International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 9 Sep. 2022, pp: 1417-1420 www.ijaem.net ISSN: 2395-5252

Estimation of Embodied energy of building located in North-eastern India

Somdeep Chakraborty[1], Santanu das[2]

[1] *Assistant professor, Tripura Institute of Technology, West Tripura, (India) PIN 799009*
[2] *Scientist SD, NESAC, Department of space, Govt. of India,Umiam (India) PIN 793103*

Date of Submission: 20-09-2022 Date of Acceptance: 30-09-2022

ABSTRACT: - To support the continuous rise in population in the urban areas, demand for infrastructure is also increasing day by day even in the farthest corner of the Indian cities. This growth in urban structures is highly energy intensive and provides a strong negative impact on the environment directly or indirectly. In this context the operational energy consumption has been assessed by several building rating systems in different parts of our country. But very limited researches have been conducted related to the energy already entrapped in the building itself that too with a very limited sources of data which is hardly applicable for north eastern states of India. Modern buildings are complicated systems and their characteristic features differ from one place to another due to the change in socio-cultural environment, climatic and geological aspects. Accordingly the amount of embodied energy is likely to be different from place to place and needed to be assessed in order to optimise for sustainable development. This discourse is an attempt to quantify the embodied energy of residential buildings located in one of the north eastern cities of India.

Keywords: Building material; Embodied energy; Seismic zone; sustainability;

I. INTRODUCTION

Urbanisation is taking place in a faster rate in India. As per World Bank report the population residing in urban areas in our country already crossed 34% in 2017 and According to the survey by UN State of the World population report in 2007, 40.76% of population is expected to reside in urban area by 2030. Though the north eastern states like Assam, Tripura, Meghalaya and so on had a rich tradition of solar passive buildings and vernacular architecture that are eco-friendly and organic in nature but due to land constraint in cities and acceptance of global trends, higher preference of multi-storeyed buildings have been increased in recent past. Being in an earth quake prone area (seismic zone-V) and humid tropical climate, most of the residential buildings are preferred to be of Reinforced Cement concrete structure [1] with large opening with regular shading device. Due to this paradigm shift in design and technologies along with a change in lifestyle in recent decades, the trend of construction industry has resulted a huge consumption of energy resources which are required to be addressed very soon. As per the study by UNEP [2] during its entire lifespan, a typical building is responsible for up to 25-40% of energy use, 30-40% of solid waste generation and 30-40% of global green house gas emissions. Under such circumstances this paper tries to identify the energy consumption of an urban residential building in order to provide the basic information to the technical authorities for future adoption of policies and selection of materials.

STUDY LOCATION

In terms population, the city of Agartala is presently the second largest city of north-eastern India. The city is surrounded by international borders on its three sides and connected to the mainland of India through the state of Assam for which the city location is considered as one of the farthest corner of our country. Transportation of building materials like cement, steel is quite expensive and time consuming. Besides, these areas are highly vulnerable to earthquake where very high-rise buildings are mostly avoided by local builders and promoters and consumption of steel in the structure is comparatively high. Two multi-family residential buildings located in two different areas of the City of Agartala have been selected for the study. These are five storied RCC frame structured building constructed in between 2016 to 2018 in a span of 19 months. Total floor area of these two buildings on all floors is approximately 30000 (thirty thousand) square feet or 2787 square metre. Both the plots have an access

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 9 Sep. 2022, pp: 1417-1420 www.ijaem.net ISSN: 2395-5252

way more than 10 metre wide. The buildings are made of good quality material (without luxury) as stated by the builder and families from upper middle class are targeted customers in both the cases.

METHODOLOGY

There are several inputs to be taken under consideration while quantifying the embedded energy of a building in reality. To perform the Assessment of the embodied energy of these two buildings i.e. the energy consumed till the process of construction the following stages are considered:

a. Energy entrapped in the body of the building in form of building materials
b. Energy consumed during construction by man and machines.
c. Energy consumed by the support materials needed for construction.
d. Energy spent for the transportation of materials to the site from the supplier.

