Alternative Approaches for Sustainable Construction Utilizing Specific Decision Support

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Abstract— Sustainable development refers to an economic, environmental and social development that meets the needs of the present and does not prevent future generations from fulfilling their needs. However, sustainable construction leads to a higher cost compared to the traditional building construction. This has become an obstacle for the society to undertake this concept. This study firstly provides an overview of conventional methods of building construction i.e. the initial step towards developing a sustainable decision making tool that can optimize cost, emissions and other construction related issues. In order to make a difference in energy sustainability a comparative assessment is conducted between the conventional method of sustainable construction and the alternatives opted. The efficiency of building construction is also determined with proven techniques that are more widely used to measure the effectiveness (and, indirectly, the productivity) of construction works. Also, selecting inappropriate materials may influence the performance of the building and preclude the achievement of the desired sustainability goals. Consequently, decision makers need proper information about candidate materials such as their properties and characteristics. This study fulfils an identified need to study how perceptions may affect decision making to increase the understanding of issues affecting knowledge in product sustainability and awareness of sustainable materials.

Key words: Sustainable Construction

I. INTRODUCTION

It is strongly believed that most construction works related to the concept of sustainable construction, are influenced by the basic concept of sustainability based on scarcity of resources where it helps to reduce impact to the environment with mainly focused on the technical issues such as materials and building components, construction technologies and energy efficient concepts. In order to achieve a sustainable future in the building industry, multi-disciplinary approach covering a number of features are adopted such as: energy saving, improved use of materials, material waste minimization, pollution and emissions control etc. There are many ways in which the current nature of building activity can be controlled and improved to make it less environmentally damaging, without reducing the useful output of building activities. To create a competitive advantage using environment-friendly construction practices, the whole life-cycle of buildings should, therefore, be the context.

However for the concept to become more binding, concrete and actionable, participation is required from numerous actors at various levels of society. Contributions from individuals, organizations, regions, states and societies are all relevant in any kind of sustainability-oriented development. To explore options for development of a construction; specific decision support tool for sustainability, the constraints within the industry and alternative approaches for implementation are explored. Qualitative, quantitative and algorithmic approaches are examined, discussed and evaluated for application on construction sites. The feasibility and practicability of implementation in traditional and turn-key contexts are evaluated and suggestions for implementation are proposed.

II. SUSTAINABLE BUILDING

A "green building" (GB) or a "sustainable building" is a high performance building that is designed and constructed in a resource-efficient manner to preserve energy, water, materials, and land throughout its life cycle while providing healthy environments for its occupants through the application of "environmental" principles. For implementing sustainable building design three general objectives which should shape the framework (while keeping in mind the principles of sustainability issues (social, environmental and economic) are: Resource conservation, Cost efficiency and Design for Human adaptation.

In India the biggest challenge to achieve while considering the sustainability will be the future population of the world and price that will have to be paid in return. It is acknowledged that wastage in the construction industry is as high as 30%. These wastages are activities that absorb resources, man hours and materials but create no value. Also India is the largest consumer of synthesized material which has a per capita consumption of 1.5 tons per annum in concrete ;a major energy 'sink' due to its large volume of production and also environmentally unsustainable due to large quantities of CO2 emission associated with its manufacture. Raw materials for concrete include non-renewable natural resources like lime stone aggregates, River sand and aggregate etc.

The critical dilemma faced by SB sector is believed to be low because of several impeding factors such as lack of knowledge, poor enforcement of legislation, education, experience and passive culture. Categorically, it affects mainly the small to medium size developer's companies where the concern is on the perception that SB will require heavy capital investment and infrastructure. On the other hand, large companies have the capability (capital, experience and expertise) to apply sustainable principles in their project, while small-medium companies are inclined on fulfilling minimum standard required by the government and to ensure that their project is sellable to various levels of income earners. Studies related to the implementation of SB for sustainable building are still lacking. It is found out that there is no standard process used in sustainable construction and value planning (VP) applications due to lack of awareness among clients.

