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Assessment of the Sustainability Performance of a Typical Residential Apartment in Kolkata

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Abstract—*The environmental impacts of the ever-growing building and real estate sector, particularly from the viewpoint of sustainability and climate change, have always been a major cause of concern worldwide. Construction sector in India is in a stage of 9-10% annual growth, resulting in consecutive ascent of demand in land, electricity, potable water, energy intensive construction materials and many other resources. The concept of 'Green Building' design, construction and certification is gradually gaining popularity in this country as an effective means of increasing sustainability of the building construction projects, particularly the commercial buildings, and reducing their negative impacts on environment. The extension of the concept to residential buildings is a recent phenomenon; and to popularize it among the developers and potential buyers a clear picture about the extra cost involved, if any is necessary. In the present paper the sustainability performance of a typical stand-alone residential apartment building in Kolkata, built conventionally, is assessed following the criteria specified in 'IGBC Green Homes' guidelines. The material quantity and construction cost of the building is also estimated following standard procedures. The results are compared with the probable cost of a hypothetical building, structurally and functionally similar to the actual conventional one, but implementing various sustainability features to make it a certified green building following the mentioned code. The tangible and intangible benefits of the hypothetical green building over the conventional actual one are also discussed.*

1. INTRODUCTION

Energy consumption and demand in prevailing mechanized life is increasing rapidly and building sector (residential or commercial) is identified as one of the major consumer. The worldwide average of energy consumption in building sector, for the year 2004 amounts to be about 24% and is predicted to grow by 34% in the next 20 years, at an yearly average rate of 1.5%. In India, residential sector consumes about 10%, and 23.4% of primary energy, and electricity respectively. Apart from energy, building sector consumes other resources like water and different construction materials to a huge extent. The concerns behind sustainable 'Green Building' development are two-fold viz. exhaustion of non-renewably energy and other natural resources and hazardous impacts on environment such as global warming, ozone layer depletion, climate change, etc. which are being addressed with due importance and seriousness presently. [1-3]

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by efficiently using energy, water, and other resources, protecting occupant health and improving employee productivity, and reducing waste, pollution and environmental degradation. The goals are achieved through better sitting, design, construction, operation, maintenance, and removal. [4-5]

The concept of 'Green Building' design, construction and certification is gradually gaining popularity in India particularly for the commercial buildings. The extension of the concept to residential buildings is a recent phenomenon; and to popularize it among the developers and potential buyers a clear picture about the extra cost involved, if any is necessary. Properly designed Green building can actually be proven as economically beneficial if analyzed considering all the available direct and indirect savings in fiscal resource, apart from its positive impacts on the environment. The present study actually aims to prove that green construction can also contribute to direct financial benefits for the developers as well as users.

2. STUDY OBJECTIVES

The primary objective of this study is to methodically calculate and compare the involved cost and acquired financial benefits; by implementing green building requirements on a typical, stand-alone, residential apartment building in Kolkata following the rules of 'IGBC Green Homes'. There are a number of codes present in India to manifest the techniques to construction of sustainable buildings. Among these, 'IGBC Green Homes' is the first rating program developed in India, exclusively for the residential sector. It is based on accepted energy and environmental principles and strikes a balance between known established practices and emerging concepts. [6]

3. DESCRIPTION OF THE BUILDING

To fulfill the study objectives the material quantity and cost of a typical stand-alone residential apartment building in Kolkata, built conventionally, is estimated following standard procedures. The sustainability performance of the same is assessed following the criteria specified in 'IGBC Green Homes' guidelines. The results are compared with the probable cost of a hypothetical building, structurally and functionally similar to the actual conventional one, but implementing various sustainability features to make it a certified green building following the mentioned code. Both of these are described in the subsequent sections.

3.1 The Conventional Building

The building considered, is located at Picnic Garden in Kolkata (22°34' N, 88°22' E), the capital of the state of West Bengal, India. It is a five (G+4) storied building with three identical apartments at each floor levels. The total site area is about 602 sq m (6480 sq ft) of the aforementioned flat. Again, from the survey, the total exposed site area is about 295 sq m (3176 sq ft). The super built up area of the project is 1834 sq m (19740 sq ft). The total number of dwellers in the twelve apartments of the building is 48. The building is a typical R.C.C. framed structure where ordinary burnt clay bricks were used. It was constructed following the local building rules; however, green building norms were not taken into account.

3.2 The Sustainable Alternative

To conceptualize the hypothetical green building, it was targeted to achieve the criteria for a gold rated green building, and depending upon the ease and feasibility of incorporating the changes, the 'IGBC Green Homes' guided methodologies are adopted and manifested. The six different subsections mentioned thereafter, namely Site Selection and Planning, Water Efficiency, Energy Efficiency, Materials and Resources, Indoor Environmental Quality, Innovation and Design, are taken for individual credit points as per the code.

The site selection criteria as laid in IGBC green home is considered. The current site area which is covered with concrete is replaced with grass pavers thus reducing the surface run off of rain water. The roof and non-roof heat island effect is minimized. The landscape design is simulated to include 15% vegetated site area. Moreover, high reflectance tiles are used in the 50% area of roof in order to decrease roof heat island effect.

