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Sustainable Building Management by Using Alternative Materials and Techniques

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Abstract

Nowadays house construction is the basic need all over the world. Since the conventional building materials are causing degradation of the environment and also inadequate it must be replaced by alternative building materials which are environment friendly or efficient. The mining of popular fine aggregates and quarrying of coarse aggregate results in depletion of hard rock and environmental imbalance. In view of this there is need of developing alternative material. In most industrialized countries, the building sector accounts about one third of total energy consumption. In order to ease this problem radical improvement is employed in building energy efficiency management. The framework design is in such a way so that it can balance between the issues such as environmental, economic and social issues. This is achieved by altering the construction method and materials used for any conventional building. The objective is to promote alternative materials to housing in such a way, that if compared with conventional materials it should prove to be an ideal alternative. Using alternative building materials saves manufacturing cost, transportation, energy, time and these materials have high potential in replacing the conventional materials without compromising the strength and durability. Use of alternative technology is advantageous as it uses the locally accessible raw materials, waste products obtained from industry etc. In this present study, we have considered conventional building materials with alternative building materials by taking a residential project of 2340 SFT (including ground and first floor) and an industrial project of 3100 SFT. The cost reduction is found to be 20.17% and 18.19% in residential building and industrial building respectively hence ensuring that they are cost effective and energy efficient. Similarly, the reduction in embodied energy consumption is found to be 38.72% in residential and 17.78% in industrial building which shows that the utilization of alternative materials in construction ensures the building as Eco-friendly.

Keywords: Energy efficient, Sustainable building, Embodied energy, Alternative technology.

1. Introduction

The greatest driving force behind housing conditions today is the population explosion. There is large attrible to the rapid urbanization process in most of the developing nations. The construction industry in India employs large amount of man-power and also the materials required in construction [1]. In India, residential buildings are the one that is constructed 2×10^6 greater than other type of buildings like industrial and commercial buildings annually. The materials used in construction accounts for large embodied energy consumption of about 61% when compared to the total building energy [2]. To overcome this problem sustainable building development came into existence, where the choice of material and technology to be employed in construction were appropriate and it satisfies the requirements of the consumers and also helps in the improvement of the society. The term "Sustainability" is defined as something that improves the quality of life and in turn creates a healthy environment for the people to live in. It also helps in improving the social and economic condition not only for the present but also for the future generation [3]. The (WCED) World Commission on Environment and Development in 1987 made attention for the sustainable advancement in the construction field all over the country [4]. Firstly, it provides the detail about the approach that is based on the international standard series ISO14040 and secondly it is reviewed thoroughly and evaluates how the different materials and the combination of components are used in a different manner. Where the housing was influenced by the building materials which are readily available in region, by reducing the overall cost of construction. Alternative materials were mainly adopted in construction to overcome the problem of exhausting resources. These materials are which have many practical uses in areas such as sustainable architecture and engineering. The selection of the materials and technology was mainly dependent on the methodology adopted [5]. Where estimation of the cost and embodied energy of both the conventional and

alternative building was carried out and finally by the comparison the “Eco-friendly” building is identified. In order to evaluate the building which is cost and energy efficient the step was taken towards the estimation of building components. The method of calculating the probable cost of resources involved in the construction of any structure is known as cost estimation. The resources may be of any form such as materials, machinery, labour etc. There is a difference between building material and technology used in construction industry [6]. Building material is a physical material employed in the construction process. However, building technology is nothing but the different type of methodologies used in the construction process of different building elements. Construction of buildings have a contribution towards environmental damage which may be either directly or indirectly. This problem led to the development of new material applications, introducing the concept of recycling and reuse of discarded materials and alternatives for the construction and selection of alternative materials which is both cost and energy efficient.

2. Scope of Project

The idea of traditional way of construction of conventional building are those that is studied and employed from past generation. India is a developing country where economy is considered to be one of the major factor in the construction industry. The construction using conventional materials is related with the wet construction (in-situ) using reinforced concrete, not utilizing new technologies and labour intensive. Some of the building materials such as clay, wood, rocks etc. used in construction ruin the environment and hence it is told to be substituted by alternative materials. The growth and expansion of construction activities in the country are observed to have an impact on the natural environment. The design and the construction methods adopted are the major consumer of the natural resources [7]. In order to ease this problem fundamental improvements are done in building energy efficiency management. The outline has been defined and planned in order to balance the various issues and that is changing construction methodologies adopted for the construction of any conventional building. The objective is to promote alternative materials to housing in such a way, that if compared with conventional materials it should prove to be an ideal alternative. Use of alternative technology is advantageous as it uses the locally accessible raw materials, waste products obtained from industry and agriculture etc., [8]. Hence, with the aim of reducing the environmental impacts and maximizing the social and economic worth of the building, a step had taken towards the implementation of alternative materials and technologies and creating ‘Healthy Environment’. Where the alternative buildings enhanced the marketability in construction sector by reducing the liability and adverse effect on environment, the alternative like filler slab roofing, SMB masonry which are extensively used in today’s construction have made positive impact in construction [9].

