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A STUDY OF EXISTING BUILDINGS FOR PROMOTING SUSTAINABLE DEVELOPMENT IN FUTURE

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ABSTRACT

The construction industry is a wide area and needs concern as it takes into account energy at a large scale. The paper aims to study the existing buildings, having sustainability features. The comparative study of the three buildings shall be performed to analyse the better among them. The sustainability features are categorised under five different heads. Each of the building is to be observed in the light of these five areas and the scores obtained. The comparative study shall be performed with the help of Analytic Hierarchy Process, which is based on the process of comparing the buildings among themselves. The building thus obtaining the higher rank shall be considered for its sustainability features so as to create guidelines for future development.

Keywords: Life Cycle of Buildings, Renewable, Building Design, Building Materials, Photo Voltaics, Decision Matrix, Analytic Hierarchy Process

I. INTRODUCTION

The global warming is an alarming situation for the world. The only solution to the problem is sustainable development, which can be managed by efficient planning and management for future. It is need of the hour to promote and move towards sustainable ways. One such strong area of concern is the construction industry. The innovation in construction technology and materials need properand timely management. It is therefore important to concentrate on the Life Cycle of buildings, which starts at the beginning of the idea to build and ends with the demolition of the building. The amount of energy involved at various stages of construction and maintenance stages has a lot of potential for improvement and save energy. Sustainable development for future should take into consideration the success stories and those shall be taken as lessons for future development.

II. HISTORICAL BACKGROUND

In 1990's, the United Nations Rio Earth Summit, raised the issues regarding global warming and problems of ecosystem were also discussed. The UN's second conference was held in 1996 in Geneva that focussed on climate change. The Inter-Governmental Panel on Climate Change (IPCC) brought to notice that during 20th Century, the Earth warmed up by between 0.3 and 0.6°C and sea levels rose to an average by 15 to 25 cm. An international think tank "The Club of Rome" was founded in 1968 and in 1972 they published "The limits of Growth". The idea was that, the economic development must be combined with environmental protection. The

first UN Summit on man and environment took place in 1972. Gro Harlem Brundtland's report "Our Common Future", was discussed in 42nd UN Congress in 1987.

The concept of Sustainable development was introduced here. During the Rio Earth Summit in 1992, the heads of state committed that they shall explore "Development which fulfils current needs without compromising the capacity of future generations to fulfil theirs".

The principles of Rio Declaration made way for Agenda 21 that was the development plan for 21st Century. The concern was on the economic as well as social dimensions. The Kyoto agreement in 1996 was a step further in this direction. All the nations participating pledges to reduce the greenhouse gas emissions over a period of 2008 to 2012 back to 1990's levels. In 2000, there was a meet in The Hague where representatives from 180 countries met to resolve the details of Kyoto agreement. The 2nd UN Conference on Human settlements in 1996, Istanbul focussed on application of Sustainable principles in building.[1]

III. THE CONSTRUCTION INDUSTRY

The Construction Industry has major environmental impacts. The consumption of total natural resources is 50%, energy usage is 40% and water consumption is 16%. The waste production during construction and demolition is more than the volume of household waste.[1] Sustainable construction focusses mainly on three areas of design, which are related to the Life cycle process; construction, utilization and demolition. The self-sustained building concept must have a closed cycle of flows of energy, water and materials[2].The construction industry is essentially a service industry whose responsibility is to convert plans and specifications into finished products, it is exceedingly complex and highly individual in character [3].Construction industry consumes large amount of energy, water, materials and land. This contributes to the exhaustion of natural resources and consumption of energy [4][5].

Shen et al. (2004) have studied various organisations, those which have been working on environment management systems like Building Research Establishment Environmental Assessment Methodology (BREEAM) in UK, the Building Environmental Performance Assessment Criteria (BEPAC) in Canada, the Green Building Challenge (GBC) in US and Hong Kong Building Environment Assessment Method (HK-BEAM) in Hong Kong. The Chartered Institute of Building (CIB, 1989) have identified certain areas for environmental management in construction activities. Some of these areas are efficient use of energy, environment friendly building materials, control of toxic chemicals, pollution control, recycling and waste management [6].

The client and the contractor may not be interested in the energy efficient designs and the reasons could be that the benefits of such designs can be realized only in the long term, whereas the business in construction industry is oriented towards short term profit making. Various construction activities, like generation of excessive noise, dust, chemical particles, odour, toxic gases and solid wastes can cause pollution and harm the environment (Shen et al. 2000). A paper by Riley et al. (2003) analysed that contractors can help in achieving sustainable project objectives by providing conceptual estimating services during preconstruction, sourcing and procuring sustainable materials, managing construction waste and helping to ensure that indoor air quality requirements are met.[7].

