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Sustainable Building and Its Comparative Analysis with Conventional Building

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Abstract: ***Sustainability concept which can be defined as "meeting the needs and expectations of the present without compromising future generations to meet their own needs and expectations" [1]. Buildings have a significant environmental impact, consuming roughly 40% of natural resources extracted in developed countries, nearly 70% of electricity and 12% of potable water, and producing between 45% and 65% of waste disposed of in our landfills. Furthermore, they are responsible for a massive amount of harmful emissions, accounting for 30% of greenhouse gas emissions directly caused by their operation and another 18% indirectly caused by material exploitation and transportation. Given the building industry's significant influence, the sustainable building approach has a high potential to contribute significantly to sustainable development. The goal of sustainable building construction is to reduce environmental load, connect with the environment, and improve occupant health. In this paper a comparison is carried out between a conventional building and a sustainable building based on various parameters and cost estimation. The paper concludes by justifying the reason of the cost difference between the two buildings. It is expected that the outcome of this paper will be useful to someone who wants to understand about the cost difference between a conventional and sustainable building construction.***
Keywords: Sustainability, Environmental Impact, Conventional Building, Sustainable Building Construction, Cost Comparison.

I. INTRODUCTION

Sustainability means using of natural resources in such an equilibrium condition that they do not reach decay and depletion at an unrenewable point [1]. Sustainability is a multi-dimensional system which aims increase in life quality of all people [1]. Sustainability in construction is all about following suitable practices in terms of choosing materials, their sources and construction methodologies as well as design philosophy, so as to be able to improve performance, decrease the environmental burden of the project, minimize waste and be ecologically friendlier. Sustainability actually foresees a continuous development with changing only our consumption habits without reduction in our present life quality. Sustainability has three main dimensions/components called environmental, economic, and social.

A. Sustainable Building

The era of sustainable buildings has arrived with the start of the twenty-first century. Typical buildings produce a lot of waste during construction and operation, use energy inefficiently, and emit a lot of pollutants and greenhouse gases. In contrast to traditional construction, sustainable building construction aims to utilize resources like land, energy, and water wisely boost the usage of recycled and renewable materials, and improve the quality of the air inside and outside. The practice of increasing the efficiency with which buildings and their sites use energy, water, and materials, as well as reducing the impact of buildings on human health and the environment, through superior surveying, design, construction, operation, maintenance, and removal throughout the entire lifespan of a building.

According to B. Sarath Chandra Kumar and Gupta S.K. [2]. Sustainable building can also be defined as an activity that aims to:

1) Reduce or eliminate the impacts on the environment, natural resources, and other non-renewable sources in order to promote the long-term viability of the built environment.
2) Promote the long-term viability of the built environment.
3) Improves occupancy health and productivity.
4) Lowers construction to operating costs and applies a lifecycle approach to community planning and development.

Sustainable buildings are also referred to as high performance or green buildings.

B. Comparison between Conventional building and Sustainable building based on various parameters

Table 1 - Comparison between Conventional building and Sustainable building

Parameters	Conventional Building	Sustainable Building
Objective	The conventional building does not have any objectives.	The objective of sustainable building is to minimize waste, consume less non-

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		renewable resources, and create environments that are healthy and productive.
Materials used	The materials implemented in conventional building materials are often non-recyclable, which can further affect the environment.	Components used in sustainable buildings should be durable, reusable and recyclable, include recyclable components in their composition, and be sourced from the area where the building activity will take place - they must be local materials.
Design	Conventional building are constructed with the goal of providing the highest level of usefulness. Conventional designs also take little to no account of the surrounding environment.	Sustainable building will take into account a design that has as little as feasible, if any, impact on the surrounding and overall environment. They evaluate the current situation and attempt to construct within the limitations that exist. Sustainable designs also take into account natural flow and symmetry.
Cost considerations	In conventional building because the materials are readily available and have been used for a long period of time they are often cheaper to buy in bulk.	In sustainable building the cost must be considered because the materials are not readily available and can be more expensive compared to its conventional counterpart.
Energy Efficiency	Conventional building are not that energy efficient.	Sustainable building is said to be more energy efficient due to usage of power efficient appliances and also because of the integrated solar power plant as compared to its conventional counterpart.
Operational Cost and Maintenance	Conventional building have high operational and maintenance cost.	Sustainable building have low maintenance when compared to its Conventional counterpart which can save a lot of maintenance cost in the long run.
Economic Benefits	In conventional building the initial cost of construction in lower than that of its Sustainable counterpart	In sustainable building the initial cost is more than that of conventional one but in the long run it reduces operating costs and there is an increased property value.