3. Basic Building Materials

Energy in the building is categorized into two types: (1) Energy required for manufacturing of building materials (embodied energy), (2) Energy involved during the maintenance of building constructed during its useful life. The embodied energy of different construction materials is given in Table 1.

Table 1. Embodied energy of basic construction materials [1].

Sl. No	Type of material	Thermal energy(MJ/KG)
1	Cement	5.85
2	Sand	0.0204
3	Coarse Aggregate	0.22
4	Lime	5.63
5	Steel	42
6	Aluminium	236.8
7	Glass	25.8

Analysis of the energy consumption as described above is essential to completely understand about the requirement of energy by any building. These embodied energy of materials are related to the production methods adopted in India by the manufacturers [10].

4. Alternative Building Materials

The alternative building materials should not jeopardise naturally available materials, which has several applications in the field of sustainable construction. We should also need to pay regular attention to the selection of building materials, design and the recycling aspects. [5]. The main purpose of using is to minimize the negative effect on the environment and construction of “Energy Efficient Building”. Energy consumption is rapidly

increasing due to the increase in population and urbanization. The carbon dioxide emission has rapidly increased from past 20 decades because of human activities like construction, factories, vehicles, deforestation, mining etc. The conducted survey reports that the construction activities occupy 38% of total energy consumption of the world. Buildings consume energy at different phases and for different purposes.

- In the manufacturing phase of construction, energy is consumed for having raw materials of construction and manufacturing materials its transportation.
- In the phase of using energy is consumed for providing proper inner air quality in accordance with indoor visual, thermal, acoustic comfort conditions and for maintenance, restoration and renewal of construction.
- In the phase of destruction of the construction, energy is consumed for destroying building and debris removal obliteration of the construction waste, recovery of some construction materials in recycled process.

“Energy Efficient Design Approaches” have been developed to decrease the above energy consumption of the construction during its life cycle. With the application of some energy efficient methods, about 30-90% saving in energy consumption has been made in construction sector.

5. Methodology

- We have considered the appropriate residential and industrial building for the analysis.
- Estimating the cost and total embodied energy of the selected residential and industrial building.
- Study about the various alternative materials and technology for the selected building.
- From the above data we will analyse both the buildings w.r.t cost and energy by replacing the conventional materials with alternatives.

6. Case Study on Residential Building

Name: B.C. Nagaraju, #2492, 4th Main, D-block, Corner site Kuvempunagar, Mysuru-570023.

