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Biophilic Design: A Way to Achieve Human Comfort & Well Being

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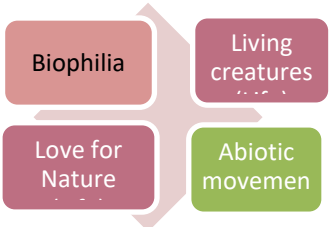
ABSTRACT

Currently, urbanization is occurring globally. Places are designed for several activities like work, play, sleep. However, it is important for these built environments to possess not only functionality but also energy, morality, and inspiration. Biophilic architecture presents an excellent approach to attain human comfort and well-being, thereby enhancing productivity through the utilization of natural elements. This paper centers around the Principles of Biophilic Design and its progression, examining its relationship with sustainability, and elaborating on the quantification of biophilic design and the existing gap in quantifying it within the Indian context.

Keywords: Biophilic Architecture, Human comfort & wellbeing, Quantification of Biophilia

1. INTRODUCTION

Human health and psychology are important factors in designing an efficient working environment. If we look back in history, nature has been an integral part of our lives. Green spaces are an effective aspect of any space's planning. This human-nature connection is studied by researchers and ecologists. The term "**Biophilia**" was first introduced by Erich Fromm, and later on E.O. Wilson elaborated on it through the "Biophilia" hypothesis. Further, this connection is observed in biophilic design, where biophilic dimensions, elements, and attributes in Kellert's BD framework are introduced. The aim of this paper is to understand existing certification of Biophilia and propose new certification with respect to Indian context. Also, the contribution of biophilic design to sustainability is illustrated in this paper.



2. METHODOLOGY

This investigation has been performed through the qualitative research method. For this personal interviews, user survey and biophilic score cards were used. The evolution of Biophilia and the use of natural elements like light, air, water, and vegetation in built environments are studied through literature studies. To fill the research gap in quantification, comparative analysis of world-wide green certifications has been done, and a new set of criteria has been suggested for the Indian context.

3. Background—the emergence of biophilic design

The Biophilia Hypothesis is a theory developed by Edward O. Wilson created the Biophilia Hypothesis in 1984 to explain why people have a natural urge to engage with nature and its various elements.

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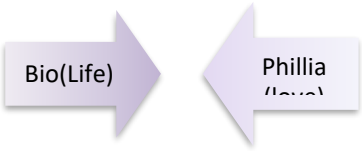


This connection has a positive impact on human's health and psychology. Researchers and ecologist worked on this Biophilia concept a decade later to collaborate their thinking and debate the concepts presented by Wilson. After discussions among experts from industry, government, finance areas on the practical implementation of the benefits of Biophilia into urban design and architecture, another book has been emerged, i.e., 'Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life'. The focus was on the use of biophilic elements in built environments.

Implementation of natural elements in buildings for human comfort and well-being gave rise to biophilic architecture. Let us see how the guidelines for biophilic design by various researchers helped to make building biophilic.

As the year passes, the concept of biophilic design has succeeded with time. Here is a table that gives a comparative analysis of various researchers. (Table 1)

Year	**Philosophy By**	**Concept**	**Outcome**
1973	Erich Fromm	Biophilia	Love to life
1984	Edward O. Wilson	the innate tendency to focus on life and lifelike processes	link with nature is not only physiological but has a genetic basis.
1993	Wilson	Biophilia hypothesis	The innately emotional affiliation of human beings to other living organisms'
1993	Stephen Kellert	Dependence on 'nature' was also expounded	Nine values of biophilia
2008a	Kellert	The inherent human inclination to affiliate with natural systems and processes	Exploring the relationship between humans and the natural environment.
2008b	Kellert	Ecosystem & Fire as well as Attraction, exploration and Discovery added	Addition of Attraction, Exploration, and Discovery One of the strongest human tendencies is an aesthetic connection to nature.
2015	Kellert and Calabrese	Simplified framework entitled Biophilic Experiences & Attributes	The framework have different emphases, strengths, and limitations.
2020	Browning & Ryan	Human nature relation with built environment	Flexible and adaptive, allowing for project-appropriate implement-ation

Table 1: Comparative analysis of Evolution of Biophilia

The evolutionary dependence on 'nature' was also illustrated by social ecologist Stephen Kellert by identifying nine values of biophilia: 'utilitarian, naturalistic, scientific, aesthetic, symbolic, humanistic, moralistic, dominionistic, and negativistic'.

The study on Biophilia progressed further, with Kellert introducing dimensions, elements, and attributes of Biophilic design to incorporate natural elements into architectural design. The first dimension, Organic, illustrates the direct or indirect connection, while the second dimension, Place-based, defines the connection between buildings and landscapes with the ecology or geography of the site.
Kellert (2008) explains six elements (Fig2) and attributes that range from natural aesthetics to fostering harmonious relationships in urban environments which were divided in two dimensions Organic & Inorganic