IV. METHODOLOGY ADOPTED FOR STUDY

The methodology adopted for study is as follows. The literature survey has been conducted for finding out the major areas of concern for sustainability issues related to construction industry. The issues have been categorised into five different heads. Three case-studies have been selected for study. The choice of buildings was based on the Architects working on sustainability features since they have been working and who have a concern for environmental issues. The comparative study of these buildings was conducted and the features of the best building among them have been highlighted as guidelines for future development. The tangible as well as intangible features are included in the study of buildings.

V. SUSTAINABILITY ISSUES

After extensive study of sustainability features and areas of scope, the issues related to sustainability have been identified. These issues are categorised into five different areas of concern. The issues can be listed in the following way: Efficient Site Planning, Water conservation, Renewable/Waste Resource Management, Building Design and Building Materials/Finishes/Techniques.

5.1 Efficient Site Planning

Nature needs to be incorporated in the planning to make it a balanced approach. It improves the microclimate of a place, relieves environmental pressures and brings relief in all the three ways; ecologically, socially and economically also. Vegetation improves the microclimate, retains rainwater, absorbs noise, reduces dust, extracts CO_2, maintains temperature, acts as windbreaker etc. It also influences the quality of life of people, improves aesthetic value and ecology. Natural drainage is also affected by permeable and impermeable surfaces, type of soil and its preservation. Retention systems like low area drain, ditches, ponds, underground collection cisterns and planted roofs or terrace gardens can also influence the sustainability of a place.[8].

It is important to preserve the existing features on site and incorporate them into design. These can be either the vegetation or natural existing topography and other features on site.

5.2 Water Conservation

Sustainable Construction aims to reduce the impact of water usage on its natural cycle. There are three main areas that need to be handled with care; Consumption efficiency, Resource catchment and Improvement in the quality of water when returning it to the environment. It is observed that 5% of water consumption is for hygienic purposes and 95% is because of evacuation of wastes. It becomes important to improve the efficiency of appliances, recycle and recover water from rain.

An area covered with grass and trees absorbs almost all the rain water falling on it. It also helps in preventing soil erosion. Thus permeable surfaces are of extreme importance as they help maintain the natural water cycle. There are three categories of water. Rainwater is obtained from rain. Grey water is obtained as waste water from domestic appliances like kitchen, washbasins, washing machines, showers etc. Black water is obtained from toilets and goes into sewer system.

Rainwater is a good quality water as compared to other waste water. It can be stored or conserved and reused for flushing, washing machines and landscaping purposes. Landscaping with native species shall also reduce the demand for water. Recycling of grey water has great potential in saving water, as this water is less

contaminated. The grey water can be treated and used for flushing as it is of lower quality. The storage and reuse needs important considerations and planning, as this water should not be stored for more than one day, preferably. Water demands can be reduced by using efficient machines, low volume flushes/fixtures and low flow showerheads etc.

5.3 Renewable/Waste Resource Management

It is very important to reduce usage of fossil fuels and nuclear energy. Some of the advised measures include passive energy, efficient appliances, improved insulation, efficient lighting, solar thermal energy usage and Photo voltaic. Singh (2007) discussed that the potential of Renewable energy technologies is high in India. It is stated that on 31st December 2002, the contribution reached 3700MW, which was 3.5% of the total grid capacity in India. Government has taken various measures for promotion of renewable resources in the country like setting up various bodies like: CASE (Commission for Additional Sources of energy) was set up in 1981;MNES (Ministry of Non-Conventional Energy Sources) in 1992 and IREDA (Indian Renewable Energy Development Agency Ltd.) in 1987. Winrock International has set up the REPSO (Renewable Energy Project Support Offices) in some selected developing countries. REPSO is working in India to promote the biomass energy, solar photovoltaic, small hydro, wind power and solar thermal electric vehicles etc.[9]

There is a lot of potential for saving energy by increasing the usage of Renewable sources of energy but it needs to create awareness among the users about the long term advantages of using them. Besides this, higher initial cost acts as a barrier in the adoption of such means. Passive means of controlling the microclimate include the command on solar gains. Its presence may reduce the demands from fossil fuels. The space between buildings also plays a crucial role in adoption of solar panels in an urban setting. More compact planning in urban areas will create hindrance in usage of PV panels on the facade. The “South” direction should be in designer’s mind while planning orientation. The thermal comfort, acoustic comfort, ventilation, wind direction and solar gains together make a good and considerable solutions.