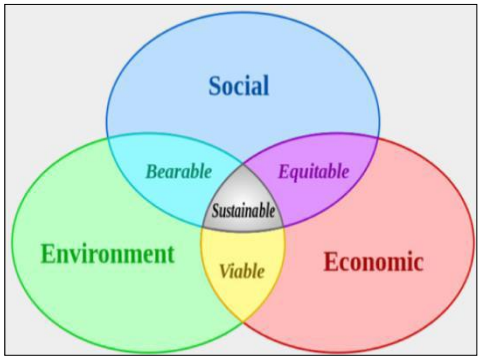


Fig. 1: Conceptual representation of sustainable development

III. SPECIFIC DECISION TOOL

Decision analysis is often used to help decision makers choose among alternatives, based on the expected utility associated to each alternative as function of its consequences and potential impacts. The ultimate goal of decision making is to select one out of different available alternatives, which most likely leads to the most favorable outcome. Decision making process can be structured into four steps:

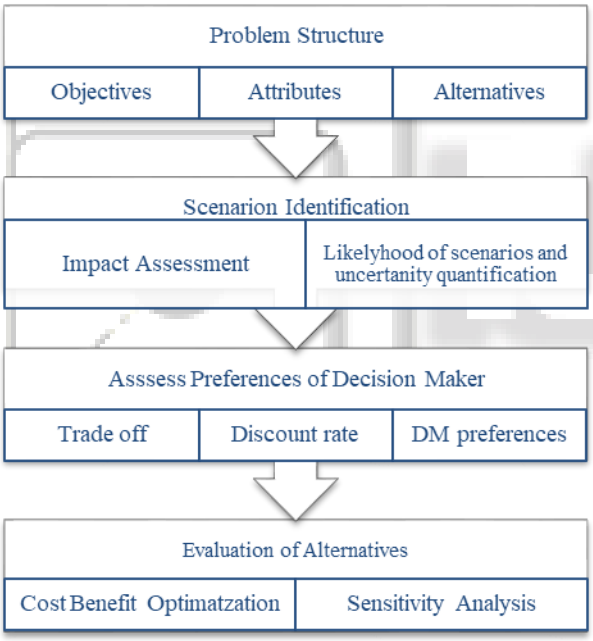


Fig. 2: Steps of the Decision Making Process

A. Green Rating System

An alternative approach to regulation is the establishment of a rating-based approach for construction operations. In India this philosophy is approached and employed by systems (IGBC) Indian Green Building Council which provides LEED ratings. LEED is a point-based system; different green features of a building will earn different points. LEED projects earn points by adhering to prerequisites and credits across some measurements for building excellence from integrative process to indoor environmental quality. The number of points the project earns determines its level of LEED certification. Based on the number of credits achieved, a project earns one of four LEED rating levels: Certified, Silver, Gold, and Platinum .Also similar to that India has provided National rating system, The Green rating for Integrated Habitat Assessment (GRIHA) and The Energy and Resources Institute (TERI) which has developed jointly with the Ministry of New and Renewable Energy in India. GRIHA rating process assesses a building out of 34 criteria and awards points on a scale of 100. In order to qualify for GRIHA certification, a project must achieve at least 50 points .A procedure is use to determine the sustainability level of the work. Achievement of specific improvement levels of sustainability on the job-site would correlate with specific ratings and levels of performance.

1) Green Rating for Integrated Habitat Assessment (Griha) Rating System:

It is India's national rating system particularly to address and assess commercial, institutional and residential buildings. GRIHA rating system has total 34 criteria to and a minimum 50 points out of 104 to achieve the star rating. SVAGRIHA (Small Versatile Affordable GRIHA) was jointly developed by ADaRSH and TERI. SVAGRIHA is a significantly simplified, faster, easier and more affordable green building rating system and functions as a design cum- rating tool. SVAGRIHA has been designed as a variant of GRIHA specifically developed for projects with built-up area less than 2500 sq. m. SVAGRIHA can help in design and rating of individual residences, small offices, commercial and institutional buildings. The rating comprises only 14 criteria:

Sr. No.	Category	Initial points
1.	Landscape	6
2.	Energy	21
3.	Water & waste	11
4.	Materials	8
5.	Others	4

Table 1: Category ratings provided by SVAGRIHA

B. Leadership in Energy and Environmental Design (LEED) Rating System:

The fundamental objective of this system is to study the environmental effects of building and ensure energy efficiency. The rating consists of total 55 criteria with 110 points under the category and sub-category. A basic LEED certification is awarded if a building amasses between 40 and 49. LEED Silver and Gold certifications are 50–59 and 60–79 points respectively. The highest LEED certification is LEED Platinum, awarded to buildings that attain 80 or more points. The quantitative value for sustainable construction for main category, according to LEED is as follows:

Sr. No.	Category	Initial points
1.	Sustainable sites	10
2.	Location and transportation	16
3.	Water efficiency	11
4.	Energy and atmosphere	33
5.	Material and resources	13
6.	Indoor Environmental Quality	16
7.	Innovation	6
8.	Regional Priority	4
	Total	110