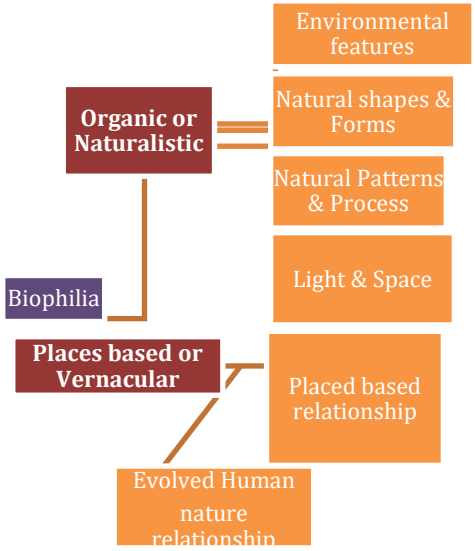
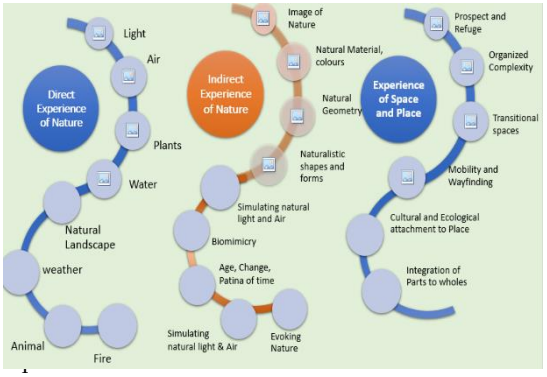


Fig 2. BD elements and attributes (Modified from Kellert, 2008)

Further Kellert and Calabrese (2015) introduced revised framework for Biophilic design, it framed under 3 main heads. The frameworks have different importance, assets, and Boundaries. This framework was a guideline for designing a structure as all planning aspects are considered in it. Following fig explains this framework



sed framework for BD by Kellert and Calabrese (2015)

In 2014 Browning, W.D., Ryan, C.O., Clancy, J.O. (2014) came up with 14 Patterns of Biophilic Design which articulates the relationships between nature, and design of the built environment it has been divided in 3 types .(Table 3)

1. Nature in space
2. Nature Analogue
3.Nature of the space

Nature in Space	**Natural Analogues**	**Nature of the Space**
Visual connection with Nature	Biomorphic Forms and Patterns	Prospect
Non visual connection with Nature	Material connection with Nature	Refuse
Non rhythmic Sensory Stimuli	Complexity and Order	Mystery
Thermal & Airflow Variability		Risk/Peril
Presence of Water		Awe
Dynamic & Diffuse light		
Connection with Natural Systems		

Table 3 : 14 Patterns of Biophilic Design by Terrapin Bright Green

Nature in Space: It is direct connection to nature. Examples of elements are water, animals, potted plants, breezes, water features, green walls, and courtyards.
Nature analogues: man-made elements which includes patterns, graphic artwork.
Nature of the Space: The best experiences are produced when revelatory moments are combined with spatial patterns from nature and natural equivalents.

A. Contribution of Biophilic Design to Sustainability

Biophilic design is a concept that aims to bring people closer to nature. While achieving this, the advantages of biophilic design extend beyond individual benefits to the potential to contribute to global development goals.
The use of natural materials, passive design strategies, and green infrastructure makes biophilic design an effective way to reduce carbon emissions and protect biodiversity.
Biophilic design can also promote social interaction and a sense of community. It can contribute to economic growth by improving the productivity of work and reducing absenteeism in the workplace. Productivity rate is increases in space which is incorporated with Biophilic elements .It can also contribute to environmental goals. Reducing carbon footprints and promoting the use of natural materials and passive strategies in planning.

Sustainable Goal	**Sustainable Goal Details**	**Biophilic Design approach**
1	No Poverty	Green buildings that incorporate local materials and support local economies.
2	No hunger	Promoting sustainable food systems and agriculture through the use of green roofs, green walls, urban farms
3	Good Health & Well being	Positive impact on human health and well-being by reducing stress levels, improving air quality, and promoting physical activity
4	Quality Education	Inspiring and engaging learning environment, leading to better educational outcomes for students
5	Gender Equality	Biophilic Design can support this goal by creating inclusive and equitable spaces that promote gender diversity and support the needs of all genders
6	Clean water & Sanitation	water-saving features such as rainwater harvesting, greywater

		recycling
7	Renewable Energy	reduce energy consumption by incorporating natural lighting and ventilation
8	Good Job & Economic Growth	creating healthy and supportive work environments that foster employee well-being, productivity, and satisfaction
9	Innovation & infrastructure	can promote innovation and entrepreneurship through Healthy environment
10	Reduced inequalities	
11	Sustainable cities & Communities	by integrating nature into the built environment and improving the quality of urban spaces
12	Responsible Consumption	by using natural materials and reducing the environmental impact of buildings and infrastructure
13	Climate Action	by reducing energy consumption and greenhouse gas emissions, as well as increasing the resilience of buildings and infrastructure to climate-related risks
14	Life below water	Indirect: recycled or renewable materials, to reduce the use of virgin materials that may contribute to ocean pollution
15	Life on Land	incorporating green spaces and other natural elements
16	Peace on Justice	by creating spaces that promote a sense of calm, relaxation, and well-being. By providing comfortable and attractive environments, can promote positive interactions and communication between

		individuals and groups, which can help to build more peaceful and inclusive societies
17	Partnership for the Goals	can bring together public and private sector partners to promote sustainable development, conservation, and climate action

Table 4 : Contribution of Biophilic Design to Sustainability

Implementation of Biophilic design helps to minimize energy consumption challenges by using natural element in effective way

B. Quantifying Biophilic Design

The use of natural elements in planning is always beneficial. Biophilic design is the connection of humans with nature by proposing vegetation, natural light, air, water, etc. But it is necessary to know how a building can be called biophilic. For this, a building needs to be quantified. There are some ways in which quantification can be done. It can be qualitative or quantitative.