Waste is also a source of energy. Burning of waste can release harm full gases in the environment. The household waste can be reused in the form of energy. The human waste can also be utilized in the form of organic matter after treatment. The organic waste from kitchens can be used as compost for gardens and parks.

The waste produced at different stages of construction and after deconstruction is a matter of concern. Proper segregation on site and recycling and reuse of waste materials is essential. The waste generated on site can have huge environmental impacts. The process of reuse and recycling of waste can save environment and create employment also at the same time. Flyash can be used to save expensive building materials having high embodied energy. Precast systems can save energy involved in transportation, thus saving time and energy.

5.4 Building Design

The building should be so designed so as to reduce the demands. The energy that is required for space heating and cooling should be managed by the orientation of the building itself. The design, orientation, type of building, interior spaces, the U-value of glazing and exterior surfaces etc. are some of the potential areas of concern.

Another important issue in building design is to meet the demands in sustainable ways. The recommended U values for walls and glasses are useful in saving energy. The building structure and services should be well

integrated. Energy efficient and "intelligent" services can be incorporated in the design. Adequate amount of daylight is essential for saving energy as well as for wellbeing of occupants. The height of openings and orientation for daylight is to be chosen intelligently depending upon the activities to be performed. The courtyard planning plays a very important role in such context. In addition to controlling the environment and microclimate, it also helps in controlling and providing ways and means of daylight without glare.

Solar thermal panels and solar photovoltaic panels PV's are incorporated in designs for lighting systems as well as water heating. The management of solar gains and ventilation system is important.

5.5 Building Materials/Finishes/Techniques

The building material should be non-polluting, local and appropriate for future deconstruction. The environmental impacts can be enormous because of the uncontrolled extraction process and transformation of materials. The important strategies can be stated as: reduction in the amount of material consumption, reuse, recycling, minimization and management of wastes. Another important methodology can be substitution of building materials with those materials that have lesser environmental impact.

The rate at which development is taking place and materials extracted and used, needs a caution. The important criteria for selection of a building material can be summarized as: its suitability in terms of appearance, maintenance and performance. The cost of material should be appropriate in terms of placement as well as maintenance. The material should have a low embodied energy in terms of its extraction, finishing and transportation. The chosen material should have less or no impact on environment in terms of CO_2 emissions. The health hazards in terms of its processing and placement should not be there. These can also be controlled by usage of low VOC materials in the interiors.

The building material chosen should have high performance and appropriate U value. Double glazing can be adopted for better insulation and less loss of energy. These measures shall help in reducing the energy consumption in buildings. Exterior finishes should be reflective, preferably in order to manage energy.

VI. THE THREE CASE- STUDIES

The three case studies selected for study are**: RETREAT - Gurgaon, TAPASYA BLOCK, (Phase I), New Delhi,** and **TRANSPORT CORPORATION OF INDIA, Gurgaon.** The choice of buildings is based on their sustainable features and the Architects are involved in sustainable design professionally. All the selected buildings have been worked upon in the 20th Century only. A comparative study of these buildings shall be conducted in terms of tangible and intangible features. Analytic Hierarchy Process (AHP) is adopted as a tool for making a comparative study of these buildings. Secondary data available from various sources and primary data collected through interviews with Architect and Project Manager, has been taken for making the comparative study.

6.1 Retreat- Gurgaon

Resource Efficient TERI Retreat for Environmental Awareness and Training, Gurgaon

RETREAT is a 36 hectare TERI campus at GualPahari, in Haryana. There is a 30 room hostel, having conference facility for 100 people. Dinning space, kitchen, recreational area, computer room and a library are additional features. The Architects for the project are Ar. Sanjay Prakash and TERI itself.

6.2 TAPASYA BLOCK, (Phase I), New Delhi

Tapasya Block was constructed for Sri Aurobindo Ashram Trust (Delhi Branch), a charitable society. The first phase consists of a hostel like block to house 80 people including the students, visitors and ashramites. The extension in second phase shall comprise of offices, swimming pool, library, dinning, meditation and other facilities. The Architect for the project was Ar. Sanjay Prakash.

