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Waste to Resource for Sustainable Development

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Abstract

Objective: Waste is to be utilised as a resource material to reduce greenhouse gases. Green building concept is based on design efficiency, energy efficiency, water efficiency and material efficiency. Therefore, the objective of the study is to suggest "green index" for the materials which are energy efficient for use in the buildings for sustainable development. **Method/Analysis:** An empirical analysis has been made for working out "green index" for the building materials based on parameters of energy efficiency, waste content, durability, safety, local availability and maintainability. At present there is no basis on which any material can be classified as "green material". In absence of green index, material which uses waste during their manufacturing process or containing any quantity of waste are classified as green without any differentiation between two green materials. **Findings:** "Green index" value of a building material has been suggested based on embodied energy, waste content, durability, maintainability, toxicity and safety during installations, local availability, its recyclability and energy requirements during its use. Lower value is to be given to the materials having lower green value. Various materials using waste like fly ash, construction and demolition waste, and waste wood particles are considered in the study. Suggested "green index" will help one to determine and compare the values of green indices of different materials for selection of most green material available in the market for building construction. **Applications/Improvements:** Application of "green index" includes in determination and rating of various building materials for selecting most green material. Green index thus would be helpful for rating agencies, users as well as to the manufacturers of the building materials.

Keywords: Energy Efficiency, Green Building Materials, Green Index, Waste

1. Introduction

As per United States National Research Council[1], "Science has made enormous inroads in understanding climate change and its causes, and is beginning to help develop a strong understanding of current and potential impacts that will affect people today and in coming decades. This understanding is crucial because it allows decision makers to place climate change in the context of other large challenges facing the nation and the world. There are still some uncertainties, and there always will be in understanding a complex system like Earth's climate. Nevertheless, there is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities. While much remains to be learned, the core phenomenon, scientific questions, and hypotheses have been examined thoroughly and have stood firm in the face of serious scientific debate and careful evaluation of alternative explanations."

Jeffery A. Schneider[2] reported that according to the National Academy of Sciences, the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities. Human activities have altered the chemical composition of the atmosphere through the buildup of greenhouse gases - primarily carbon dioxide, methane, and nitrous oxide. The heat-trapping property of these gases is undisputed although uncertainties exist about exactly how earth's climate responds to them (US-EPA). The reason, the temperature has risen so much in the past 150 years is because of how much more we have used fossil fuels, which gives off carbon dioxide. Gary Brasch[3] reported, "According to NOAA, the global

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warming rate in the last 25 years has risen to 3.6 degrees F per century, which tends to confirm the predictions of temperature increases made by international panels of climate scientists (IPCC)".

Thus, it is imperative that the climate change is due to human interventions and needs immediate attention in all the fields, particularly in infrastructure development.

2. Energy and Fossil Fuels

Traditionally fossil fuels[4] such as coal, gas, and petroleum products have been used in producing electricity, manufacturing building materials and industrial products, running of vehicles etc. Due to combustion of the carbon, CO_2 is produced which contributes to a large extent to global warming. It is reported that in 2002, about 40% of US carbon dioxide emissions came from fossil fuel combustion, mainly coal, required for electricity generation, about 33% from vehicles and 12% from buildings. Thus, energy requirements appear to contribute most of the carbon dioxide emissions responsible for climate change. Even if theory of climate change is not fully understood and causes of climate change are not fully known, there seems to be increasing evidence showing the connection between the global warming and emission of greenhouse gases and thus emission of greenhouse gases needs to be reduced by switching over to renewable resources like sun, wind, water etc.

Electricity[5] is the main source of energy required in almost all the productions and even processes. The sources of electricity in 2009 were fossil fuels 67%, renewable energy 16%, mainly hydroelectric, wind, solar and biomass, nuclear power 13%, and other sources 3%. The majority of fossil fuel usage for the generation of electricity was coal and gas. Ninety two percent of renewable energy was hydroelectric followed by wind at 6% and geothermal at 1.8%, solar photovoltaic was 0.06%, and solar thermal was 0.004%. Thermal power plants using fossil fuels not only produce CO_2 but also fly ash, a waste product generating aerosols. It is also not feasible to shut down thermal power plants and thus there is a need to make use of waste generated from these plants by converting it into a resource material.

Sector wise total world energy[6] use in 2008 was in industry about 28%, transport 27% and residential and service 36%. In case, residential is clubbed with the energy required during construction and embodied energy in construction materials, this will amount to maximum. Thus, there is a need to curtail dependency of energy produced from non renewable resources in this sector. This can be done by using energy efficient materials in the construction, and making best use of renewable resources like sun and wind that is by following green building concept.

