Study of Embodied Energy by Data Comparison for Highrise Building

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Abstract— Energy is essential aspect for the life time of any building. Structures are estimated in terms of their energy requirement and eventually their impact on environment to find their sustainability in due course of time. This assessment of energy is considered as widely developed topic. This energy in building is divided into two main stream based on their functions, i. Operational Energy ii. Embodied Energy. The Operational energy is the energy that is required to support the energy, whereas the Embodied energy is the energy that is enveloped in making the building initially. The selection of the materials or techniques used for construction or infrastructure project directly affects the total embodied energy of the structure. Thus selecting a structural system with less Embodied energy may reduce the overall embodied energy of the building. In this study, embodied energy is derived through rigorous exercise of counting the total materials used, their material, transport and different process energy and the total accounted for two different structural systems in high- rise buildings. For which earlier works done in the field is used and help of professionals taken. At the end of the study, it is concluded that the embodied energy for RCC frame building per unit area of that high- rise building is more than the embodied energy of similar scaled Steel composite building. The difference for the case studies used is almost 15%. The percentage figure looks not so significant, however, the total embodied energy difference which is counted in GJ is huge when compared toe to toe. The study thus suggests, that selection of structural system, especially for high- rise buildings with respect to their embodied energy can affect positively on the overall environment impact of the structure.

Key words: GHG, LCA, RCC

I. INTRODUCTION

Embodied Energy is the total amount of energy required for a product or material to have achieved the current state or properties. This will include the energy used at different stages like extraction, processing, manufacture and transportation. This energy consumption at various stages produces Greenhouse Gases (GHG) like carbon dioxide, which eventually contributes to the greenhouse effect and harms the environment. Reducing Carbon Dioxide (CO2) emission from buildings and non-renewable resources consumed during construction is a priority in the fight against global warming (Lam et al, 2010). Thus, embodied energy reflects the overall impact of a material or system on the environment and hence the study on embodied energy is important in general.

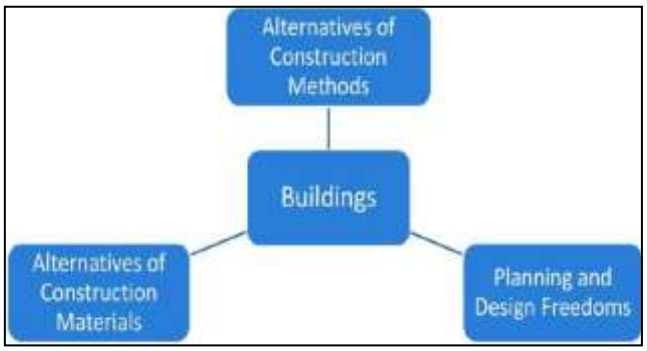

Fig. 1:

Unlike other industries, construction industry has lot many distinctiveness. This is in terms that the final product of construction industry is a building containing numbers of materials and equal numbers of techniques of construction. This vastness of materials and techniques give many alternatives for any single task. Mostly the selection of materials or techniques is done based on their Cost differences, architectural requirements, climate or location based conditions, available resources and time constraints. However, there is one more important aspect, especially neglected in Indian construction industry, their impact on environment. By providing readily available data and spreading awareness on this aspect is a very important measure. As per past research works, using alternative building construction systems, methods and techniques can

Fig. 2:

Reduce the overall environmental effect and also reduce embodied energy as well as CO2 emission in the process. (Balubaid et al, 2014) However, there is a difference between Embodied energy and the life cycle assessment (LCA),

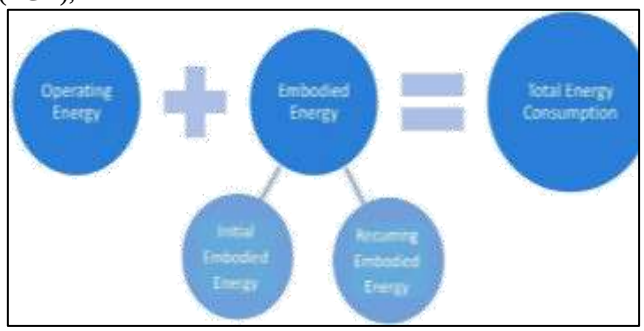

Fig. 3:

LCA computes all the impacts over the complete life of a material or element, while embodied energy only considers the early aspect of the impact of a building material. It does not include the energy used during the operation or disposal of materials. The total energy consumed by the building throughout its life cycle includes embodied energy

(EE) and operating energy (OE). Embodied energy is embedded in building materials during all processes of production, on site construction and final demolition and disposal while, operating energy is consumed in operating and maintaining the inside environment (Ding,2004). Also there are two types of embodied energy considered for building materials as per definitions, i. Initial Embodied energy ii. Recurring Embodied energy

The difference between both the types of embodied energy is that the Initial embodied energy of a particular material is the energy used to produce that material in that state up till their construction phase. While the recurring embodied energy is the energy used after the installation or construction phase to retain that phase of the specific material, or in other words their maintenance. Wherever the word embodied energy is mentioned in the paper, which should be considered as Initial Embodied energy only as the Recurring embodied energy has many unpredictable factors affecting to it, which may be very site specific.

In recent past the race to build vertical has been increased day by day, the reasons for which are many and varied; the shortage of suitable land, the increasing land price, the desire to live close to CBDs, builders to gain more profit, vast construction techniques and structural freedom, shortage of housing spaces etc. are the main factors. Although there is no precise definition of high-rise building that is universally accepted, various bodies have tried to define what 'high-rise' means, as per NBC any buildings more than 16m high are considered as high- rise buildings. In this study however, we will consider super tall buildings of around 40-50 floors as high-rise, looking at the current trend of development in India that can be viewed as justified. High rise buildings are one of the top most structures in demand in construction world today. In general almost each and every construction companies today are working on it.

