).] As a natural cellulose fiber, bamboo fabric can be 100% biodegraded in soil by microorganisms and sunlight" [(12)] showing that not only is bamboo an environmentally sustainable natural resource but also that disposal of the material has no damaging effect on the environment.Bamboo provides bamboo products suitable for use as roofing or cladding materials.

In Asian countries, it is used as a substitute to steel reinforcement in concrete and more recently bamboo has been manufactured for use as household flooring systems whereby the bamboo is steamed, flattened and glued together into flooring panels.

Figure 8: Bamboo as material

5) Ferro Cement:

Ferrocement has a very high tensile strength to weight ratio and superior cracking behaviorin comparison to reinforced concrete. Prefabricated ferrocement cavity walls present a series of possibilities for the solution of building construction at maximum reduction of the electrical energy.

Advantages of ferrocement as a construction material may be summarized as follow: 1. Very high quality control. 2. Pre-Fabricated products. 3. Easy production and installation.4. Shading devices to provide shading and day lighting to the building (use light weight and low cost environmental element).
5. Fast construction. 6. Manpower can be easily trained at site. 7. Improved structural performance.
8. Cost reduction, 15-50% cheaper than conventional techniques. 9. Less maintenance. 10. Reduction in dead weight, 50-75% lighter than conventional techniques

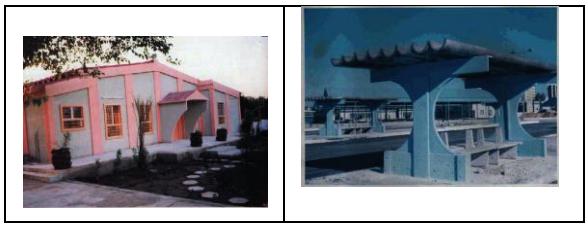

Figure 9: Buildings constructed with ferrocement

Sustainable Construction Techniques With green building becoming a critical part of today's world, more and more new construction technologiesare being developed to keep upwith this escalating shift to sustainability. The followinglist is the commonly adopted some of the techniques recognized in sustainable construction: 1.Low volatile organic compounds (V.O.C.) paint.2.Plywood processed without using formaldehyde.3.Install big windows that provide plenty of fresh air and natural light.4.Install energy and water efficient appliances. 5. Install low-emitting carpet.6.Proper site selection and prevention of pollution on the construction site.

Following is brief discussion about sustainable technology adopted in context to the sustainable

development.**1) WaterSystems Store, Recycle, Reuse** [12]This includes using lowwater use appliances, toilets, and faucets, recycling grey water (water produced by sinks, showers, and laundry), and eliminating irrigation. Recycled grey water can be used to irrigate the landscape rather than being discharged into the municipal sewer system.***Flush Toilets:*** These Specialized Water Saving Toilets produces a 10 to 15 Liters per flush toilet,some speciality flush systems save 90% water savings compared to conventional toilets. ***Composting Toilets:*** These can reduce the waste volume by 90%. When human wastesare mixed with enough plant matter (i.e.kitchen scraps, garden wastes, etc.) and when exposed to enough air, will decompose and become nutrient-rich fertilizer.***Water Heating:***All water pipes, cold and hot, should also beinsulated. A bottom board can also be installedbeneath the heater to prevent the loss of heatinto the floor. A timer can be installed on the tank toautomatically turn it off at night when thehot water is not needed. · A tankless heater or "demand" heater can beused. Solar energy can be used to help supplementthe energy input required.***Solar Water Heating:***In this system the panelscollect heat from the sun and transfer it to aglycol solution in copper coils. The coilstravel to a heat exchanger to deliver heat tothe water tank.Simple steps can be taken to reduceenergy consumption: Insulate the water tank, insulate the interior/exterior piping, install water-saving fixtures,and lower the thermostat setting. *Solar Water Heating Systems:*Most systems use flat plate collectors thatare mounted to face the sun.

a)Closed Loop Systemsb) Thermo siphoning
c)Open Loop Systemsd) Drain Back Systems
e) Batch Heater Systems

2) Heating, Cooling, andVentilation [12]In this new technique there is pushtowards using an integrated mechanical system.This means that space heating and cooling, waterheating, ventilation, and heat recovery worktogether as one unit. Furthermore, energy efficient air tight homes require a ventilation system to retain high indoorair quality.The mechanical system provides space heating, waterheating, passive solar storage, heat recoveryfrom grey water, and partial cooling. It isbased on a heat recovery pump that movesheat between an ice water storage tank and ahot water tank. In the winter, heat isextracted from the ice water and delivered tothe hot water tank. Space heatingrequirements are met via a fan coil unit.