3. Green Building Concept

Green building concept is an integrated approach of layout of the building, architecture, engineering (civil, electrical, and air conditioning), landscaping/ horticulture, maintenance and housekeeping, thus includes sustainability criteria of site design, water conservation and quality, energy and environment, conservation of materials and resources, and indoor environmental quality. Hence, the concept revolves around conservation of energy, use of waste materials and waste water through design and selection of appropriate materials and technologies to save depleting conventional resources for sustainable development, simultaneously ensuring indoor environmental quality. Therefore, energy demand is to be partly or fully met from renewable sources like sun/wind. Use of net zero energy buildings, is gaining importance due to their independency on conventional non renewable resources though initially costly. Some of the benefits of green buildings are energy and water conservation, healthier and safer occupation, reduction in harmful greenhouse emissions, demonstration of owner's commitment to social responsibility and the environment.

Use of green building materials particularly manufactured from waste materials indirectly help in reduction of emissions of greenhouse gases. Some building materials manufactured from waste have now become a resource material, as mentioned in the following;

3.1 Portland Pozzolona Cement (PPC)

Cement manufacturing is one of the sources responsible for emissions of green gases and aerosols. Normally Ordinary Portland Cement (OPC) has been used globally. In PPC, about 30% fly ash can be used with OPC and thus fly ash, a waste material obtained from thermal plants requiring large space for dumping, water for preventing it to fly and responsible for producing aerosols can be used as a resource material. India now produces about 75% blended cement, largely PPC. Fly ash earlier considered a waste material has already been converted into a resource material.

3.2 Fly ash Bricks and AAC Blocks

Traditionally burnt clay bricks have been traditionally used in building construction. These require soil and considerable energy in kilns which emit greenhouse gases. Hon'ble Supreme Court of India has directed to use fly ash bricks in the areas near thermal power plants. Such bricks are now available in most part of the country and largely used in the construction. Use of fly ash bricks reduces CO_2 levels as these bricks do not use coal for combustion and are manufactured from a waste material. Autoclaved aerated concrete blocks are also being used extensively in the country, particularly in metropolitan cities. These blocks have density less than even water (about 600 kg/cum) and thus reduce the load of the structure, resulting into use of less quantity of materials. Use of fly ash and AAC blocks thus saves natural clay.

3.3 Fly Ash Mixed Cement Concrete

Conventional cement concrete has been traditionally used but it had low strength. This required higher sections of structural sections like slabs, beams, and columns. Use of high strength concrete, simultaneously, using waste products as admixtures has higher strength of concrete and requires thinner sections and thus consumes less cement and other natural materials helping in reduction of CO_2 levels. To make it energy efficient, fly ash is also added in making cement concrete as part replacement of cement. Readymade cement concrete (RMC) utilizing fly ash is being extensively used in reinforced cement concrete works in India.

3.4 Wood Substitutes

Timber is obtained from trees used in doors/windows, furniture, flooring, panelling etc. There are various substitutes of timber available, some manufactured from waste materials such as particle boards, medium density fibre boards, jute and coir particle boards, or from other fast growing planted trees like bamboo, rubber, Eucalyptus etc. Central Public Works Department, Government of India banned the use of wood in buildings in 1993 and made use of wood substitutes thereafter in the central government works. Use of alternate materials leads to prevention of deforestation a major cause of climate change.

3.5 Water

Water requires considerable energy in its transportation and treatment and thus water needs to be used judiciously and then waste water again requires a considerable energy in its transportation. Therefore waste water needs to be used at the nearest place. Recycling of waste waster thus has both the advantages. Hence, recycling of water and use of faucets requiring less quantity of water are essential in the buildings to reduce impact on global warming. Government of India is also giving emphasis on similar measures in old government buildings. Many local bodies in India have mandatory provisions of sewage treatment plants and rain water harvesting.

In irrigation a large quantity of water is consumed and thus large scale efforts are required to switch over to modern techniques of irrigation like sprinkler or drip irrigation than flood irrigation.

3.6 Other Waste based Building Materials

Green building materials and products manufactured from waste materials need to be used in the buildings as they consume less energy during their manufacturing and also during their use, such as flooring tiles, ceiling tiles etc.

3.7 Use of Construction and Demolition (C and D) Waste

A large quantity of C and D waste is generated in India due to two reasons, one from repair and renovation and two from construction waste. Apart from this, sub standard work which reduces life cycle of the structures also leads to generation of C and D waste. There is a need of strict quality in construction and avoid C and D waste and thereafter use of remaining waste in manufacturing of usable products. Though some efforts have been made in this direction as in Delhi, a plant has been installed which manufactures tiles, interlocking blocks, kerb stones etc. but large scale efforts are still required. Awareness of segregation of C and D waste and municipal waste needs to be generated among the citizens.

