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Life Cycle Energy Analysis of a Traditional Building in India (A Case Study)

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ABSTRACT
Some of the major environmental concerns of our time are the depletion of the ozone layer, the wastage of limited resources such as oil, gas and minerals, the loss of forested areas, toxic chemical manufacture and emissions, the obliteration of natural practice with the effluence of land, water and air. The environmental crisis has made us focus our attention on the impact buildings will have on the environment. Hence we need to be aware of the possibilities of saving energy by designing buildings according to vernacular architecture, which normally involves informal building compositions during the method of traditional building with local associates in addition to locally available materials. This paper discusses the consequence of material assortment and construction scheme with respect to its energy incurred throughout its existing sequence (Unrefined fabric acquisition, product manufacture & transportation, construction, operation and maintenance, renovation and demolition). It is all mainly related to the multi-faceted nature of environmental sustainable design.
***Keywords**:* Vernacular Architecture, Traditional Buildings, Life Cycle Energy Analysis

I INTRODUCTION

Indian architecture is entrenched with its history, culture and religion. Throughout India, buildings are made up by usual methods and exclusive of architects. Whether creating family houses or village temples, cereal stores or small rooms, the Indian designer works on the authority of the ancient and sometimes religious practice with whatever materials are to hand, to suit local conditions and extremes of climate. The builders of these structures are unschooled in official architectural design with their reflective work which enrich the diversity of culture. Usually the huge number of buildings are made for residential, commercial and industrial purposes. In world-wide buildings major energy utilization in their assembly, process with preservation is about 30 – 40% which held responsible for emitting 40% of global warming. The 24% of primary energy with 30% of electrical energy utilized for buildings in India. Indeed, the designers of these traditional buildings were often concerned with saving energy, fuel costs historically being higher than they are now, we should understand that older buildings have important lessons to teach, with regard both to innovative structural design and the existing structure renovation.

The aim of the paper is to demonstrate and discuss the use of LCEA in the context of traditional buildings and to stimulate the awareness upon the society that the old traditions in art and building architecture which carry them in forecast of National construction and to implement the concept of traditional creation negotiating the essence from ancient text and interpret it to suit modern constructions.

Typical Outline Of The Traditional Building

For simplicity and clarity, Life cycle energy analysis is demonstrated for a traditional residential building. The structures analysed is constructed before 300 years and is situated in Tamilnadu, India. It is designed according to the climatic conditions and with the number of energy saving techniques.

Life Cycle Energy

The life-cycle energy use for the building derived by the summation of three main components such as initial and recurring embodied energy, operating energy and Demolition energy which is insignificant.

(i) EMBODIED ENERGY OF STRUCTURAL SYSTEM

The attainment of raw materials and manufacture, transport and install building products is made through embodied energy at the original construction of building.Table 1 summarizes the results of studies on the initial embodied energy of the traditional building. The initial embodied energy for the studies building is about MJ

(ii) RECURRING EMBODIED ENERGY

Analysis of Life cycle energy made account for the changes in embodied energy associated on upkeeping with the improvements on building. This energy is constructive to distinguishes repainting, replacement of systems, recarpenting, lamps etc with regular periodic refurbishment due to changes in tenancy. Maintenance and replacement occur periodically but it to be carry over entire life time of a building. It can be disturbed in to two classes,

- Maintenance incurred during the intact life cycle of the element. For the merchandise which completes its duration, the number of renovate cycles required is the product life/repair interval corrected for the prospect of declined repairs by the end of the product life.
- Maintenance incurred during the incomplete duration of a invention due to the termination of the building. For the last replacement of a product, the number of repair cycles will pivot on the years enduring before the existence of the building expires rather than the product life.

Replacement consigns to the entire replacement (100%). How many times component is replaced is given by the building life or product life corrected for the possibility that if the surrogate transpires near the last part of the building life, non-essentials and replacements would be avoided. For this particular type traditional building, the recurring embodied energy is very less and hence it is neglected.

(iii) DEMOLITION ENERGY

Energy used to demolish buildings and transport and disposal of waste material is referred to as demolition energy. Current demolition practice entail passionate application of energy and haulage to landfill. In any case, the energy required to demolish the building is generally considered to be very small compared to the rest of the life cycle energy. Therefore the demolition energy is neglected. Furthermore, embodied energy reserves from reprocess or reclaim the raze materials should be attributed to the next user, not to the demolished building.