C. Key attributes of Sustainable building

According to UNEP Sustainable Buildings and Construction Initiative [10] the key attributes of the sustainable buildings are

1) Consideration of sustainability aspects in all phases of building design and planning.
2) Consideration of sustainability aspects during construction and production of building materials.
3) Use of healthy and environmentally friendly building materials and products.
4) Use of efficient systems.
5) Use of constructions and systems which are easy to maintain and service.
6) Safeguarding of high functionality, flexibility and adaptability.
7) Safeguarding of health and comfort of users, occupiers and visitors.
8) High aesthetic and urban design quality; high public acceptance.
9) Appropriate location with good access to public transportation services and networks.

II. LITERATURE REVIEW

A. Sustainability in construction sector, Mustafa Yilmaz, Adem Bakis (2015)

Sustainability is defined as meeting the needs and expectations of the present without compromising future generations' ability to meet their own needs and expectations. Furthermore, there are three types of sustainability: environmental sustainability, economic sustainability, and social sustainability. Eco-friendly and smart buildings are the result of long-term environmental policies in the construction industry, which is heavily responsible for natural resource consumption and pollution. The paper then focuses on sustainability in the construction sector, which is further divided into two sections: sustainable architecture and sustainable construction.

Application of sustainable development principles to a building life cycle from planning the construction, constructing, mining raw materials through manufacture and becoming construction material, usage, destruction of construction, and waste management is the definition of sustainable construction. Sustainable constructions, also known as smart buildings or green buildings, are high-tech structures with control and automation systems. The paper also discusses various advancements in sustainable construction made at the global and national (Turkey) levels.

B. Sustainable construction management, B.Sarath, Chandra Kumar and Gupta S.K. (2014)

The main goal of sustainable development is not only to build with future needs in mind, but also to meet current housing needs while protecting the environment and resources for the future. This paper primarily addresses issues concerning construction project management, as well as the concept of green technology or so-called sustainable development, which could reduce risks. The paper then focuses on a few sustainable practices in construction management, including site selection through evaluation, material selection through life cycle analysis, time, cost, and resource controls, durability and stability, occupant health, construction protocols and procedures, designs based on creative concepts, etc. The paper also discussed construction management practices to make buildings as sustainable and green as possible. The paper then draws the conclusion that creating a green building is a complex process that involves more than just using sustainable materials; it also requires integrating sustainability into all phases of construction practices.

C. Green Buildings and Sustainable Construction, Prithviraj Dilip Mane (2017)

The construction industry has significant positive and negative environmental, economic, and social impacts on society in all parts of the world. The green building movement in India began in 2001, with the establishment of IGBC by the Confederation of Indian Industries (CII) in collaboration with the USGBC and the World Green Building Council. When the first green building, the Sohrabji Godrej Green Business Centre, was inaugurated, it was a symbolic movement for the country. In 2022, the market for green buildings in India is expected to reach 10 billion square feet. The paper then goes over the steps taken by the Indian government to promote the concept of green building for better environmental and social protection. Given the growing concern about environmental degradation, developers should reconsider their current construction practices and adopt sustainable construction practices in future projects. In line with this goal, a survey has been organized in the current study to assess the difference in level of knowledge, awareness, and implementation of sustainable practices based on project developers' perceptions in India. The paper concludes by recommending appropriate actions to improve this knowledge at all levels of developers in order to improve the acceptance and momentum of sustainable practice in the industry.