Cement concrete roads reflect solar energy into the atmosphere while bituminous surface absorb it. Reflected energy produces green house effect and also bitumen being almost a waste should be used as a resource material for the roads. Nowadays, waste materials such as fibres are added to enhance performance and life of such roads. There is a need to make use of recycling of bituminous roads in large scale in India.

3.8 Use of Solar Energy

Use of non conventional energy such as wind and solar energy is essential for reduction of green house gases. Government of India has already decided to take up production of solar power on large scale. It is essential that use of solar energy is tapped to the fullest extent in India due to its availability in many parts and also during most parts of the year. Solar PV panels can be provided in the buildings as well as open places. Production of solar power is to be taken up as an industrial product.

4. Green Index

"Green" word used in the green building concept is a relative term hence a material is compared with other one to judge as a green material. A three star rated air conditioner is green compared to two star rated but not in comparison to a five star rated air conditioner. Hence, parameters and their weight ages are to be fixed for determining the "green value" or "green index" of the materials also suggested by CPWD[7]. The parameters and weight ages are suggested for the same in Table 1.

Table 1. Suggested weightages for green indices of parameters

Sl. No.	Parameters	Weightages
1	Embodied energy	20
2	Waste content	10
3	Life cycle/durability	15
4	Maintainability	5
5	Toxicity (i/c during fire)	10
6	Safety during installation/use and disasters	10
7	Local availability	5
8	Recyclability	5
9	Energy requirement during its use	20

In India, Indian Green Building Council[8] (IGBC) rates buildings as Super Platinum, Platinum, Gold, Silver and Certified based on the qualifying marks and has registered over 2000 buildings. Association for Development and Research of Sustainable Habitat[9] has registered more than 350 projects for rating of green buildings in India. The association rates buildings as one star, two stars, three stars, four stars and five stars based on a criterion of 34 parameters. Central Public Works Department, Government of India has decided to construct buildings qualifying for minimum three stars ratings. Thus awareness has to be generated among architects, engineers and owners of the buildings for construction of green buildings even if they are not rated. Central Public Works Department, Government of India has also constructed many green buildings and "Indira Paryavaran Bhawan"[10], a net zero energy multi storeyed building in New Delhi in which 1.4 million kWh energy is being produced annually on site through solar PV panels mounted on roof as well as on cantilever structures supported on different floors (Figure 1). By using green building measures in selection of lighting fixtures, the demand of energy has been reduced and thus total energy requirements are being met from the energy produced through solar PV panels, making building self sufficient in energy requirements. Thus, solar energy which was being wasted has been converted into a resource.

Figure 1. Indira Paryavaran Bhawan at New Delhi, a net zero energy building.

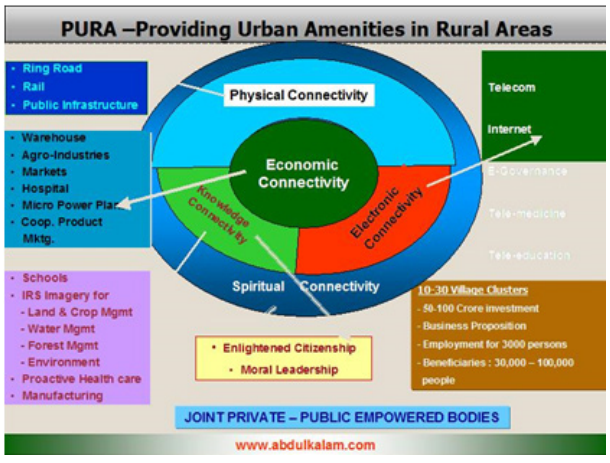

Figure 2. PURA concept.

5. Avoidance of Waste

Gandhiji said[11], "Earth provides enough to satisfy everyman's need but not enough for any man's greed". Greed always leads to wastage. All the materials or products have embodied energy and require considerable energy in their productions which comes from fossil fuels responsible for greenhouse gases and climate change. Therefore wastage of such materials and products thus lead to wastage of energy. Also all the products require water in their production and thus wastage of agricultural, industrial and building materials also lead to wastage of water. It is reported[12] that to produce 1 kg of wheat, 1350 litres, 1 kg of potato, 160 litres, and 1 kg of maize, 900 litres water is required. Dumping of 1 kg of beef results into wastage of 22000 litres of water while one kg of rice into 3000 litres. Also[13] a single A4 size paper requires 3 gallons of water in its production, one pair of shoes 2257 gallons while one pair of jeans 2636 gallons. Thus, wastage of food, raw or cooked, industrial products or natural materials means considerable wastage. It is irony that 30 to 40% food is wasted worldwide and thus not only water but considerable energy is wasted.