1. Biophilic Design Scorecard:

A tool created by Terrapin Bright Green that measures how much a building uses biophilic design elements is called the Biophilic Design Scorecard. It evaluates seven biophilic design subcategories: visual connection with nature, non-visual connection with nature, natural forms and patterns, light and space, biomorphic forms and patterns, and material connection with nature.

2. Green Building Certification:

Green building certifications, such as LEED, incorporate biophilic design principles into their criteria. For these 14 patterns of BD developed by Terrapin Bright Green, the framework of Kellert's framework of elements and attributes is followed. Buildings that achieve higher levels of certification are more likely to have biophilic design elements. This building is quantified by qualitative or quantitative measures.

3. User Surveys:

Surveys can ask questions about user satisfaction, productivity, and health and well-being in spaces that incorporate biophilic design elements

The biophilic design patterns to be investigated include nature in space patterns, natural analogue patterns, and nature in space patterns. The data type is ordinal, as respondents were asked to rank the extent to which the vocational centers exhibited the stated patterns using a 5-point Likert scale.

Although the level of satisfaction for the biophilic design patterns ranges, the average perception of the users is higher than the median value on the 5-point Likert scale used in the questionnaire.

C. Green Certification tools to asses Biophilic Design

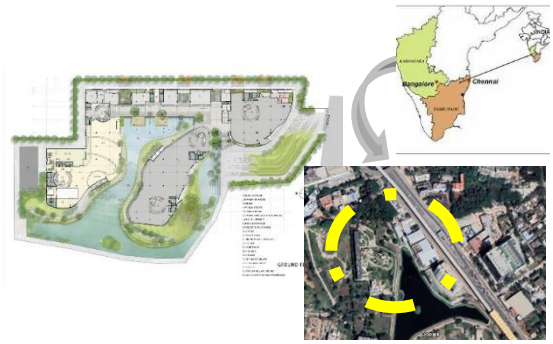
GBRTs tools now focused to incorporate health and well-being. There are some Green certification worldwide where Biophilia criteria is incorporated.some of the examples rea LEED,WELL,BREEAM.

D. Case study

The Titan Integrity Plus, Bengaluru
Area : 390000 sq.ft.
Designed by: Mindscape Architects

Building that integrates with nature : Enhancing Productivity of Employees in Workplaces through Biophilic Design Strategies

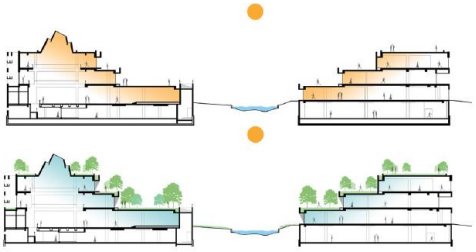
Introduction :
Corporate office of Titan is developed in 6.5 acre land, which has a reservoir on the east and expressway on North side.
The design is an exclusive example of human nature connection where site connects with the adjoining lake.



Location of Titan Integrity Plus

Requirements for LEED Certification:

-5 design strategies should comply Biophilic design . Each design planning must address biophilic design idea as assign to source from either 14 Patterns of Biophilic Design or Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life, by Kellert, Heerwagen, and Mador (Table 2). One of the biophilic design ideas must be from Table 1 OR from the Place Based Relationships division from Table 2..



Terraces provide insulation

Natural Diffused Light

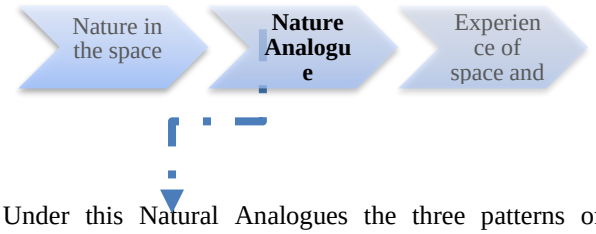
Natural Geometry

Natural Material

Presence of water

Enhances the experience of a place through seeing, hearing or touching water.

Selected Category to comply Green Certification: **Nature Analogue**



Under this Natural Analogues the three patterns of biophilic design are -

1. Biomorphic Forms & Patterns

Symbolic remarks to contoured, decorated, add up to or numerical plans that persist in type.

2. Material Connection with Nature

Minimally processed natural materials and features that represent the local environment or geology and provide an area a unique sense of identity

3. Complexity & Order

aim to inform, improve, or optimize the flow and relationships between people, goods **Five Design strategies to comply Green Certification**

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1.Biomorphic Forms and Pattern

2. Complexity and order

3.Material Connection with Nature

4.Presence of Water

5.Visual Connection with Nature.