Inclusion of embodied energy of ground water utilized in the construction directly in the site was a significant enough to ensure better result in this case.

LIMITATIONS

The assessment process could not touch few parameters which are worthy to be mentioned for future research and clarification.

- The energy consumption for transportation of labours could not be done since most of them used bicycles to reach the site.
- All the concretes are assumed to be Ready Mix Concrete (OPC).
- Other infrastructures like drains, boundary walls are excluded.
- Few building services materials including lifts could not be included for lack of quality installation.
- Transportation of low weight materials have not been considered

ENERGY ASSESSMENT

To find out the embodied energy of the building (part a) the list of materials and their quantity of utilization was prepared from the Bill of quantities (BOQ) and working drawings obtained from the promoters office[3]. Most of the structure was made of ready mix concrete and other 15(fifteen) major materials like cement, sand, steel, aluminium, brick, wood, glass, tiles, stone, Gypsum, polymeric render, etc were taken under consideration. The production process of building materials differs from country to country. Hence, the coefficients of embodied energy of different materials are collected from 'India Construction Materials database of Embodied Energy and Global Warming Potential'[4] for suitable analysis.

The machine involved in major activities on the construction site was listed as piling machine, pile breaker, builders hoist, wielding machine, stone polishing and cutting machines, Backhoe loader, mixing machine and pumps. Out of these the mixing machine for material mixing, backhoe loader(JCB) for earth cutting, site clearing and filling trucks are run by fossil fuel have contributed differently in the energy consumption. An approximate amount of fuel (diesel) has been provided by site supervisor for further assessment (part b). In case of manpower the builders were not accommodation to the labours except the site supervisor. Hence, the rest of the energy consumed by all machines and human activities on site are assumed to have been taken from total electric consumption throughout the construction period. Electrical energy consumption was assessed from the readings available in the two numbers of electronic meters installed by the TSECL in the very beginning of the construction. The amount of energy consumption obtained was again converted into Giga Joule (assuming 1 Kwh = 0.0036 GJ).

Energy consumed by the supporting materials (part c) like shuttering ply, nails, bamboo (for scaffolding), wires, blades which were used only for these constructions including the ground water pumped up regularly were considered as a part of this account and found to be quite significant to add 870 GJ in the total energy i.e. 0.32GJ/sqmt of built up area.

Transportation (part d) is another major factor in the assessment of embodied energy. Since the transportation distance is the important parameter for calculating the energy spent on transportation and materials having variable weight are being supplied from variable distances, only six heavy materials like cement, concrete, steel, sand and brick are considered in this case. Others light-weight materials are mostly supplied to the site by manual labour and hence not included in the study. The method discussed by Reddy Venkatarama B.V. and Jagadish K.S [5] are adopted for quantification. Lifting of materials from ground level to the desired height is already included in the operation of builders hoist machine.

II. RESULTS AND DISCUSSION

Amongst the 16 (sixteen) materials considered in this study the brick, steel and concrete are found to be have consumed maximum share of total energy including all parameters (Figure 1).

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 9 Sep. 2022, pp: 1417-1420 www.ijaem.net ISSN: 2395-5252

It has been observed that the aluminium is the highest energy consuming material in building construction [5] but in this case it is not recognisable due to its use in less quantity.