D. Sustainability in the civil engineering and construction industry: A review, Terlumum Utsev, Michael Tizza, Habibu Abubakar Saini, Terlumum Sesugh (2022)

The construction industry has a substantial impact on global GDP. Construction, on the other hand, accounts for 36% of global energy use and 39% of CO2 emissions, whereas manufacturing accounts for only 3% of global CO2 emissions. Environmentally friendly construction techniques can help to reduce the negative effects of construction. This paper discusses the concept and substance of sustainable development, the triple bottom line of sustainable development the importance of the triple bottom line to the construction sector, corporate sustainability, and knowledge transfer. Sustainability in construction works, how construction works affect the environment, environmental benefits of construction, barriers to sustainability in the construction industry, and steps to sustainability in construction are all discussed.

The paper also highlights various research gaps that need to be filled. The paper concludes by stating that the social sustainability success of a project is dependent on meeting the needs of a diverse range of stakeholders, and that sustainable construction creates a more equitable working environment, lowers costs, increases productivity, and improves health.

It also provides economic benefits, more efficient resource use, promotes environmental protection, and improves overall quality of life.

E. Comparative Analysis of a Conventional and a Green Sustainable Office Building, Lalit Srikar, Ignatius Thomas, Nikhilesh K, Neeraj N, Dr. B T Shivendra (2022)

Diverse businesses are embracing sustainability more and more, but the construction sector is lagging behind by a noticeable margin. 39% of all carbon emissions worldwide are attributed to building and construction, according to the Global Status report from 2017. Operational emissions make up 28% of the total, while the remaining 11% is made up of embodied carbon emissions from the materials and construction methods.

The paper compares a sustainable office building against a conventional one in extreme detail. Software like AutoCAD 2021 and Sketch Up were utilized to render the designs of the building models for the in-depth comparison. Quantity and cost estimation were done using the STACK (Take-off and cost estimation) software.

This research also discusses the embodied carbon, cost-benefit analysis, and operational energy of two theoretical models of conventional and sustainable structures. The advantages of establishing a sustainable office building in India are extensively highlighted in the paper's conclusion.

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III. METHODOLOGY

The purpose of this section is to do a cost comparison of a conventional building and a sustainable construction. The building taken under consideration for this comparison has a total built up area of 3000 sq. ft. Only the major construction materials were included for convenience of calculation. For the materials, the cost analysis was performed using current market values in India (particularly from the Thane region). The data obtained from numerous sources such as websites, journals, research papers [5] and books was used to do cost comparisons between conventional and sustainable building. As a result, the data shown here is approximate and may change depending on the circumstances at that point.

A. Cost estimation between Conventional and Sustainable Building

Table 2 - Conventional Building

Sr. No.	Item	Unit	Quantity	Rate (in Rs)	Amount
1	Excavation	cubic ft.	6000	9	54000
2	Soil Filling	cubic ft.	4500	10	45000
3	Ordinary Portland Cement	bags	1290	410	528000
4	Steel	kg	7500	85	637500
5	Sand	cubic ft.	3600	70	252000
6	Aggregates	cubic ft.	4020	60	241200
7	Bricks	no.	27900	8	223000
8	Tiles	square ft.	2100	35	73500
9	Paint	liters	360	300	108000
10	Windows and Doors	square ft.	3000	80	240000
	Total				2402200
11	Electrical Wiring			7%	168154
12	Water Supply and Sanitation			7%	168154
13	Labour Charges			20%	480440
14	Scaffolding, Shuttering			15%	360330
15	Consultation and Miscellaneous			12%	288264
16	Contingencies			5%	120110
	Grand Total				3987652