Table 2: Credit category points by LEED

IV. VALUE ENGINEERING

The steps in the value engineering methodology and the correlated activities which for a sustainability workshop following IGBC guidelines are as follows:

- Information Phase – This stage requires the collection of information so that the team can understand the project, can understand the constraints and goals, and can evaluate the objectives of the study workshop.
- Functional Analysis – This phases is a core-element of value engineering and correlates verb-action combinations of activities in a flow-chart style flow connecting the 'how' to the 'why' for the elements under consideration. For sustainability, an approach to map processes will be beneficial to focus the workshop team on elements and processes for improvement through the creative phase.
- Creative Phase – This phase provides ideas and uses a wide variety of techniques, such as brainstorming, morphological analysis, checklists and flow-charts, and fishbone diagrams to facilitate ideas.
- Evaluation Phase – Ideas developed through the creative phase are evaluated for feasibility.
- Development Phase – Ideas are developed into specific proposals.
- Presentation – Proposals are presented to the decision makers, which will be the contractors and/or owners.

A. Productivity Approach

Many approaches have been carried out to find out the alternatives on sustainable building or green building. Labor efficiency is the basic estimate of construction industry. To improve labor effectiveness, various factors can be addressed, including motivation, job safety, environmental factors, and physical limitations. Management practices include scheduling, planning, data collection, job analysis, and control. Material timeliness is ensured by proper procurement scheduling, site layout, and other issues. For this many activities were taken into account to find out labor productivity by various field methods. All these methods include observation on site and analyzing them w. r. t time and work done. Also to increase the labor productivity pre-workshop for labor can be beneficial for the construction to understand the project done. Following is the methods used to calculate labor efficiency:

B. Measuring and Interpreting Work for Crew Effectiveness-

Field observations are taken for a work sampling of cast-in-situ R.C.C. components for the basement. The basic objective is to observe an operation for a limited time and from the observations infer how productive the operation is. Statistical sampling theory is applied because the amount of time spent collecting data has to be limited. In addition, the number of workers observed is normally a small sample (per m or per area or per no.s) taken from the entire population of possible observations (every glance at the worker is considered an observation and therefore, every work sample can result in a multitude of observations). Instead of dealing with the whole population, the procedure is to collect a sample, analyze it, and build a confidence limit around it. Work sampling estimates the percentage of time a laborer is productive relative to the total time the person is involved in the operation.

V. CASE STUDY

The respective study site is located at Camp, Amravati, and Maharashtra. The construction project "DEVALAY" is a commercial + residential building of area 280.89m^2. It consist of total 8 floors- a basement parking, a commercial floor and (18 flats) 6 residential floors.

Case study	Foundation Area	No. of Floors	Type	Local Environment	Basement
Detail	280.89 m^2	7	Residential	Urban	1

Table 3: General details

Cement	PPC+30% fly ash base
Sand	Quartz sand + Crushed Sand
Steel	TMT Fe 500

Table 4: Details of materials used in foundation & basement

Material	Amount Used	Type
Concrete	105.647m^3	Machine mixed
Steel	19.22TN	Mesh + bars
Formwork	10TN	Wooden + steel

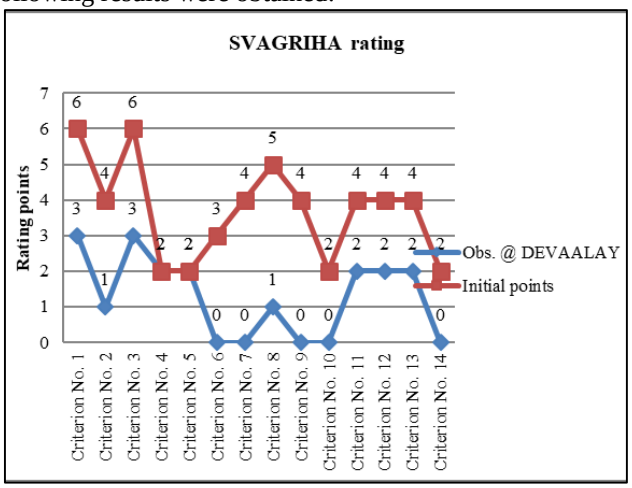
Table 5: Details of materials w. r. t type & amount

Category	Fuel Type	Units
Poclain 0.6m^3	105.647m^3	24Hrs.
Heavy Duty trucks	19.22TN	20Ro.
Medium Duty trucks	10TN	11Ro.
Concrete mixer	Diesel	-
vibrator	Electric	-
Bar cutter	Electric	-