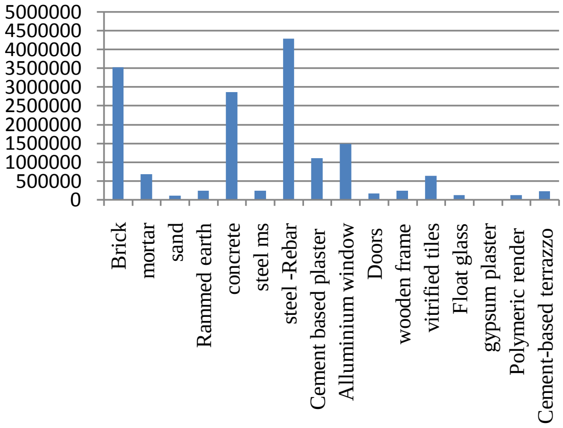

Figure 1 – share of energy consumption by different materials

The quantification of embodied energy of these two residential building assessed in the four stages mentioned earlier is obtained as 6.07 GJ/ square metre of total built up area.

Table 1

	Stages	Embodied Energy (GJ)
1	building materials	15592.33
2	Man and machines	36.84
3	Supporting systems	870.35
4	Material transportation	420.34
Total		16919.86
Built up area = 2787 sqm		
Energy rate per sqm		6.07

Though some of the building service materials were excluded from the study as mentioned in the limitation earlier, still the value of 6.07 GJ/sqm of built-up area is quite high as compared to the other studies done for the buildings in other locations of India. This may be due to the long stretch of distance required to be covered by the major materials and higher amount of steel required for the earthquake (coefficient to be added) resilient design which increases in the quantity of steel.

Even though the result pertains to the condition of North-eastern states of India, many other places in near vicinity may utilize this discourse for similar construction strategy.

A comparative study is quite contextual in this discussion. (table 2) to understand the effectiveness of the studies.

Table 2

Sl.No	Place	Building Category	Embodied energy (GJ/sqm)
1	India [5]	Conventional RC	4.21
		Double storey load bearing wall (LB)	2.92
		Double storied soil-cement	1.61

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 9 Sep. 2022, pp: 1417-1420 www.ijaem.net ISSN: 2395-5252

		block	
2.	Delhi [6]	Adobe house	3.8
3.	MP,India [7]	Single storey (LB)	4.1
		Double storey (LB)	3.7
		Four storey RCC	4.3-3.1
4.	NE, India	This study	6.07

It would be worthy to mention that this study was based on the field survey and the data available in the builder's office and also through interviews of the site supervisor from time to time.

III. CONCLUSION

The results of the study indicate that a huge amount of energy is captive in the materials itself in a building. Various method may be adopted along with the selection of materials which can play a significant role in reducing the embodied energy consumption of buildings in construction industry. Further it shows that the brick and steel are highly energy consuming for their weight and transportation condition. Due to seismic vulnerability steel may not be replaced but use of brick in partition walls should be avoided or replaced by low energy consuming materials. It will be easy for town planners to assess the energy related implication for urbanizing a certain area and also working out the necessary regulations and byelaws in different built environment. Further up gradation of this discourse shall surely lead to a reduction in the environmental impact of buildings to help in preserving the valuable ecological balance in the environment for future generations.

REFERENCES

[1]. IS 456-200 Code of practice for plain and reinforced concrete, Bureau of Indian standard, New Delhi, India.

[2]. United Nations Environment Program (UNEP) and Division of Technology Industry and Economics (DTIE), Eco-house Guidelines, 2006, pp. 5–6.

[3]. Bardhan S., Emboddied energy analysis of residential multi-storied buildings in urban India, Energy and Sustainability III s, 411 -421.

[4]. India Construction Materials database of Embodied Energy and Global Warming Potential, A methodology report by International Finance Corporation, World Bank group, November 30, 2017.

[5]. Reddy Venkatarama B.V. and Jagadish K.S., Embodied energy of common and alternative building materials and technologies, Energy and Buildings, 35(2), 2003, 129-137.

[6]. Shukla A., Tiwari G. N. and Sodha M. S., Embodied Energy Analysis of Adobe House, Renewable Energy, 34(3), 2009, 755-761.

[7]. Debnath A., Singh S. V. and Singh Y. P., Comparative assessment of energy requirements for different types of residential buildings in India, Energy and Buildings 23(2), 1995, 141-146.