Table 3 - Sustainable Building

Sr. No.	Item	Unit	Quantity	Rate (in Rs)	Amount
1	Excavation	cubic ft.	6000	9	54000
2	Soil Filling	cubic ft.	4500	10	45000
3	Portland Pozzolana Cement	bags	1290	380	490200
4	Steel	kg	7500	95	712500
5	Sand	cubic ft.	3600	50	180000
6	Aggregates	cubic ft.	4020	70	281400
7	Bricks	no.	27900	6	167400
8	Tiles	square ft.	2100	50	105000
9	Paint	liters	360	400	144000
10	Windows and Doors	square ft.	3000	100	300000
11	Rain water harvesting system	liters			50000
12	Solar Power System	units			265000

	Total				2794500
13	Electrical Wiring			9%	251505
14	Water Supply and Sanitation			9%	251505
15	Labour Charges			21%	586845
16	Scaffolding, Shuttering			15%	419175
17	Consultation and Miscellaneous			14%	391230
18	Contingencies			5%	139725
	Grand Total				4834485

B. Energy Saving Estimation from Sustainable Building

Solar system plant of 5KW which was installed on roof top of the Sustainable Building on an average will produces 4 units of electricity per day:

So the electricity generated from the solar plant per month will be = 20 units * 30 days
= 600 units

Electricity generated from the solar plant per year will be = 600 units * 12 months
= 7200 units

Electricity generated from the solar plant in the next 5 years will be = 7200 units * 5 years
= 36000 units

Electricity generated from the solar plant in the next 10 years will be = 7200 units * 10 years
= 72000 units

Electricity generated from the solar plant in the next 15 years will be = 7200 units * 15 years
= 108000 units

Electricity generated from the solar plant in the next 20 years will be = 7200 units * 20 years
= 144000 units

So the overall electricity produced in 25 years will be = 7200 units*25 years
= 180000 units

IV. RESULTS AND DISCUSSION

The following are the results of the cost analysis between conventional and sustainable building construction.

1) The cost of construction of conventional building is 3987652 Rs while the cost of sustainable building is 4834485 Rs. The cost of both the building construction was calculated considering major construction materials. By comparison it was observed that the cost of construction of sustainable building is 21.23% more than that of conventional building.

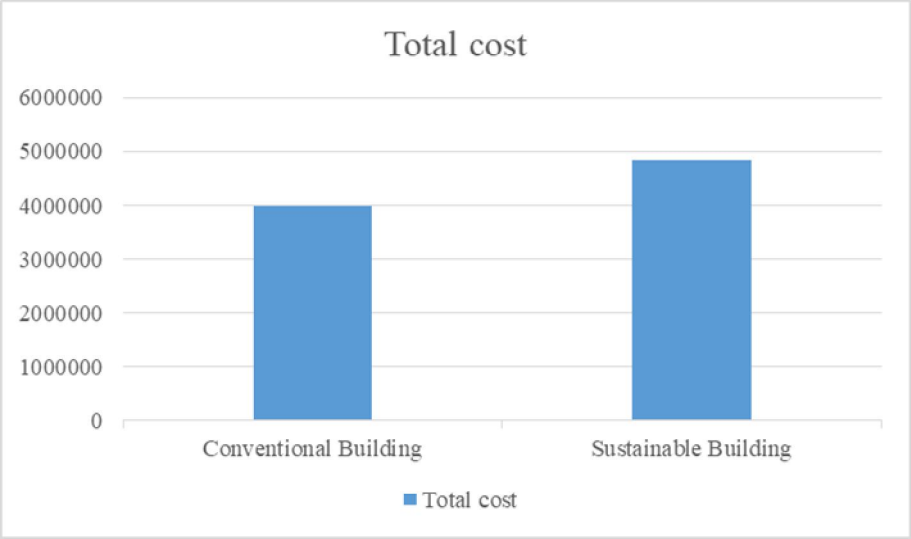


Fig. 1 - Cost Comparison between the Materials used in Conventional and Sustainable Building

2) But when the costing is broken down we found out that the raw material required for construction are in general costing equivalent but the main reason of cost increase is because in sustainable building there are additional amenities such as rainwater harvesting plant and solar power plant.