Bringing nature inside through design strategies:

The longer Part of north direction acquires glare-free instinctive light To reduce heat gain from west Green wall is introduced.
Voluminous atriums admit light and escape hot air. Also forms sense of individual community, affection and bright interaction between various areas.
The landscaped terraces covered in grass, insulate the building, thereby reducing the heat load and creating comfortable conditions, in the immediate atmosphere, and large trees provide natural shading, which make the outdoors suitable for usage, even during the hot Indian summers.
Presence of water: balances microclimate by evaporating cooling

D. Outcome:

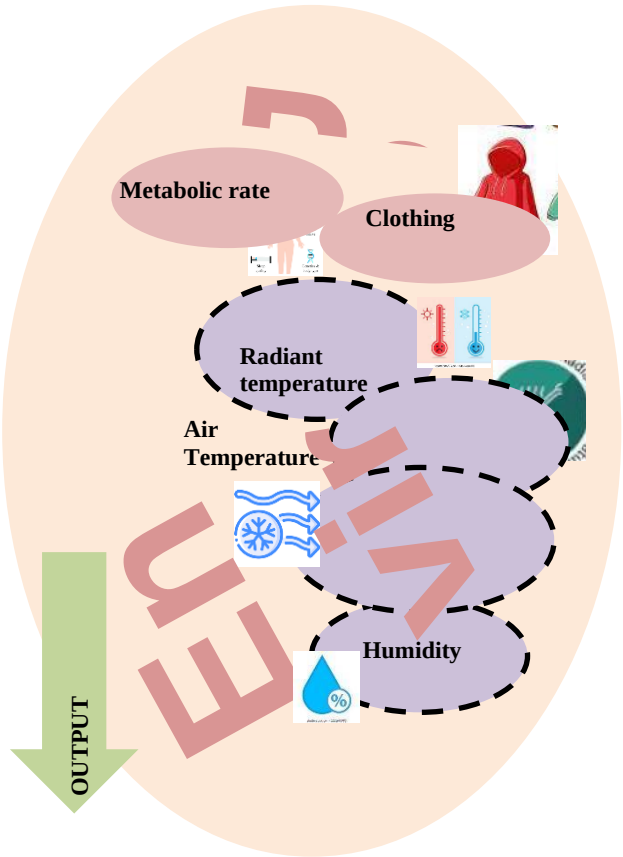
Though Biophilia is incorporated worldwide in many certifications, it is still not incorporated in Green Certification of Indian context. This gap needs to be fulfilled.
Though Air quality is given importance while designing a building in point of view of credit points, a deep thought is not given for Human comfort & well being.

E. Feeling gap and set Quantification criteria points to achieve Human comfort through Biophilia

Step 1 : To Find out standard for Human comfort & steps need to be taken to achieve these standards by various passive strategies
Step 2 : By studying Qualitative & Quantitative measures for Biophilic design of Green Certification A new set of criteria has been derivative to fill this gap.

Step 1 - Biophilic design is for Human comfort & well being

Thermal comfort in architecture refers to the conditions within a built environment that provide occupants with physical comfort. So to achieve this comfort we need to match safe levels of Air quality & Limits of temperature and Humidity by incorporating
Biophilic design strategies



Indoor parameters	Limits	Recommendation
Air temperature	fall/winter 23 to 28°C	ASHRAE Standard 55-2010, ISO 7730
Relative humidity	30% to 65%	ASHRAE Standard 55-2010, ISO 7730
Level of carbon dioxide in the air	to max 700 ppm above the external value	ASHRAE Standard 62.1- 2016

Source: Air quality parameters according to ASHRAE standard [21]

Biological positive response

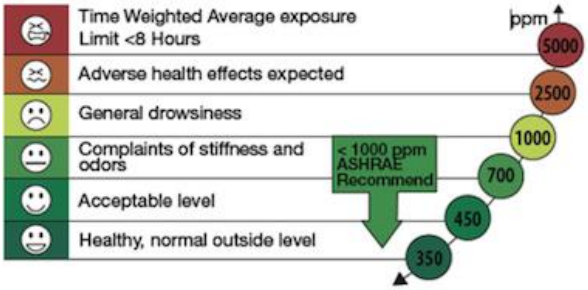
Heart rate

Productivity

Concentration

Health & well being

Air quality significantly effect on human health , comfort, and performance of occupants. Thus, IAQ is essential to living environment CO2 also contribute to indoor air pollution.



Source: https://iotfactory.eu/the-importance-of-indoor-air-quality-iaq-for-business-performance-and-wellbeing/

Step 2 – Proposed standards for Green certification

Building Standards	Qualitative Evaluation of Biophilic Design	Quantitative Evaluation of Biophilic Design
Proposed	1.Nature incorporation (Environmental elements- Light, Air, Water)	**1.** Outdoor Biophilia (25% of the site area with landscaped grounds or rooftop gardens, where 60 % plantings must be including tree canopies)
	2.Indirect Connection & Pattern (Form, Pattern, Biomimicry, Natural material, Natural Colour)	**2.** Indoor Biophilia Potted plants or planted beds > 1 % of floor area per floor wall covering area 2 % of the floor area per floor
	3.Nature interaction (Connection with the Ecology)	**3.** Water Feature (at least one water feature of 5m2 for per floor)

Through Biophilic Design

In Quantitative & Qualitative manner

Design:
Design a Training center for 8o students with Residential facility

Requirements:

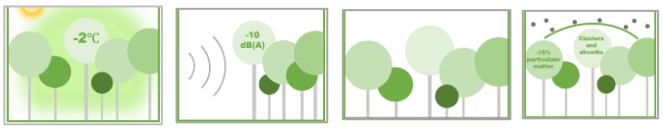
Reception & Waiting Area = 80 sq.m.
Admin area = 40 sq.m.
Cabin for Executive Engg with Waiting area=80 sq.m.
Cabins for Deputy Engg.=40 sq.m.
Conference Room=80 sq.m.
Multipurpose Hall 100=150-160 sq.m.
Classrooms 2=80 sq.m.
Smart Classroom 1=85 sq.m.
Library=80 sq.m.
Computer Lab=75 sq.m.
Staff Room=40 sq.m.
Meeting Room=75 sq.m.
Toilets – Gents = 4 WC,4 Urinal
Toilets-Ladies= 4 WC
Store Area
Canteen (Capacity 80)=100-120 sq.m.
Kitchen & Store = 50-60 sq.m.
Hostel for 80 People = 35sq.m. each room
Gym area/Recreational space=150 sq.m.

Alkaline soil:
Type of soil for proposed site
Cultural value:

Gajanan maharaj mandir on south: creates sound Pollution

Oxygen park : Miyawaki forest concept for dense vegetation

- Intensity of South Radiation decreases
- cool air as plantation on South west direction

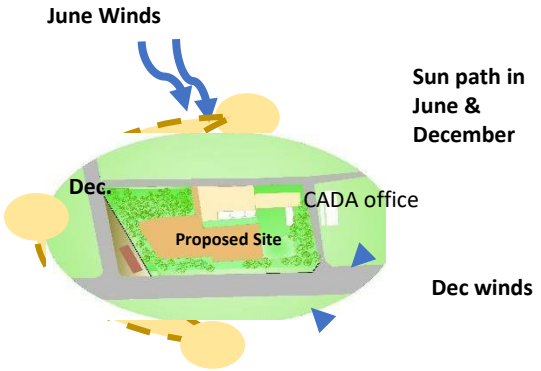


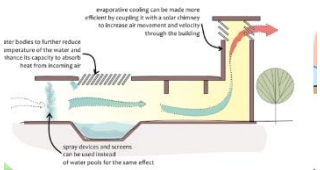
Temperature reduction | Noise reduction | Soil stability | Pollution reduction

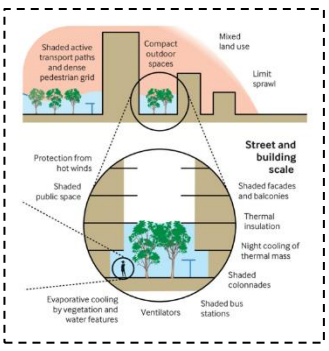
Water used to clogged in this area Due to plantation It started percolating in the soil

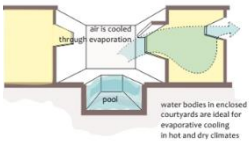
C Climatology of Aurangabad :

In Aurangabad has tropical climate ,with warm Summers, Temperature ranges from 27^0C to $39^{0C.}$









Passive strategies for Hot & D

SWOT Analysis :

Access : Direct access from main road
Secondary entrance as service entry

Miyawaki Forest : Reduction in Temperature
Buffer zone tend to reduce noise pollution

Gajajnan Maharaj Mandir : Occasional Noise Pollution

Shape of the site : Shape of the site impacts on

Existing ecology : Proposed building can be an example of Biophilic Building as it complies principle of visual connection with nature

No threats as such

No future developments \on south side due to temple

North west area is allotted for IRD office. Due to small area there will be no future expansion on this side too

Site will not be affected by future developments

Design Development

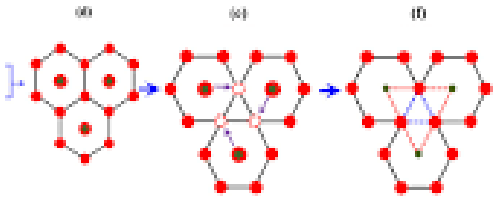
Derivation of Form……. Hexagon

Benef

- **Natural occurrence**(Biomimicry): such as honeycombs, snowflakes, and certain crystals. **Visual appeal**: harmony and balance
- **Efficient use of space**: Hexagons tessellate efficiently, meaning they can fit together without leaving any This property of hexagons can inspire efficient and sustainable design solutions in architecture and urban planning
- **Flexibility in design**: The modularity and flexibility of hexagonal shapes allow for versatile design possibilities. They can be easily combined, rotated, or

mirrored to create intricate and customizable patterns,

- **Structural stability**: Hexagons provide excellent structural stability due to their inherent strength and load-bearing capabilities. When used in architectural design, they can distribute forces evenly across multiple supports, resulting in more robust and stable structures
- **Natural lighting and ventilation:** enhance the penetration of natural light, reducing the need for artificial



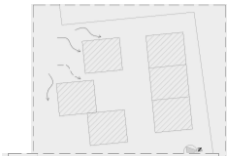
lighting and minimizing energy consumption.

Incorporating hexagonal elements in design can enhance the biophilic qualities of a space, improving human well-being and fostering a deeper connection with the environment.