(iv) OPERATING ENERGY

Operating energy comprises the energy used for space heating and cooling, hot water heating, lighting, keep cold, cooking and use with equipment operation. Space heating and cooling is often simulated using computer programs such as CHENATH, TRANSYS, TEMPAL and DOE 2. The energy used to heat, cool, ventilate and light buildings represent over 50% of India's national energy use, with approximately 20% used in residential buildings and the remainder in commercial buildings. Operating energy varies considerably with the building use patterns, climate and season and the efficiency of the building and its system. The building is partially occupied during day time between 8.00 a.m to 6.00 p.m and is entirely occupied during night time which is completely operated through week end i.e. Saturday, Sunday and other public holidays. Thus calculated annual operating energy demand of the building for its operation is rehabilitated in to primary energy through its conversion factor. A primary energy conversion factor of 3.4 is adapted for electricity from National Grid. Yearly functioning energy of the building made to be constant throughout its life span. Table 2 summarizes the operating energy associated with the building and chart 2 gives the summary of annual operating energy.

(v) LIFE CYCLE ENERGY

The focal promotes of LCEA is that the embodied energy costs of products, design modifications with approaches utilized to optimize running energy which can be evaluated. Life cycle energy was calculated using the equation:

$$\mathbf{LCE = EE_i + (EE_{rec} + OE) \times building\ lifetime}$$

where:
LCE =the life-cycle energy,
EE_i = the initial embodied energy of building,
EE_{rec} = the annual recurrent personified energy (for example, in maintenance)
and
OE = the annual operational energy (together with the space conditioning along supplementary domestic energy uses).

SIGNIFICANCE OF OPERATING ENERGY

The utilization of energy for the operation of the building is by far the largest component of life cycle energy use for a common residential building. For this typical building, the energy to heat, cool, light and provide ventilation is considerably less because of its sustainable design. The **annual operating energy** was found to be **24393 MJ**. The space provided at the centre supplies the building with natural ventilation and lighting thereby reducing the operating energy costs. Also the fuel used for cooking is obtained from small scale biogas plant with the biomass as cow dung slurry. Though the efficiency of the biogas plant depends upon the quantity of biomass fed in to it, the building manages to get the fuel for cooking throughout the year. Operating energy can be reduced by utilizing the biogas, which can be converted to electrical energy by proper transferring devices. Moreover, if the building operating energy was reduced by 75% representing universal place performance made early in the 21st century, operating energy would fall to approximately 5.5% life cycle energy use for India respectively.

SIGNIFICANCE OF RECURRING EMBODIED ENERGY

At the current energy standards, the embodied energy is irrelevant for substitution and renovation. The chronic energy is very less when compared with the initial embodied energy particularly for this building, the reason being the use of natural materials such as jiggery, agle marmelos, chebulic myrobalan which generally made the building to sustain for longer years. The use of teak wood which is prone to termite attacks needs to be repaired and taken care of at frequent intervals for a general building. But the use of herbal slurry such as neem prevents the material from such attacks. It also increases the life of the material. Now a days, in almost all residential buildings, the recurring embodied energy is found to be equal as that of initial embodied energy at its end-period. The addition of herbal slurries in the construction of the building not only increases the life time but also reduces the recurring energy of the building.

SIGNIFICANCE OF EMBODIED ENERGY

Though a net zero operational energy building is now achieved, a zero life cycle energy is likely to be more difficult. This is due to the fact that the embodied energy cannot be achieved to zero. The energy involved in processing the materials and its transportation will certainly increase the initial embodied energy. We cannot completely attain a zero initial embodied energy, but it can be minimized by suitable construction techniques. By adopting the traditional building materials and techniques, the embodied energy can be drastically reduced. Another alternative solution is utilizing the locally available materials for construction, which will reduce the transportation and fuel costs. By doing So,vernacular architecture can save up to 25% of the overall cost.

II SENSITIVITY ANALYSIS

Life cycle energy of the building has appraised on various life spans of the building to judge its impact on LCE stipulation of the building. The demand is decreasing with increase in life time of the structure. The embodied energy which decline in increase of the life span of the building causes LCE of the building to come down.