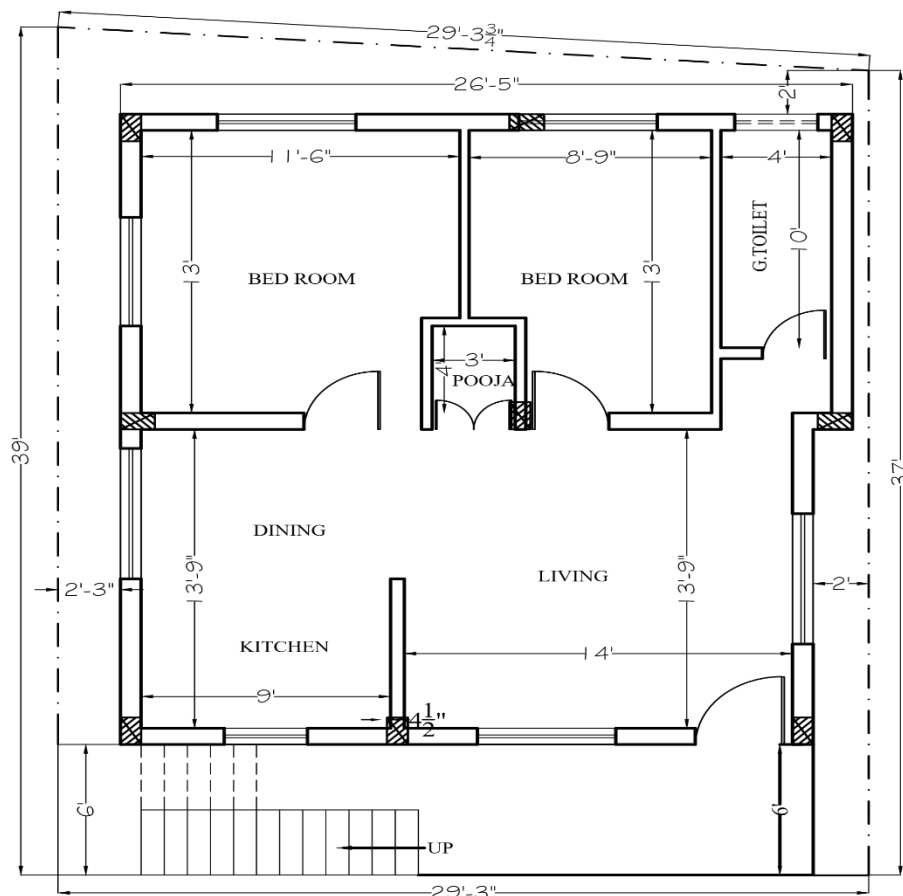


Fig. 1. Ground floor plan

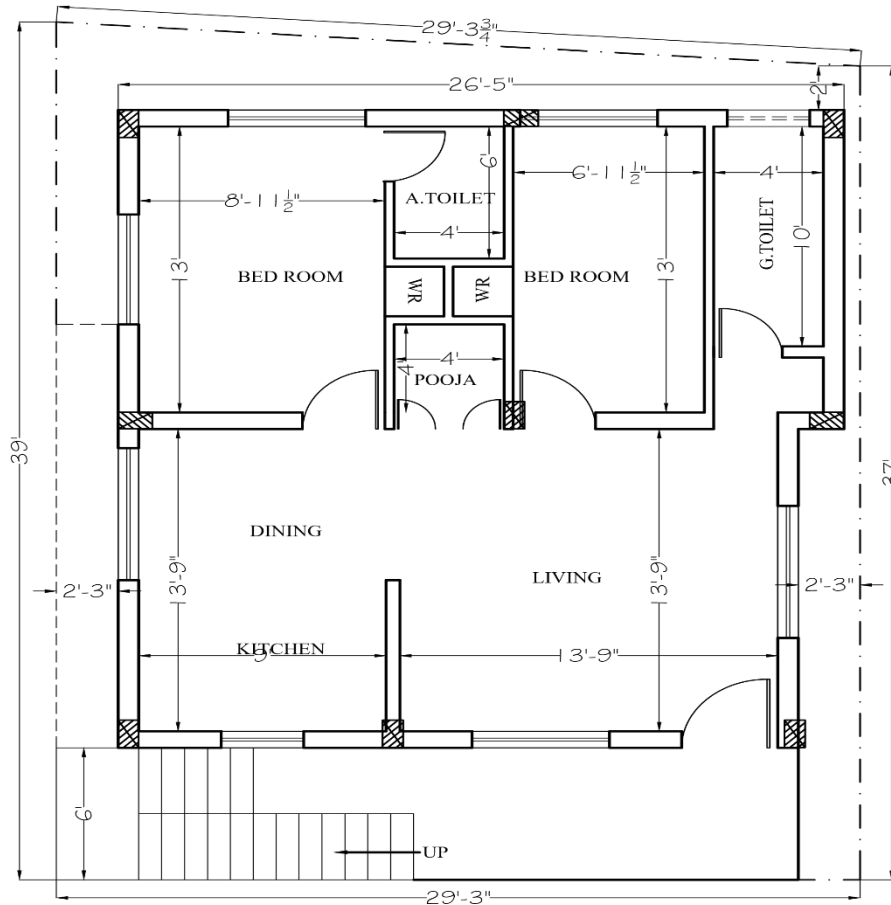


Fig. 2. First floor plan

For the present study we have considered a simple conventional residential building, Ground + First floor having 4 bedrooms, 2 kitchens and 2 living as shown in the Figure 1 and Figure 2. The site dimension is 11.7m x 9m where build up area is 167 m², which is located in Mysuru, Karnataka. Construction of this building is done using basic conventional building materials like PCC, burnt clay bricks, RCC roofing, ceramic tiles etc., For the analysis we have calculated the total energy and total cost for that particular building, which resulted in 6,78,140.54 MJ of embodied energy and Rs. 33,00,585.95 of cost as shown in Table 2 . For the comparative analysis, we have taken the same building but we have identified available alternative building materials in that particular location. Some of the materials are like the stabilised mud blocks for burnt clay bricks, filler slab technology for conventional RCC roofing, etc., Considering these alternative building materials as building components we have conducted a further analysis with respect to energy and cost. The result turns into 4,15,556.42 MJ of embodied energy and Rs. 26,36,665.74 of cost for the construction of building as shown in Table 3, which leads to 20.17% cost reduction and 38.72 % reduction embodied energy. We can conclude that by using, the alternative building materials we can reduce the cost and energy, thereby one should be aware that alternative building materials will help in achieving the sustainable construction practice by favouring environmentally, economically and socially, which is sustainability.