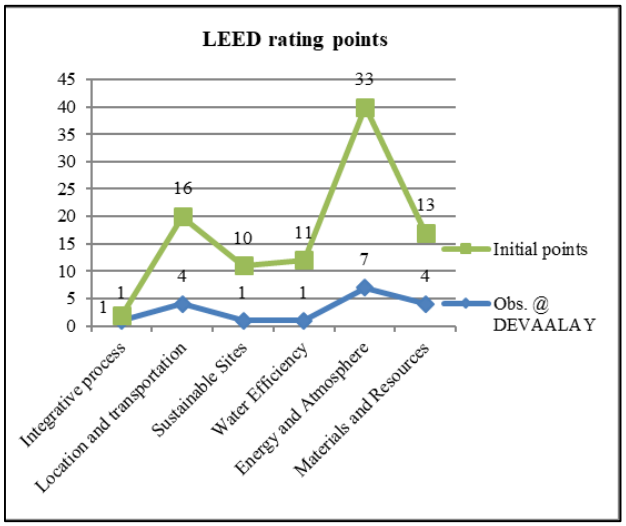
Table 6: Details of types of required equipments, tools& machineries

A. Green rating system

To calculate the quality procedure of respective building following results were obtained:



Graph 1: Analysis of SVAGRIHA rating points



Graph 2: Analysis of LEED rating points

B. Measuring and Interpreting Work for Crew Effectiveness-

Various observations were made on the site for calculating crew effectiveness. Following is the analysis of productive result of crew effectiveness:

1) Work Sampling for R.C.C. wall per 30min.

(1st Day)

Sr. No.	Productive (Direct work)	Semi-Productive (Support work)	Non-Productive (Delay)
1.		x	
2.		x	
3.	x		
4.			x
5.		x	
6.		x	
7.			x
8.	x		
9.			x
10.		x	
11.			x
12.	x		
13.		x	
14.		x	
15.		x	

Table 7: Work Sampling for R.C.C. wall (1st Day)

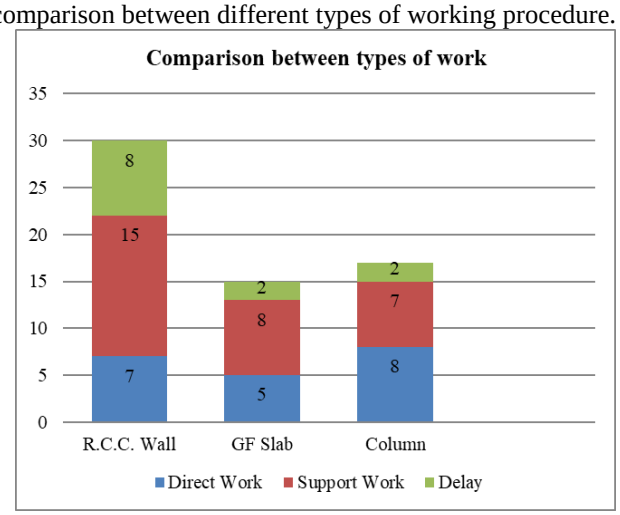
The worker's activity as one of three modes of activity: productive, semi-productive (involved in supporting the main activity), and non-productive, is categorized according to their work done on site.

Sr. No.	Labors	Productivity%
1.	Productive-3	20
2.	Semi-Productive-8	53
3.	Non-Productive-4	27
Total	15	

Table 8: Productivity of R. C. C. Wall (1st Day)

After adding all the data by each mode, final productivity was calculated. The productivity for direct work is 20% and for delay work is 27% which can be improved.

Similarly work sampling for R. C. C. wall, G.F. Slab and Column was calculated. Graph No. 3 shows the comparison between different types of working procedure.