Thus wastage means emission of greenhouse gases, whether it is wastage of food, clothes, paper, energy, water, building materials, or any other product. Greed leads wastage due to accumulation of resources which are hardly used but have considerable embodied energy. For example, one may have ten pairs of dresses locked in a cupboard and sparingly used. Thus, not only embodied energy in these dresses is wasted but energy consumed in incineration and disposal is also wasted contributing to greenhouse gases. Thus, there is a need to avoid wastage else convert into a resource as far as possible.

Apart from engineering solutions, human behaviour also needs to be changed for energy, food and water conservation. Administrative actions are also required to make use of available resources. For example a large number of buildings are vacant in India though many are living in slums. In some cases, owners neither use them nor rent them due to fear of not able to get them vacated when required. Thus large resources are wasted. As per a report published in a daily, Hindustan Times, during September 2012[14], 17.95 millions housing units that came up in India between 2007 and 2012, 11.09 million houses, nearly 62%, were either vacant or locked up. Therefore, there is a need to utilise them by removing the fear of the owners and protecting their rights and to avoid wastage of available resources.

Similarly considerable energy is wasted when individual cars are used by a single person compared to public transport. By creating efficient public transport, emission of greenhouse gases can be reduced drastically. Large amount of resources are wasted as individuals, companies and many organisations do not pool the resources. For example, an airline company may fly with half capacity and after ten minutes, another one with almost same capacity to same destination. Thus, resources are wasted resulting into increase in greenhouse gases emissions. Pooling of resources at all levels is required to reduce the wastage. Even government departments create their own infrastructure separately and do not pool the resources like every department may have its conference halls, auditoriums and board rooms though sparingly used.

6. Sustainable Development

Sustainable development is mostly defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Aim of sustainable development is to improve quality of life by ensuring quality of work life and atmospheric environment. Thus, quality of work is a function of sustainable development. A poor quality work requires a lot of resources during maintenance stage and leads to wastage of energy and other natural resources as it has less life and hence resources are required multiple times within the specified life cycle of the building in repair, renovation and reconstruction. Hence quality must be given prime importance for sustainable development.

Life cycle cost needs to be considered while designing the infrastructure as capital cost based design considers only initial cost without considering other important parameters like energy efficiency, environmental effect, sustainability, as it becomes difficult to quantify their long term benefits. For example, a "green" or "net zero energy building" may be initially 7-20% costly but additional cost may be recoverable in its payback period of 3-10 years and thus considering life cycle cost of the building green buildings or sustainable buildings becomes economical. Similarly a load bearing building with one and half brick thick wall has high insulation effect compared to one brick wall and additional cost involved in construction would be recovered in few years due to saving in electricity consumed in heating/cooling of the building. Government

of India has already announced construction of 100 smart cities therefore sustainable development with life cycle cost needs to be given weight age in the design of such cities.

A concept of "Providing urban amenities to rural areas (PURA)"[15] was given by former President of India, Dr. A P J Abdul Kalam in 2003 (Figure 2). As per the concept, urban amenities are to be provided within a reach of villages and small towns. This will reduce transportation, multiplicity of creation of assets, deforestation, and migration of rural population and also provide chances of getting necessities and employment near their residences. Thus, this will help in reduction of use of vehicles for long journeys, construction of buildings in urban areas and ultimately large reduction in energy requirements and emissions of greenhouse gases. Government of India also implemented the pilot projects at some places. Now the assessment is required to be made of its success.

Sustainable criterion has to be understood by high income group people and implemented first by them by reducing wastage as they utilize large amount of resources.

7. Conclusions

Climate change can be reduced only by adopting sustainable development. As infrastructure development consumes large amount of energy, an emphasis needs to be given on construction of green buildings and net zero energy buildings by tapping renewable energy resources.

Infrastructure development consumes considerable energy in its production, maintenance and disposal hence, quality has to be given prime importance in its development to reduce wastage.

Waste management has to be adopted through prevention, minimization, reuse, recycle and recovery. Waste has to be converted into a resource for sustainable development and prevented for "Swachh Bharat Mission" launched by the Prime Minister of India.

Green building concept has to be adopted in development of infrastructure for sustainable development. Green indices have been suggested to determine a building material for being its green.

Though everyone has to contribute in reduction of greenhouse gases, but sustainable development is based on human needs and thus has to be considered more by those in higher level of needs as they consume considerable natural depleting resources.

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