Table 2. Conventional building cost and energy estimation for the residential building

DESCRIPTION	DETAILS
Total site area	11.7 m x 9.0 m
Built up area	9.3 m x 7.95 m
Cost of ground floor	Rs. 16,58,754.09
Cost of first floor	Rs. 16,41,831.86
Energy of ground floor	3,35,830.33 MJ
Energy of first floor	3,42,310.21 MJ
Total cost and Energy of building	Rs. 33,00,585.95 and 6,78,140.54 MJ

Embodied energy is of two forms, initial embodied energy and recurring embodied energy. The calculation of embodied energy is as follows:

$$\text{Embodied energy} = \text{Quantity of the material} \times \text{Embodied energy coefficient}$$

For the taken residential project, the total cost and energy of the building constructed using conventional materials is Rs. 33, 00,585.95 and 6, 78,140.54 MJ respectively.

Table 3. Alternative building cost and energy estimation

DESCRIPTION	DETAILS
Total site area	11.7 m x 9.0 m
Built up area	9.3 m x 7.95 m
Cost of ground floor	Rs. 13,70,162.86
Cost of first floor	Rs. 12,66,502.88
Energy of ground floor	2,02,409.32 MJ
Energy of first floor	2,13,147.10 MJ
Total cost and Energy of building	Rs. 26,36,665.74 and 4,15,556.42 MJ

The total cost and energy of same building constructed using alternative materials is Rs. 26, 36,665.74 and 4, 15,556.42 MJ.

7. Case Study on Industrial Building

Name: Industrial shed, Paper industry, Bannimantap circle, Mysore-570015.

For the present study, we have considered a simple conventional industrial building as shown in the Figure 3. The site dimension is 12 m x 24 m where build up area is 288 m², which is located in Mysuru, Karnataka. The considered industrial building for the study is the structure used to store raw materials and for manufacturing products. This industrial building is normal type industrial building, where shed with simple roof structures on open frames.

Construction of this building is done using basic conventional building materials like PCC, Masonry structure, AC sheet roofing, cement flooring etc., For the analysis we have calculated total energy and total cost for that particular building, which resulted in 3,87,476.19 MJ of embodied energy and Rs.28,57,849 of cost as shown in Table 4 . For the comparative analysis, we have taken the same building but we have identified available alternative building materials in that particular location. For the roofing GI (Galvanized iron) sheets is used along with foam material like puff covering for thermal insulation. The masonry is constructed up to 1m height with blocks and later raised up to roof level with polycarbonate sheet and cladding by puff panel. The daylight factor is employed by installing side windows, open shafts in the roofing and transparent glass panel at roof level. The ventilation for removal of heat, elimination of dust, used air and its replacement by clean fresh air is done by natural forces such as aeration and by installation of mechanical equipment turbovites. With these alternative building materials and concepts, further analysis with respect to energy and cost is carried out. The result turns into 23,17,288 MJ of embodied energy and Rs. 3,18,570 of cost for the construction of building as shown in Table 5, which leads to 18.19% cost reduction and 17.78 % reduction embodied energy. This result shows that by employing the alternative building materials one can achieve the sustainability concept in construction and in turn is helpful in reducing the cost and energy.