Hexagon is often considered a biophilic shape due to its presence in nature and the positive psychological and physiological effects it can have on humans

Option 1

Building Blocks oriented to receive North light and single surface exposed to West side but, Wind flow is obstructed



Option 2

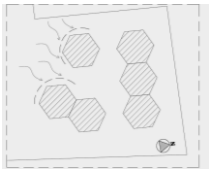
Building Blocks oriented to receive Wind inside but more surfaces exposed to side - increase in Heat gain

Option 3

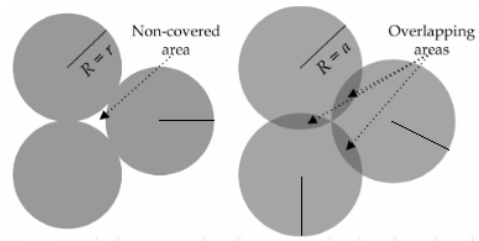
Continuous exposed surfaces- increase in Heat gain

Option 4

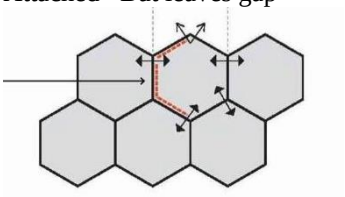
Building Blocks oriented to receive North light by multi surface single surface exposed to West side & free flow Wind penetrates in building block



Attached closely but not Packed/Interlocked

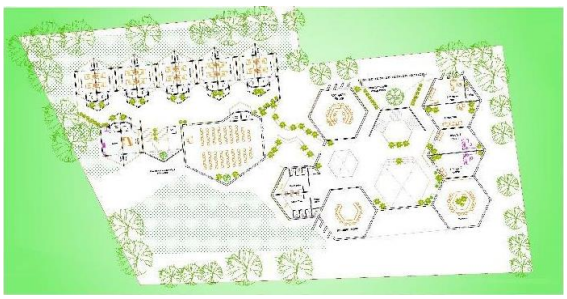


Attached –But leaves gap

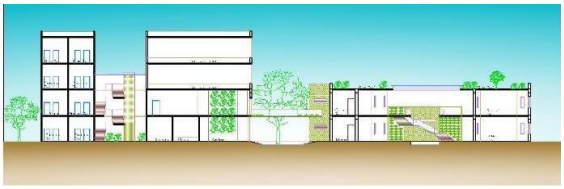


Allows for four interior and Two exterior connections

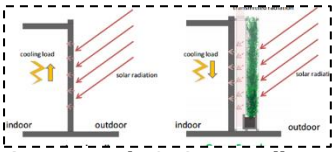
GROUND FLOOR PLAN



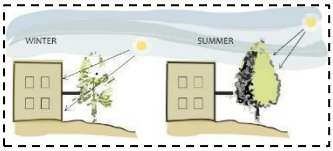
FIRST FLOOR PLAN



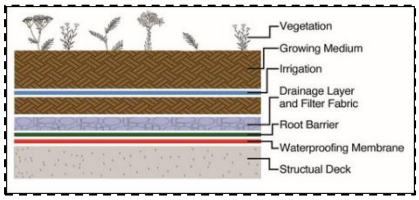
SECTION



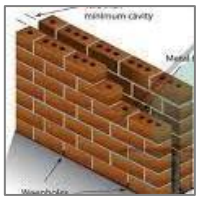
Conventional & Green wall



Deciduous Trees



Green Roof Section



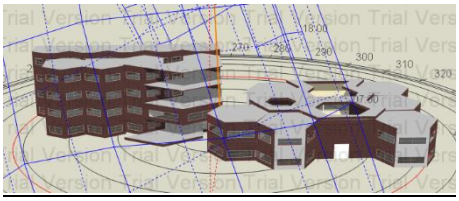
Cavity Wall

ENTRANCE VIEW

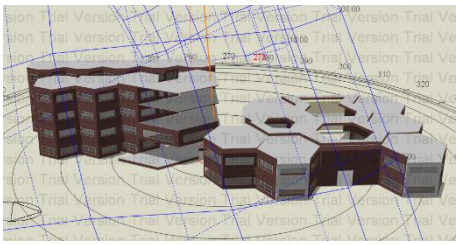
GREEN ROOF

VIEW OF HOSTEL BUILDING

Shadow Analysis of Design Proposal



15th may @ 9.00 am



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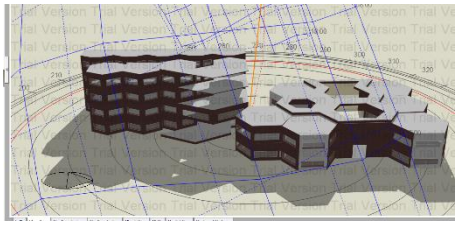

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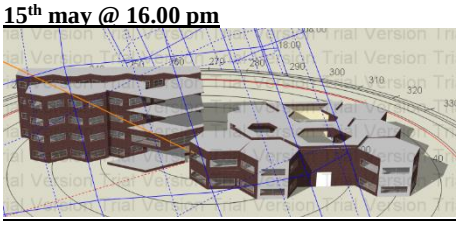