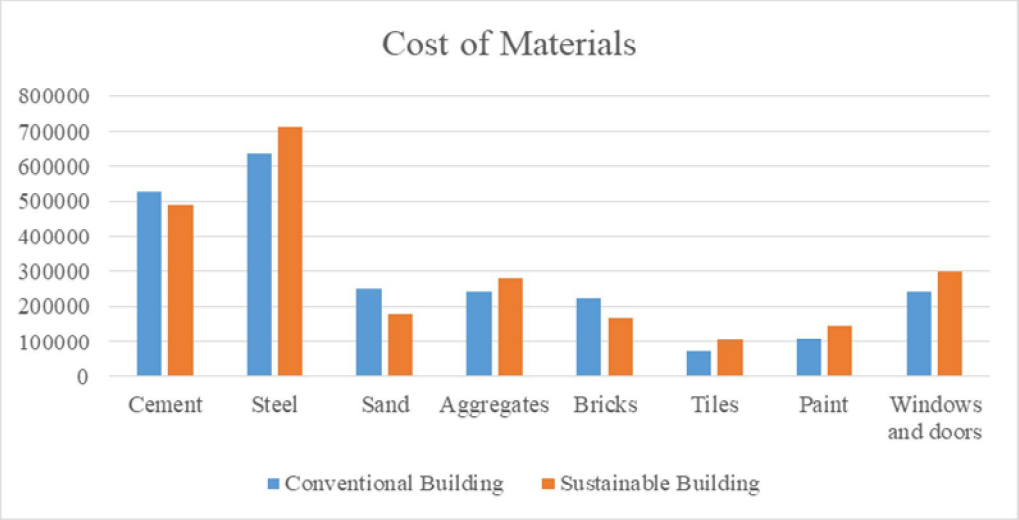


Fig. 1 - Cost Comparison between the Materials used in Conventional and Sustainable Building

3) For the calculation of the amount saved over a period of time we need the units generated from solar power plant and consider the cost of 1 unit of electricity as 11.86 Rs

Total cost saved from the solar power plant for the 1st year will be = 7200 units * 11.86 Rs
= 85392 Rs

Total cost saved from the solar power plant for the next 5 years will be = 36000 units * 11.86 Rs
= 426960 Rs

Total cost saved from the solar power plant for the next 10 years will be = 72000 units * 11.86 Rs
= 853920 Rs

Total cost saved from the solar power plant for the next 15 years will be = 108000 units * 11.86 Rs
= 1280880 Rs

Total cost saved from the solar power plant for the next 20 years will be = 144000 units *11.86 Rs
= 1707840 Rs

So the overall cost saved from solar power plant in 25 years will be = 180000 units * 11.86 Rs
= 2134800 Rs



Fig. 3 - Cost Estimation from the units generated from Solar Power plant

4) The cost difference between the conventional and sustainable building was 846833 Rs. Based on electricity generated from solar power plant the breakeven period for sustainable building will be 10 years after that the electricity generated from the solar power plant for the next 15 years will be free of cost.