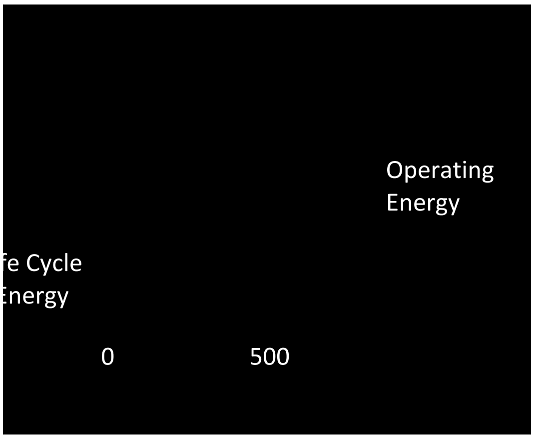

Chart 1: Life Cycle Energy

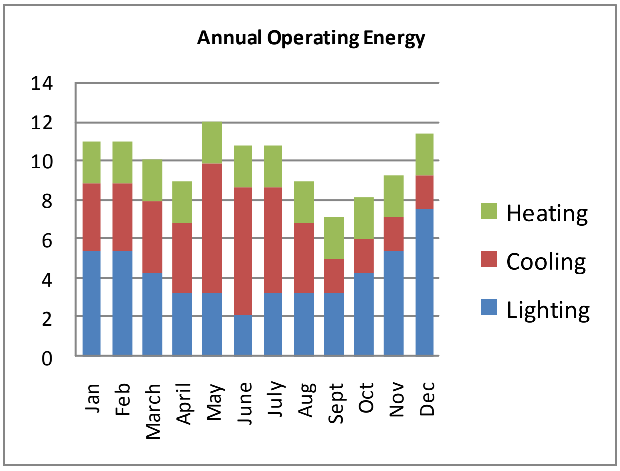

Chart 2

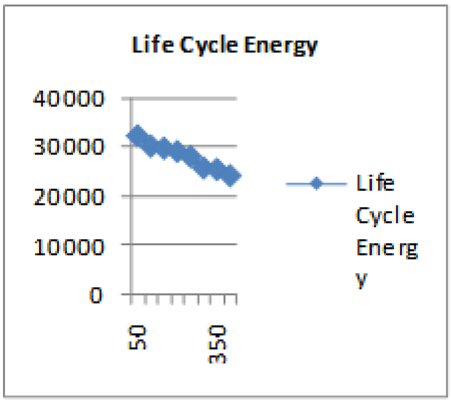

Chart 3

Chart 2 and Chart 3: Annual Operating Energy Summary & Sensitivity Analysis

Table 1: Initial Embodied Energy of the Building

MATERIAL	UNIT	QUANTITY	ENERGY INTENSITY (MJ/UNIT)	EMBODIED ENERGY (MJ)
Aegle Marmelos	m^3	0.14	-	-
Brick	m^3	105	3	315
Chebulic Myrobalan	m^3	0.14	-	-
Cow dung slurry	m^3	2	-	-
Egg	m^3	2	-	-
Jaggery	m^3	0.11	-	-
Lime slurry	m^3	5.10	7.12	36.31
Mud Slurry	m^3	4.2	-	-
Stone	m^3	10.26	1.00	10.26
Tiles	m^2	15	1.47	22.05
Teak	m^3	5.5	2.12	11.66
Wood	m^3	21.5	0.751	16.146
			Total	**411.43 MJ**

Table 2: Operating Energy of the Building

Type of Appliances	Units	No. Of Appliances	No of hours Used/day	Load	Energy (MJ)
Lamp	60 watts	5	7	300 watts	7.56
Ceiling Fan	60 watts	4	7	240 watts	6.048
Table Fan	40 watts	1	2	40 watts	0.288
TV	150 watts	1	5	150 watts	2.7
Heater	1500 watts	1	15 minutes	1500 watts	2.16
Radio	50 watts	1	5	50 watts	0.9
				Total	**19.656**

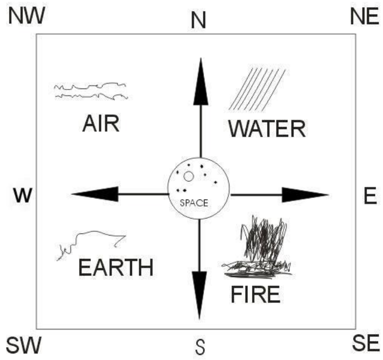

Fig.1: Typical outline of the traditional building

III CONCLUSION

Arising the way they are designed and constructed, traditional buildings respond to changes in temperature in very scrupulous traditions. Appropriately cleared, the mode of traditional buildings behave can be exploited to make them more comfortable and more energy proficient, at the same time as saving money on heating bills. Good architectural conservation is environmentally upheld as a nation we ought to be there on conserving historic buildings not only for their enlightening significance but also because it makes environmental sense. There is no single solution to assure sustained green architecture, but that designers should be aware of the factors to be evaluated when materials and components are specified. The production of sustainable building involves resolving many conflicting issues and requirements. Each design decision has environmental implications. Buildings are the aggregation of multitude of components made from a wide range of different materials. There is no universal agreement on how to calculate embodied energy and there are no universally acknowledged parameters for defining sustainable materials, products or building systems. Environmental energy is one of the methods of assessing the environmental impact of a building. However the environmental implication of material selection extends beyond the embodied energy of the materials.

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