6.3 Transport Corporation of India, Gurgaon

TCI is a corporate office modern building, set in an institutional area close to Delhi. There are 3 stories and a basement surrounding the central court. The basement houses building services and some work spaces. The Architect for the project was Ar. Ashok B Lall.

6.4 The Comparative Study

The case studies selected are to be tested on comparative basis, to identify the building having best sustainability features. This will help in preparing a checklist for future development. The comparative study is done on two parameters; the tangible and intangible features. The intangible features are then employed for comparative study using AHP.

The tangible features for comparative study can be listed in the following categories.

1. Built up area
2. Solar PV panels
3. Building Material
4. Impact on cost

The intangible features for comparative study can be listed in the following categories.

6.4.1 Efficient Site Planning

1. Preserve and plant vegetation on site
2. Top soil preservation on site
3. Preserve existing features on site
4. Terrace garden
5. Microclimate control with water bodies

6.4.2 Water Conservation

1. Permeable ground surface
2. Reuse of waste water on site by recycling
3. Low flow faucets/fixtures
4. Rain water conservation/reuse
5. Landscape using native species

6.4.3 Renewable & Waste Resource Management

1. Solar photovoltaic systems for lighting
2. Use of fly ash
3. Solar photovoltaic cells for water heating
4. Using precast systems
5. Waste management on site

6.4.4 Building Design

1. Orientation of building
2. Courtyard planning
3. Daylight in interiors
4. Basement or underground structures
5. Shading devices/methods

6.4.5 Building Materials & Finishes

1. Building materials of low embodied energy
2. High performance glass usage
3. Double glazing for insulation
4. Exterior finishes may be white/reflective/brickwork
5. Low VOC paints in the interiors

6.5 Comparative Study of Tangible Features

Table 1. Data for Comparison of Tangible Features

S. No.	Criteria under Observation	RETREAT - Gurgaon	TAPASYA BLOCK, (Phase I), New Delhi	TRANSPOSRT CORPORATION OF INDIA, Gurgaon
1	Built up area	3000 m^2	3000 m^2	2750 m^2
2	Solar PV panels	• 24 solar water heating panels • PV- 50kW gasifier • 10.7kWp solar PV	4 solar flat plate collector system for hot water	No solar panels employed
3	Building Material	• 40 mm thick expanded polystyrene on wall • Vermiculite concrete on roof	• Low energy Brickwork • No concrete and steel	• 25 mm polyurethane foam protected by dry red-stone cladding • 35mm thick reflective glazing tile on roof
4	Cost(Rs.)	23.6 million (civil) + 2.5 million(electric) + 18.54 million (technologies)	Cost reduction by 20%	30.7 million (civil) + 24 million (infrastructure) + 0.35 million (landscaping)

6.6 Comparative Study of Intangible Features

The cast studies have been scored on 5 point scoring system, for the 5 criteria (TABLE 2). The scores thus obtained shall be used for comparative analysis through AHP.

Table 2. Datafor Comparison of Intangible Features

CRITERIA		EFFICIENT SITE PLANNING					TOTAL	WATER CONSERVATION					TOTAL	RENEWABLE & WASTE RESOURCE MANAGEMENT					TOTAL	BUILDING DESIGN					TOTAL	BUILDING MATERIALS & FINISHES					TOTAL
S.NO.		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
1	RETREAT, Gurgaon			•			1	•	•		•	•	4	•		•		•	3	•	•	•	•	•	5	•		•	•		3
2	TAPASYA BLOCK, (Phase I), New Delhi						0	•				•	2			•			1		•	•		•	3	•			•		2
3	TRANSPORT CORPORATION OF INDIA, Gurgaon	•				•	2	•	•			•	3						0		•	•	•	•	4	•	•		•	•	4

Each of the 5 categories has been given equal weightage of 20%, thus making a total of 100% (TABLE 3). The comparative analysis shall be based on the scores thus achieved.

Table 3. The scores obtained by Case-studies

6.7 Analytic Hierarchy Process

AHP was introduced by Saaty (Thomas L Saaty) in 1977. It is multi criteria decision making approach, used to solve complex decision problems. Figuera et al. (2005) states that decision making has become a mathematical science today. The decisions have to be more transparent in all respects[10].Satty T. L. (2008) explained that to make a decision we need to know the problem, the need and purpose of the decision, the criteria of decision, their sub-criteria, stakeholders and groups affected and the alternative actions to be taken [11]. After this we can determine the best solution/alternate. The decision making method attempts to determine the relative importance

S. No.	CRITERIA= CASE STUDY	EFFICIENT SITE PLANNING	WATER CONSERVATION	RENEWABLE & WASTE RESOURCE MANAGEMENT	BUILDING DESIGN	BUILDING MATERIALS & FINISHES	TOTAL SCORE (out of 500)
	WEIGHTAGES In % =	20%	20%	20%	20%	20%	100%
1.	RETREAT, Gurgaon	20	80	60	100	60	320
2.	TAPASYA BLOCK, (Phase I) New Delhi	0	40	20	60	40	160
3.	TRANSPORT CORPORATION OF INDIA, Gurgaon	40	60	0	80	80	260

or weight of the alternatives. A pairwise comparison is used to find out the relative importance [12].