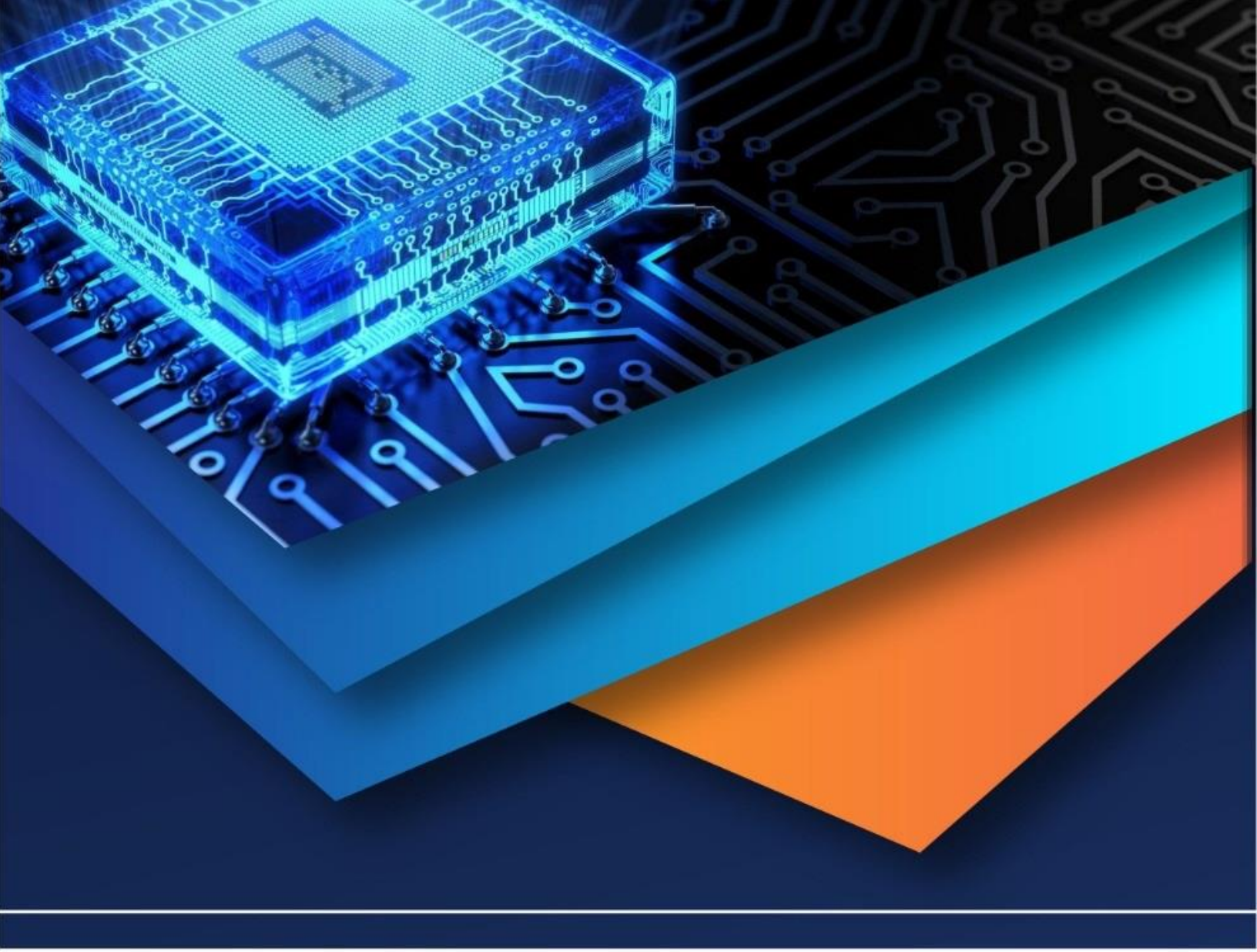
V. CONCLUSION

The study compares sustainable building with respect to its conventional counterpart based on various parameters and cost analysis. In which during cost analysis it is found out that the cost of materials required for construction are in general costing in the same range but due to the addition of rain water harvesting plant, solar power plant and some additional features the costing in sustainable building increases. The initial cost of the sustainable building is 21.23% higher than that of conventional building. Although the initial cost is higher, the savings in energy usage will more than offset the cost difference between the two structures in ten years. As a result, maximizing energy and water resources in sustainable building not only reduces the use of natural resources, but also helps to minimize direct and indirect cost savings for electric bills, and developing a sustainable building raises its property value. Overall, for a rapidly developing country which is witnessing a boom in the construction industry, this study showcases the potential and advantages for approaching building construction with sustainability in mind.

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