Analysis of such an apartment building project showed that the material manufacturing stage had the largest amount of energy consumption and GHG emissions (Taehoon Hong et al, 2013). Considering that the amount of materials being used in this kind of structure is very high compared to low and mid-rise structure, they are the prime choice of study in case of embodied energy.

II. NEED OF STUDY

CASE STUDY PROJECT 1		
1	PROJECT NAME	Sterling Globe Grand Wing A
2	FLOORS	B+S+7
3	TYPE	Residential Space
4	LOCATION	Bawadiya Kalan Jattkhedi Road
5	ARCHITECT	Anugh Gupta & Parikalpana Associates
6	CURRENT PHASE	Completed in Dec 2017
7	PLOT AREA	1474 Sqm
8	CONSTRUCTION AREA	1338 Sqm
9	COST	8 Crores(Approx)
10	MAX. HEIGHT (Mumty Level)	27 m From Road Level

For the past few years, especially after the recent energy crisis situations there have been a lot of research and energy codes prepared on energy consumption and their reduction. Buildings consume 32% of the world's renewable and nonrenewable resources, 12% of water available, 40% of energy consumption, produce 40% of the waste being deposited into landfill sites, and contribute 40% of CO2 emissions (GBCA, 2010). Until recently, the share of operating energy was considered larger in the total life cycle energy of a building. However, due to advent of energy efficient equipments and high performance envelope materials, the potential for curbing operating energy has increased and current emphasis of energy conservation has shifted towards embodied energy in building materials (Dixit, 2008) However, most of the building developers and designers are unable to grasp the concepts of energy efficiency or reduction in the process. This is partly due to the unawareness or lack of knowledge of such requirements which is prevalent among them. Because of imperfect solutions on construction, planning & design as well as services in high-rise buildings, a huge amount of energy resources is being consumed. (Parasonis & Keizikas, 2010) Energy consumption during manufacturing can give an approximate indication of the environmental impact of the material and for most building materials, the major environmental impacts occur during the initial processes. The total amount of embodied energy, therefore accounts for large amount during the construction stage, so reducing embodied energy can significantly reduce the overall environmental impact of the building. The selection of the materials or techniques used for construction or infrastructure project directly affects the total embodied energy of the structure; therefore it is important to choose the right materials as well as right methods. There has been good amount of research done in the field regarding the embodied energy for building materials and construction activities for small scale buildings, but the lack of knowledge is found where the embodied energy is considered for the techniques of construction mainly the structural type of the building, that too in the high rise building e.g. RCC Frame structure, Composite structure etc. The selection of building's structural system has to be made carefully as each system has different impact on energy efficiency. Development of tools to select embodied energy based construction systems is considered timely as it may help many designers, engineers and developers in conscious decision making. (Balubaid et al, 2014). In case of high-rise buildings, considering the amount of materials and therefore the amount of embodied energy that can be saved by the right decisions of choosing right construction method or structural system, and by doing that reducing the significant impact of the structure on the environment, the importance of this study is undoubtedly substantial.

III. AIM

The aim of the study is to present the difference in initial embodied energy for the structural system for construction of high-rise buildings and suggesting the more suitable system in Indian context with help of case-study analysis at the end of the study.

IV. OBJECTIVES

Selecting a building and gathering data regarding materials and techniques used in its construction as CASE-STUDY-1, Selecting a building and gathering data regarding materials and techniques used in its construction as CASE-STUDY-2, CALCULATING the total initial embodied energy for the structure of these various structural systems & COMPARISON of the derived data, • Preparation of CONCLUSION showing the difference between two different structural systems with respect to their initial Embodied energy.

V. OUTCOMES OF THE RESEARCH WORK

This paper argues that initial embodied energy in high-rise building's structural system is different significantly from type to type. • Case-study data to show and compare the embodied energy calculations to support the arguments. • The study also shows that choosing the right structural system is important to know their environment impact with respect to embodied energy.

VI. SCOPE & LIMITATIONS

Building typology to be considered for the study is high-rise/Mid-rise structures only (more than 16m high).

The Recurring embodied energy has many unpredictable factors affecting to it, which may be very site specific, therefore that will not be considered in this study.

Case-study comparison between the total initial embodied energy will be between any two or more structural types/technique. The context of the study will primarily be considered in the Indian construction industry.

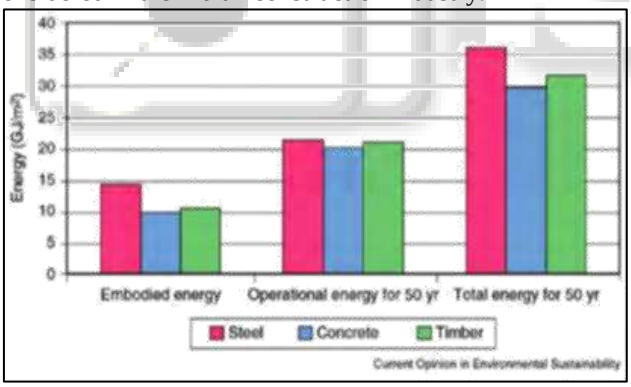

Fig. 4:

VII. CONCLUSION

After the detailed study of embodied energy of RCC Frame structure as well as Composite structure, it is concluded that the Embodied energy of Composite structure is significantly lesser than the RCC frame structure. Therefore it is referred safe to say that the Composite structure system is better than the RCC frame structure in High-rise buildings with respect to Embodied Energy.

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