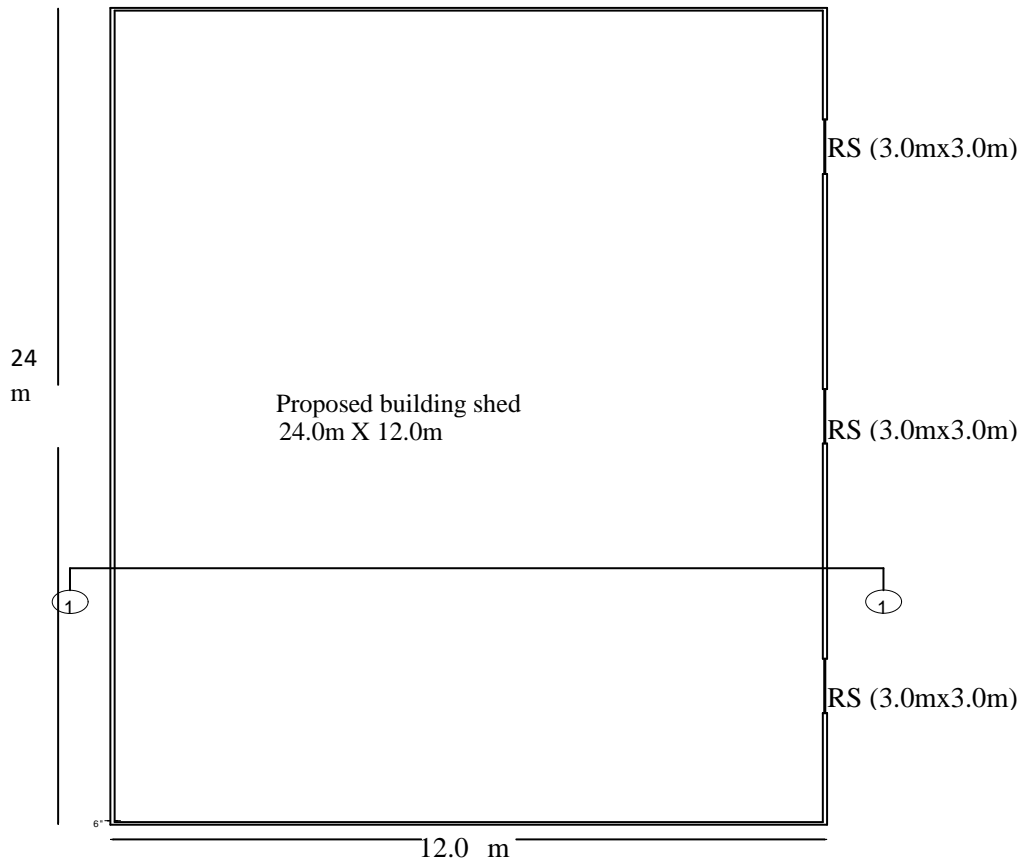


Fig. 3. Industrial building plan

Table 4. Industrial Building cost and Energy Estimation

DESCRIPTION	DETAILS
Total site area	24 m x 12 m
Built up area	288 m ²
Total cost of building	Rs. 28,57,849.37
Total energy of building	3,87,476.19 MJ

The total cost and energy of industrial building constructed using conventional materials is Rs. 28, 57,849.37 and 3, 87,476.19 MJ

Table 5. Industrial Building Alternative Cost and Energy Estimation

DESCRIPTION	DETAILS
Total site area	24 m x 12 m
Built up area	3100 sqft
Total cost of building	Rs. 23,17,288.85
Total energy of building	3,18,571.82 MJ

The total cost and energy of industrial building with same area by use of alternatives for construction was Rs. 23,17,288.85 and 3,18,571.82 MJ.

8. Results and Conclusion

For the study we have considered two building, one is the residential building and the other is an industrial building. For the comparison, the embodied energy of different construction materials both conventional and alternative materials is calculated along with their respective cost. The total energy and cost incurred for the residential building construction using the conventional building materials is 6,78,140.54 MJ and Rs. 33,00,585.75

respectively. For the same if the alternative materials are used instead of the conventional materials the total energy and cost is found to be 4,15,556.42 MJ and Rs. 26,36,665.74. Similarly for the industrial building the total energy and cost incurred when the conventional building materials are used is 3,87,476.19 MJ and Rs. 28,57,849 respectively. For the same if the alternative materials are used instead of the conventional materials the total energy and cost is found to be 3,18,570 MJ and Rs. 23,17,28 respectively. From the above figure it is evident that by employing alternative building materials in construction there is considerable reduction in energy and cost. The energy reduction in residential and industrial building is found to be around to be 38.72% and 17.78% respectively and similarly the cost reduction in residential and industrial building is found to be around 20.17% and 18.19% respectively.

From the above result, it is obvious that the energy consumption by the alternative materials is less compared to the conventional building materials and this is same in case of the cost incurred in both the situations. Considering the alternative materials in construction not only reduces the energy consumption and cost but also helps in achieving the concept of sustainability building construction. This sustainability concept is essential as these materials help in energy conservation by efficient use of construction materials and to improve the indoor building environment, which has an impact on the occupant's health for the complete life cycle of the building.

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