Water fixtures present in the existing building are conceptually replaced by more efficient counter parts in the hypothetical green building and then a study is made in the net water savings possible by such installation. Rainwater harvesting methods are also designed and a separate tank for collection of the same is also designed. Segregated turf area is designed and moisture sensor controlled drip irrigation is provided to the landscape vegetation. Drip irrigation is decided to provide by continuous supply of water through water pipes running uniformly although, and by making holes in uniform distribution in the pipes. Central shut off valve provided for irrigation. Moreover water meter is incorporated in the new conceptual design.

The current electrical appliances as observed by the survey were found to be unrated. Current MOP (market operating price) of all such equipments is also listed. In the hypothetical building they are conceptually replaced by more energy efficient fixtures. In order to achieve energy efficiency, 20% reduction in LPD (Light Power Density) is considered.

The location, area and openings of the windows are considered. The glass material initially present were found to be sufficient to satisfy the criteria as per IGBC Green Homes Guidelines, so no change was made in that regard. No smoking signs in public and common zone and exit signs for lift and staircases etc. are also provided.

Vermi-composter is decided to provide to achieve solid waste management. The building already has septic tank in operation. Fly ash blocks and composite and certified woods are used for construction. Most of the materials used for construction are local materials. The proposed green building is also provided with separate bins for organic and dry and wet inorganic waste.

4. QUANTITY AND COST ESTIMATION

The material quantity of the conventional building is estimated following standard procedures of centre-line method. The total cost of construction and the valuation of the existing building along with all its appliances and

Table 1: Estimated Material Cost for the Conventional Building.

Serial No.	Description of Material	Total Cost (`)	Recycled Value (%)	Total Recycled Cost (`)	Local Value (%)	Distance Manufacturing (km)	Local Cost Value (`)
1	Steel	2939478	60	1763687	100	< 400 km	2939478
2	Cement	295054	25	73763	100	< 400 km	295054
3	Tiles	2970027	24	712807	0	> 400 km	0
4	Glass	31837	18	5731	100	< 400 km	31837
5	Sand	590107	0	0	100	< 400 km	2065375
6	Brick	1916508	0	0	100	< 400 km	1916508
7	Wood	1710933	0	0	0	> 400 km	0
Total		10453944	24.45	2555988	70.34		7248252

fixtures are calculated using the rate chart available in the market. For the other appliances, which are not included in standard rate chart, a thorough market survey was conducted to obtain the price of those items. The estimated value of the material cost for the conventional building is provided in Table-1. From detailed calculations, the total cost of construction of the conventional building came out to be around ` 23206625.00 (about ` 1176.00 per square feet).

For the hypothetical green building, all the changes are enlisted and analyzed thoroughly for calculating the extra cost incurred on that of the existing building. The proposed Green Building is designed in such a manner to acquire at-least 70 points in order to be eligible as Gold rated one. In this state, the overall estimation of this Green Construction helps determining the added cost for embracing the decided sustainable techniques, over that of the normal construction already existing in operational stage. The comparison of the sustainability performance along with the cost involvement on account of various sustainability parameters for the conventional building and its green counterpart are detailed in Table-2. On evaluating the additional costs (`1833085.00 in total) incurred on account of building a gold certified green building, the total cost of construction came out to be around ` 25039710.00 (about ` 1268.00 per square feet).

5. BENEFIT ESTIMATION

There are several tangible and intangible benefits of the hypothetical green building over the conventional actual one. Apart from contributing to the environment by sustainability, optimization and resource-efficient criteria, there can be substantial amount of tangible monetary benefits for the developers from various government initiatives discussed as follows.

To promote green development all over India, Central and Local Governments has taken initiatives by providing incentives in different forms for energy efficient and sustainable development. Thus, the building under current project is able to be benefited by the following grants:

The developers can avail 10% additional Floor Area Ratio (F.A.R.) for a gold certified 'Green Building' as per provision under rule 69A of the said rules, notified by Kolkata Municipal Corporation affairs department vide notification no. 54/MA/O/C-4/3R-3/2014 dated 05.02.2015. [7]

The authorities recently gave green signal to the decision of 2% reduction in the building plan sanction fee for developers who would be able to present a provision where recycling of grey water can be done using the dual-pipe system so that the water could be used for gardening or washing cars. A further 2% incentive would also be given if the solid waste generated for the building is recycled through composting. [7-8]

Officials mentioned that the current rules will be amended by the state government once the recommendations are passed. According to NKDA rules, a 2% incentive is already provided for having provisions of rainwater harvesting and solar energy. [7-8]

Taking all of the above mentioned benefits into account, the total incentive benefit of the green building for a developer is computed to be nearly ` 6500000.00.

6. DISCUSSION

As both of the buildings are considered to be built at the present time, no differentiation is considered in the costs of the materials. If the rates at the time of conventional building's true construction are bought to the present date, it will be observed that the material cost for the present construction would be less than that of the conventional building, owing to a number of recycled materials used in construction nowadays. However, there are a number of extra costs incurred in this project as detailed in Table-2; the main cost coming due to CFC free equipment, which is mandatory for a Green Building.