3] Indoor Air Quality The best strategy for improving indoor airquality is through controlling the pollutantsat their source.Sustainable ways to improve indoor Air Quality are 1.Select low-emission materials,2. Plants as Environmental AirCleaners

4)Use Sustainable Building Materials If building a green home is your goal, then usingenvironmentally or eco-friendly products should be on your list which can reduce the impactof construction on the environment. Each and every part of house such as roofingmaterial, building material, cabinets, counters and insulation to flooring should beenvironmentally friendly. Use products such as reclaimed lumber, recycled plastic, recycledglass or natural products such as bamboo, cork and linoleum which are made of natural,renewable materials.

5) Cool RoofsA cool roof is a roof designed to maintain a lower surface temperature in bright sunshine than a traditional roof. The surface of a cool roof reflects more sunlight and releases more heat than a so-called hot or dark roof.

6) Zero-energy Buildings [13]

Zero-energy buildings are speciallydesigned and engineered to rely on renewable sources of energy, such as solar and wind power, allowing them to operateindependent of the electric grid. This green scheme not only saves energy, but it also prevents additional greenhouse gasemissions.A zero-energy design utilizes solar cells and panels, wind turbines, and biofuels, among others, to provide for the building'selectricity and HVAC needs.

Discussion

The role of materials for greater sustainability is discussed.A number of ways are suggested to make the constructionindustry more sustainable including reducing the energy ittakes to run buildings (lifetime energy), reducing the highlevel of waste in Construction, utilizing wastes to make construction Materials, reducing emissions during the production ofbuilding materials, sequestering carbon by utilizing carboncontaining materials and building using more durablematerials. There are no economic disadvantages of any ofthese methods and some; such a reducing embodied energiesare clearly economic. Underlying all is technological change,particularly in relation to materials.Materials are the key to sustainability in the builtenvironment and innovative new materials will allow architects and engineers to build structures that have greatervalue as they are more pleasing to use, live in or look at, healthier and much more sustainable.

Technology can make it possible to achieve a far greatermeasure of sustainability, to economically reduce, re-use andrecycle.

Future Scope:

1) Technological innovation in the field of automation with higher level of micro-processor based controlling systems leads to better performance of technologies like solar panels, Integrated HVAC & Electrical systems.2) In context to the Indian scenario new experimentation for the application of agro-waste as substitute for the sustainable construction material shall be explored.3) Non-conventional materials for a sustainable construction material with bio-construction system reinforced with cellulose fibers can be considered. Example of such system can be metakaolin +lime + hemphurds + waste paper pulp in place of conventional concrete.4) A digital computer based sustainable design tool for the building material applications for a particular building project involves integrated design approach. This involves Life Cycle Analysis based on CAD model. However present technological limitations do not provide a correct/optimum solution to the problem. Advancements in algorithm & more realistic data for the analysis engine can fine tune such tools. It will change the scenario of present building design technology.

Conclusion

Sustainable building materials are those which are produced or sourced locally. These materials are containing recycled & industrial waste materials and byproducts. Sustainable materials have a lower impact on environment & are thermally efficient. The production of these building materials require considerable less amount of energy in production when compared to the modern or traditional construction materials.

The advantages in selection of sustainable building material lies in the fact that they are not only economically viable but also reduce toxic emissions thereby reduce overall environment impact. Sustainable building material & technology should be utilized appropriately & contextually in each neighborhood development. The use of sustainable material & technology not only reduces transport & production cost, carbon emissions but also provides avenues for employment & skill development for community members.

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