Graph 3: Comparison between productive analyses

VI. Conclusion

This study paper summarizes and highlights the importance of sustainable construction. A case study was conducted to approach for alternatives for various decision making tool in analyzing the setbacks for green building. Following are the approaches determined as a sustainable solution:

- The green rating system discussed many attributes that were based on the project. To be crucial in the GB certification process hybrid approaches was used: LEED rating system, GRIHA (SVAGRIHA) rating and customized tool like BSIM. The performance scores of the attributes were entered for each credit by self-report and the credit values were given accordingly.
- From the SVAGRIHA rating points, it was observed that out 50 points, the site DEVAALAY only scored 18 points. For 50 different criterions of rating sustainability in the building, the project matches the rating system showing an average value on site observations. Hence, it can be concluded that site need more development, need to adopt sustainable measures for construction, etc.
- In LEED rating systems there are total 9 main categories under which there are 58 criterions for a green/sustainable building. From the site DEVAALAY the observation were taken and out of 110 points it scored only 23 points. To achieve a silver rating minimum points has to be scored out 110 is 80.Although LEED is a global certified rating; it is highest ranked certification for a sustainable building. Therefore, to achieve any certificate of LEED (silver, gold or platinum) first it should match the basic requirements of sustainable building by national certification. And of course, if it does it will be easy to match the LEED certification.
- Productivity means, input = output. Also the work sampling for crew effectiveness shows that amongst productive, semi-productive and non-productive only semi-productive labor has been doing effectively well. But the crew for productive and non-productive gives half input of what the semi-productive crews are able to

perform. Implementing workshops for crew training, would increase productivity & increase output.

REFERENCES

[1] Abd-Karim, S.B., H.W. Wah, A. Jaapar, M.S.N.M. Suhaimi, and M. Ali Berawi. 2017. "Advocating Sustainable Building Paradigm through Value Management." Journal of Design and Built Environment 17: 95–106. https://doi.org/10.1002/jctb.2037.

[2] Chang, Rui Dong, JianZuo, Zhen Yu Zhao, Veronica Soebarto, Yujie Lu, George Zillante, and Xiao Long Gan. 2018. "Sustainability Attitude and Performance of Construction Enterprises: A China Study." Journal of Cleaner Production 172: 1440–51. https://doi.org/10.1016/j.jclepro.2017.10.277.

[3] Energy, Renewable, Green Rating, and Integrated Habitat Assessment. n.d. "The Little Book of GRIHA Rating."

[4] Florez, Laura, Daniel Castro, and Javier Irizarry. 2013. "Measuring Sustainability Perceptions of Construction Materials." Construction Innovation 13 (2): 217–34. https://doi.org/10.1108/14714171311322174.

[5] Ilayaraja, K., and MD. ZafarEqyaabal. 2015. "Value Engineering in Construction." Indian Journal of Science and Technology 8 (32): 18–26. https://doi.org/10.17485/ijst/2015/v8i32/87285

[6] Mattoni, B, C Guattari, L Evangelisti, F Bisegna, P Gori, and F Asdrubali. n.d. "Critical Review and Methodological Approach to Evaluate the Differences Among International Green Building Rating Tools."

[7] Rachwan, Racha, Ibrahim Abotaleb, and Mohamed Elgazouli. 2016a. "The Influence of Value Engineering and Sustainability Considerations on the Project Value."Procedia Environmental Sciences 34: 431–38. https://doi.org/10.1016/j.proenv.2016.04.038. 2016b. "The Influence of Value Engineering and Sustainability Considerations on the Project Value."Procedia Environmental Sciences 34 (January): 431–38. https://doi.org/10.1016/J.PROENV.2016.04.03

[8] Sandanayake, Malindu, Guomin Zhang, and SujeevaSetunge. 2019. "Estimation of Environmental Emissions and Impacts of Building Construction – A Decision Making Tool for Contractors." Journal of Building Engineering 21 (October 2018): 173–85. https://doi.org/10.1016/j.jobe.2018.10.023.

[9] Seyis, Senem, and EsinErgen. 2017. "A Decision Making Support Tool for Selecting Green Building Certi Fi Cation Credits Based on Project Delivery Attributes." Building and Environment 126: 107–18. https://doi.org/10.1016/j.buildenv.2017.09.028.

[10] Small, Edgar P., and Mansoor Al Mazrooei. 2016. "Alternative Approaches for Development of a Construction-Specific Decision Support Tool for Sustainable Construction Operations." Procedia Engineering 145: 1013–20. https://doi.org/10.1016/j.proeng.2016.04.131.

[11] Uğur, LatifOnur, and NeşeLeblebici. 2018. "An Examination of the LEED Green Building Certification System in Terms of Construction Costs." Renewable and Sustainable Energy Reviews 81 (June 2017): 1476–83. https://doi.org/10.1016/j.rser.2017.05.210.

[12] Yin, Belle Chua Lee, Richard Laing, Marianthi Leon, and Leslie Mabon. 2018. "An Evaluation of Sustainable Construction Perceptions and Practices in Singapore." Sustainable Cities and Society 39: 613–20. https://doi.org/10.1016/j.scs.2018.03.024.