In course of studying the stipulations of the IGBC Green Homes rating System, it was found that the existing building is not even satisfying some of the mandatory requirements of green building. Thus, extra costs were also incurred in this way.

Table 2: Sustainability Performance and Cost Comparison between the Conventional Building and the Sustainable Alternative.

Serial No.	Choices	Conventional		Green Building		Difference in Cost	Remarks
		Points	Cost (`)	Points	Cost (`)		
1	Basic House-hold Amenities	2	—	2	—	—	No Change
2	Natural Topography or Vegetation	0	—	2	25260	25260	Drought Tolerant Vegetation
3	Heat Island Effect, Non-roof	0	270335	1	667380	397045	Grass Pavers Installed
4	Heat Island Effect, Roof	0	137928	4	196268	58340	High Reflective Tiles

5	Parking Facilities for Visitors	1	—	1	—	—	No Change
6	Electric Vehicle Charging Facility	0	—	1	1000	1000	Negligible
7	Construction Workforce Facilities	0	—	2	20000	20000	
8	Design for Differently Abled	2	1400000	2	1400000	—	No Change
9	Green Home Guidelines	0	—	1	—	—	
10	Soil Erosion Control	NS*	—	S*	20000	20000	
11	Landscape Design	0	—	4	Already covered	—	
12	Management of Irrigation Systems	0	—	0	—	—	No Turf and Drought Tolerant Species
13	Rainwater Harvesting	0		4	15000	15000	Water Tank Required
14	Water Efficient Plumbing Fixtures	0	750600	4	825000	74400	New Plumbing Fixtures
15	Waste Water Treatment & Reuse	0	—	0	—	—	
16	Water Metering	0	—	1	6000	6000	3 Meters Provided
17	Enhanced Energy Performance	7	—	10	27500	27500	Motion Sensor, Reduced LPD
18	On-site Renewable Energy	0	—	6	100000	100000	Solar Panels Installed
19	Solar Water Heating System: 50%	0	—	4	40600	40600	SWH Installed
20	Energy Saving Measures in Other Appliances & Equipment	0	20000	2	50000	30000	BEE 4 Star Rated Pump & Motor
21	Distributed Power Generation	0	—	0	—	—	No Change
22	Energy Metering	0	—	1	4000	4000	3 Meters Installed
23	CFC Free Equipment	NS*	1110000	S*	161484 0	504840	
24	Organic Waste Management	2	—	4	200	200	Pit for Vermi-composting
25	Handling of Construction Waste Materials	1	—	1	—	—	No change
26	Reuse of Salvaged Materials	0	—	0	—	—	Nil
27	Materials with Recycled Content	2	See Table-1	2	See Table-1	—	No Change
28	Local materials	2	See Table-1	2	See Table-1	—	No Change
29	Rapidly Renewable Building Materials & Certified Wood	0	—	0	—	—	No Change
30	Separation of House-hold Waste	NS*	—	S*	8400	8400	Separate Bins provided

31	Enhanced Day-lighting	4	—	4	—	—	No Change
32	Enhanced Fresh Air Ventilation	2	—	2	—	—	No Change
33	Exhaust Systems	2	21600	2	21600	—	No Change
34	Low VOC Materials, Paints & Adhesives	0	2769851	0	2769851	—	No Change
35	Building Flush-out	1	—	1	—	—	No Change
36	Cross Ventilation	4	—	4	—	—	No Change
37	Tobacco Smoke Control	NS*	—	S*	500	500	10 Signboards Provided
38	Innovation & Design Process	2	—	4	—	—	Previous Innovative Credit Points Already Accredited
39	IGBC Accredited Professional as Green Building Consultant	0	—	1	500000	500000	IGBC Accredited Professional consulted
Total		34	6480314	79	7813399	1833085	

**Note*: NS (Not Satisfied); S (Satisfied)

7. CONCLUSION

It can be seen that in order to construct a Green Building in the place of the conventional one, an extra amount equivalent to `1833085.00 (about `92.00 per square feet i.e. 7.82% extra) has been incurred. On the other hand, the probable monetary benefits earned by the developer, as per the various Government Initiatives already discussed, amount to `6500000.00 (about `329.18 per square feet i.e. 28.00%). Hence for the present case, the net benefit earned is `4666915.00 (about `236.42 per square feet i.e. 20.10%). Hence, this proposition seems to be quite attractive from a developer's point of view.

From a user's point of view, one reaps both tangible and intangible benefits. Tangible benefits are in the form of reduction of electricity and water usage costs. Intangible benefits are in the form of better environment and facilities. Hence, Green Buildings will always attract the interest of the user.

With rapidly changing and growing economy due to urbanization and globalization we must emphasize and analyze properly the advantages of energy efficiency, conservation, and smart construction techniques. Vividly, this concept is true for issues related to the environment; but it is equally valid for reasons related to the competitive sphere of the business world. Apart from acting as a safeguard to the environment and health, overall implementation of green building criteria in construction sector will also help improvising the economy of developing countries like India.

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