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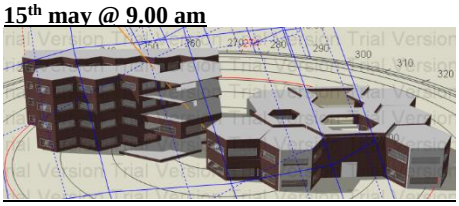

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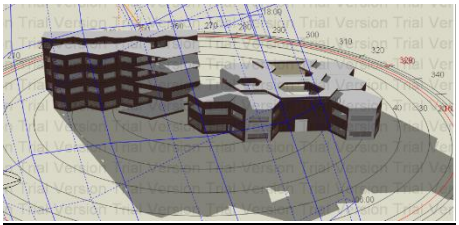
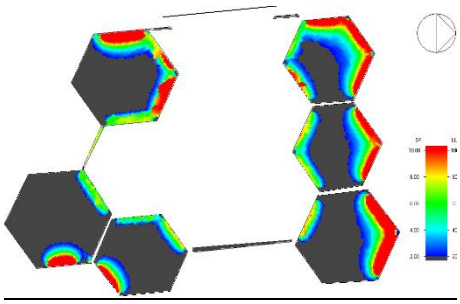


15th may @ 16.00 pm

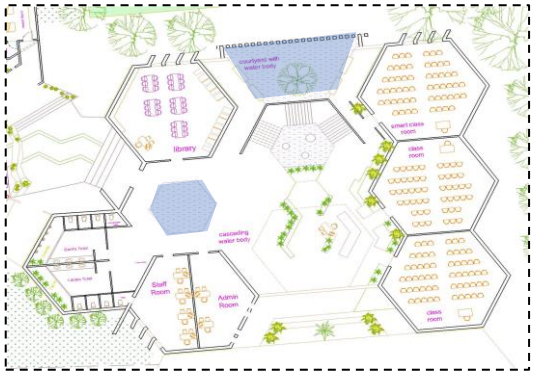


Daylight Analysis

Green Certification :

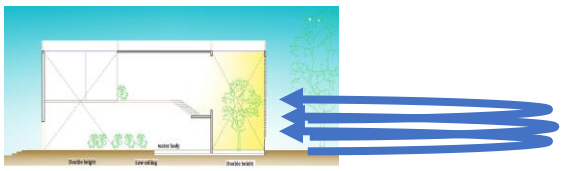
Qualitative Approach & Quantitative Approach

1.Qualitative Approach :

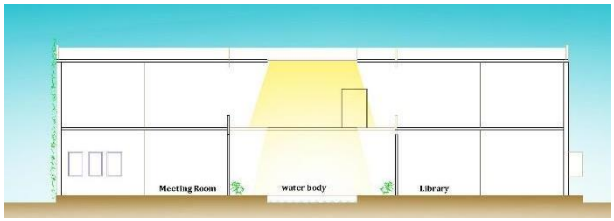


N

KEY PLAN



SECTION THROUGH COURTYARD



SECTION THROUGH ATRIUM & GREEN WALL

1.Nature incorporation
-Light
-Air
-Water

Diffused light ,South West Winds, Court with water body

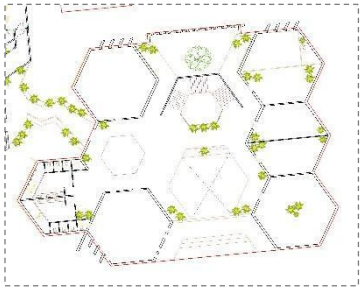
Skylight though Staircase

Presence of Water

2.Indirect Connection & Pattern
-Natural material
-Natural Colour
-Biomimicry form

Natural Material

Natural Colour



Natural Form: BEE Hive

3.Nature Interaction
-Ecology connection

	Name of Tree	Foliage Dia.	Radius of Foliage	Area of Folia-ge	No. Of Trees	Total Foliage area
Mango	Mangifera indica	9	4.5	63.58	11	699.43
Neem	Azadirachta indica	15	7.5	176.62	4	60
Amaltus	Cassia fistula	12	6	113.04	4	48
Behda	Terminalia bellerica	5	2.5	19.62	12	60
Arjuna	Terminalia Arjuna	15	7.5	176.62	4	60
					Total	**927.435**

1.Quantitative Approach :

Outdoor Vegetation Calculation

Green Visually

Name of Tree	Foliage Dia.	Radiaus of Foliage	Area of Foliage	No.Of Trees	Total Foliage area
Hibiscus	1.5	o.75	1.76	25	44.15
Ixora Dwarf	1	0.5	0.81	10	8.1
				Total	**52.25**

Indoor Vegetation Calculation-Training centre

floor	Floor rea	Expected Green wall area(>2% of floor area)	Expected Green area-potted plants(>1 % of floor area)	Proposed Green wall	Proposed Potted area
First floor	928.96	18.5792	9.2896	49.89	40.07
Second Floor	848.94	16.9788	8.4894	49.89	40.07

Total Vegetated Area Calculation:

Site area	Veg-tated area expected	Expec-ted vegetation-Tree canopy	Pro-posed vegetation-Tree canopy	Proposed Green roof	Pro-posed shrub area	Pro-posed ground cover	Total proposed vegetation
	25 % of Total area	(60% of 25% vegetation)					
4691.07	**1172.76**	703.66	927.43	750	52.25	573	2302.68