The AHP is used here to make a comparative study of the 3 case studies, to identify the best among them (TABLE 4), based on the features of sustainable development.Making comparative study using Analytic Hierarchy Process (AHP) gives the Ranks. The Ranking obtained based on the priorities from AHPis as follows:

Table 4. The Ranks obtained from AHP

	Category	Priority	Rank
1	RETREAT	69.1%	1
2	TAPASYA	6.0%	3
3	TCI	24.9%	2

Table 5. The Decision Matrix obtained from AHP

	1	2	3
1	1	8.00	4.00
2	0.12	1	0.17
3	0.25	6.00	1

The result thus obtained (TABLE 5) from the AHP identifies RETREAT, Gurgaon as the building with the most sustainable features. The sustainable ways can be standardised to be used as guidelines for future development and as a checklist for achieving maximum sustainability.

1 The Guidelines for Future **Sustainable Development**

1. The exterior facade should be shaded with trees, which act as protective layer. Deciduous tree plantation towards south is advisable, as these would shade the building in summer and shed its leaves during winter season.
2. The orientation of building is generally guided by the site itself but efforts should be put in to take maximum of winter sun and cut summer sun either with the help of adjustable screens or blinds, to get maximum of daylight, without glare.
3. The building oriented towards south is beneficial.
4. Openings should be so designed so as to provide views as well as glare free daylight. The level of window openings may be raised to throw light deeper into the space. Properly designed skylights at higher level help in providing glare free light.
5. The underground building help in stabilizing the internal temperature.
6. The courtyard planning with a water body, acts as an environment generator for the spaces looking towards them. Such spaces largely effect the microclimate of a place. Transparency should be maintained with such spaces.

7. Proper landscaping helps to control the wind direction.
8. Solar water heater, PV panels, gasifierscan be installed for using the valuable solar energy.
9. The co-friendly chillers running on LPG can be employed.
10. Compact fluorescent lamps can be installed for saving energy.
11. The walls making the structural system can be made in polyurethane foam, protected by stone cladding or polystyrene for better insulation.
12. The roof insulation can be achieved with reflective glazed tile paving or vermiculite concrete and China mosaic.
13. Maximum FAR and ground coverage, with restricted height is recommended because energy consumed in construction process is reduced. This also helps in reducing the energy that shall be consumed in the Life cycle of the building, including maintenance.
14. The height restriction saves the investment on vertical transportation, thus saving energy.
15. Use building materials with low embodied energy.
16. Keep the use of glass and aluminium to minimum.
17. Water on site can be conserved by soft landscaping and features like water bodies.
18. Waste water can be treated based on aerobic and anaerobic decomposition of the contents in the roots of the reeds and microbial organisms. The water thus obtained can be used for irrigation purposes.

VII. CONCLUSION

The guidelines for sustainable development is the aim of this paper. An attempt is made to conclude to certain features that can be adopted for saving the environment. The target is to achieve these, with the help of a comparative study of existing buildings, which are running successfully. The three buildings under observation were; RETREAT - Gurgaon, TAPASYA BLOCK, (Phase I), New Delhi and TRANSPORT CORPORATION OF INDIA, Gurgaon. The features for sustainable development were categorised in the five areas: Efficient Site Planning, Water conservation, Renewable/Waste Resource Management, Building Design and Building Materials/Finishes/Techniques. The scoring for the buildings was done on five points and each category was given equal weightage. The decision matrix thus obtained was used for comparative study using Analytic Hierarchy Process, were each building was compared with the other two. The result of comparison ranked RETREAT – Gurgaon, as the building with maximum features for sustainability. The important features adopted in this building are then quoted as guidelines for future development. Some of the important issues can be summed up as daylight, orientation, solar energy usage, building materials with low embodied energy, underground construction for temperature control, waste water management on site etc.

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