Water Feature calculation

Floor	Expected Water Feature area (min 5sq.m.)	Proposed area for water element
First Floor	5	111.21
Second Floor	5	7.5
For Hostel (Ground floor)	5	8.6
For Hostel (Each floor)		17.2

Green column at Hostel ducts:

Visually connection with nature though less sunlight

Plants who does not needed sunlight

Indoor Vegetation Calculation-Hostel Block

floor	Floor area	Expected Green wall area(>2% of floor area)	Expected Green area-potted plants(>1% of floor area)	Proposed Green wall	Proposed Potted area
First floor	742.97	14.8	7.4	67.53	10.32
Second Floor	742.97	14.8	7.4	123.73	20.81
Second Floor	533.94	10.66	5.33	43.34	12.47

Second Floor	533.94	10.66	5.33	43.34	12.47

Tree Sequestration Data

	Name of Tree	Ht.of Tree	DBH	Wt.above ground	Total green Wt.	Total Dry Wt.	Total Carbon	Total CO2	Total tonns
Mango	Mangifera indica	25	8	400	480	348	174	638.58	31
Neem	Azadirachta indica	20	9	405	486	352.35	176.17	646.56	0.32
Amaltus	Cassia fistula	15	6	135	162	117.45	58.725	215.52	0.1
Behda	Terminalia bellerica	22	7	269.5	323.4	234.465	117.23	430.24	0.1
Arjuna	Terminalia	35	12	756	907.2	657.72	328.86	1206.91	0.6

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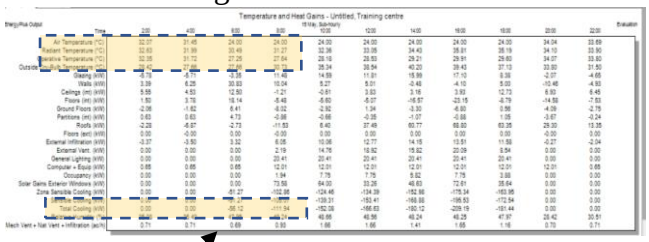
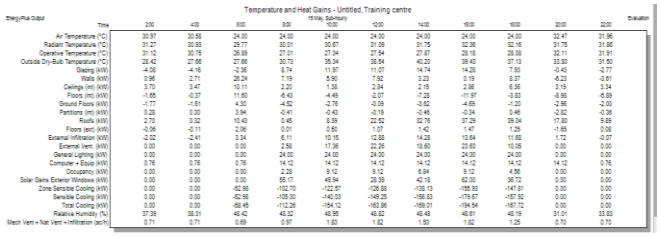
Temperature reduction calculations through software

Addition of Green wall & Green Roof reduces Heat gain



Base Case **Design Case**



Partitions (int) (kW)	-0.35	-1.07	-0.88
Roofs (kW)	37.49	60.77	68.80
Floors (ext) (kW)	0.00	0.00	0.00

Base Case

Partitions (int) (kW)	-0.19	-0.46	-0.34
Roofs (kW)	22.52	32.76	37.29
Floors (ext) (kW)	1.07	1.42	1.47

Design Case

Ppm of CO2 calculations for Good Air Quality

Ppm of proposed site is 400,while good quality ppm is 350,Hence we need to reduce 50 ppm to achieve good Air quality

Plants	Light intensity	Percentage of CO_2 reduction (%)	Total CO_2 reduction (ppm)	Mean of standard deviation
Anthurium	300 lux	2.2	18.30	0.45
	700 lux	10.80	101.00	1.26
Dumb Cane	300 lux	5.50	55.4	0.45
	700 lux	11.10	111.33	0.18
Golden Pothos	300 lux	6.10	60.67	1.10
	700 lux	10.03	101.33	0.63
Kadaka Fern	300 lux	6.50	64.6	1.13
	700 lux	12.48	123.3	0.84
Prayer Plant	300 lux	7.00	71.67	0.64
	700 lux	14.40	154.63	0.62
Spider Plant	300 lux	*0.20	*0.67	1.32
	700 lux	0.10	1.02	1.17
Syngonium	300 lux	6.72	64.67	0.98
	700 lux	10.08	104.00	0.73

PPM Calculation as per type of Plant

Potted Plants in atrium

Vegetation in Lobby

Classrooms & admin area

Type of Plant	Lux Level(700)	Area to be covered	No Of Plants	Reduction of ppm
Anthurium	101	390	65	50
Prayer Plant	154	390	42	50
Golden Pothos	101.33	390	65	50

Lobby & Corridor area

Type of Plant	Lux Level (700)	Area to be covered	No Of Plants	Reduction of ppm
Anthurium	101	1770.43	295	50
Prayer Plant	154	1428.33	152	50
Golden Pothos	101.33	1770.43	295	50

Hostel area

Type of Plant	Lux Level(700)	Area to be covered	No Of Plants	Reduction of ppm
Anthurium	101	2243	374	50
Prayer Plant	154	2243	240	50
Golden Pothos	101.33	2243	374	50

Conclusion & Result :

Biophilic Design strategies can improve human comfort ,well being & productivity .Theses strategies helps to achieve sustainability.
Suggested guideline of certification with respect to Indian context can fill the gap of quantifying Biophilia.

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