

Application of Biophilic Design in Architecture

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Abstract

Application of Natural elements in designing is need of today's planning. These green planning not only enhances beauty of spaces but also provide healthy environment. Green spaces improve productivity of work and reduce carbon footprint. The study explains Evolution of Biophilic design, its principles and pattern. Application of Biophilic design in sustainable architecture is also part of this research paper. The aim of the paper is to asses awareness of Biophilic architecture.

Keywords: Biophilic design, Patterns, Healthy atmosphere, Sustainable architecture

1.INTRODUCTION

In today's scenario, construction is backbone of the economy of city. while doing this, concrete jungles are spreading vigorously neglecting existence of green spaces and its importance in urbanization. Though vegetation is observed while planning any structure, we should even give an attention towards use of other natural elements to improve quality of spaces .This paper is focusing on use of natural elements like Air, Light, Water as well as Landscaping used in construction through case studies. Paper also explains Link between human and nature using principles and elements of Biophilic design. Our instinctual responses to the natural world form the basis of human psychology. Our brains have evolved to naturally seek out environments that promote our physical and emotional wellness. Many psychologists and researchers did research on this and derived with Biophilic Principles and attributes. Paper gives comparative analysis to study evolution of biophilia.

METHODOLOGY

To derive with the design strategies of Biophilic design, evolution of Biophilic design is studied. For that theories and Principles are compared for period of time. Case study of Biophilic structures gave existing design strategies. Biophilic design is quantified by Biophilic Scorecard, Certification and Public Surveys.

A. Evolution of Biophilic Design

Erich Fromm first described the human personality trait known as biophilia, which was later elaborated by E.O.

Wilson(1984), both agreed that biophilia has a biological basis, Hence it is necessary to research on connections between human and Living things. Wilson claims that our natural attraction for Nature and creature is spirit of our humanity and hold us to all other living things (Fig1.)

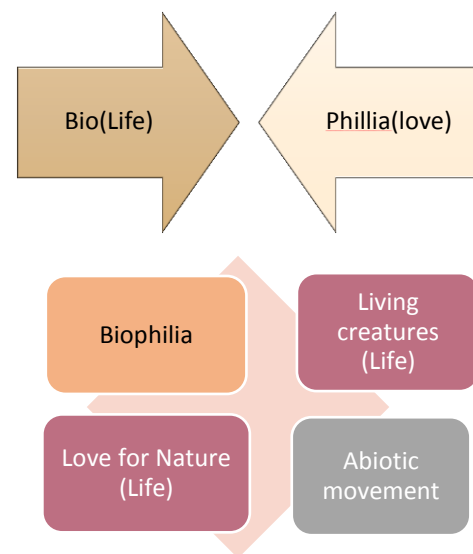


Fig 1. Connection with Nature

Later on, Wilson, together with Stephen R. Kellert, published the collection of essays 'The Biophilia Hypothesis' (Kellert and Wilson, 1993); This hypothesis asserts that human reliance on nature is not restricted to physical nourishment but it covers human craving for aesthetics, intellectual, cognitive, and even spiritual meaning and satisfaction.

As the year passes concept of biophilic design succeeded with the time, here is the table which gives 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
1996	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	Biophilia theory have shifted from its initial focus on life or living organisms to exploring the relationship between humans and the natural environment.
2008b	Kellert	Ecosystem & Fire as well as Attraction, exploration and Discovery added	Aesthetic attraction towards nature is one of the strongest inclinations of human species
2015	Kellert and Calabrese	Simplified framework entitled Biophilic Experiences & Attributes	The frameworks have different emphases, strengths, and limitations.
2020	Browning & Ryan	Framework for biophilic design that is reflective of the nature-health relationships most important in the built environment	Flexible and adaptive, allowing for project-appropriate implementation

Table 1 : Comparative analysis of Evolution of Biophilia

At the beginning of the 21st century, the notion of biophilia was developed and adapted within the architectural drawings. (chart1) Designers started to give special attention to connection of emotional aspect of humans with the nature.

The evolutionary dependence on 'nature' was also expounded by social ecologist Stephen Kellert by identifying nine values of biophilia: 'utilitarian, naturalistic, scientific, aesthetic, symbolic, humanistic, moralistic, dominionistic, and negativistic'. These values were instrumental in promoting the health and well-being of our forefather. (Table 2)

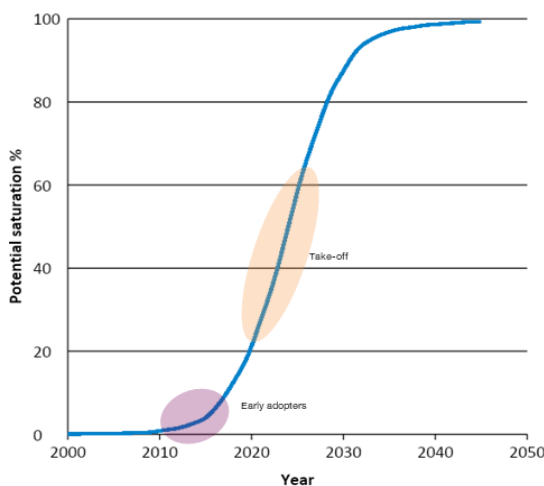


Chart 1 : Evolution of Biophilia

Value	Description	Function
1.Utilitarian	Practical and material exploitation of nature	Physical sustenance and security
2.Naturalistic	Satisfaction from direct experience and exploration of nature	Curiosity, discovery, recreation
3.Ecologistic-Scientific	Systematic study of Nature (Forms, functions, interrelationships)	Knowledge, understanding, observational skills
4.Aesthetic	Physical appeal and beauty of nature	Inspiration, harmony, security

5.Symbolic	Use of nature for expression in language and thought	Communication, mental development
6.Humanistic	Strong emotional attachment and "love" for aspects of nature	Bonding, sharing, co-operation, companionship
7.Moralistic	Spiritual reverence and ethnical concern for nature	Order, meaning, kinship, altruism
8.Dominionistic	Mastery, physical control, dominance of nature	Physical skills and prowess, ability to subdue
9.Negativistic	Fear, aversion, alienation from nature	Physical skills and prowess, ability to subdue

Table 2 : Nine values of biophilia by S.Kellert

The hierarchy and intensity of these values changes individually as well as within human communities but their healthy and adaptive expression belongs to each individual of our species. Further in 2008, Kellert argue that biophilic design takes advantage of an intrinsic human affinity to incorporate natural and local systems and processes into the design of the built environment. Kellert (2008) delineates six items/elements (Fig2) and attributes that go from natural looks to friendly friendships in metropolises. These elements consist of environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships.

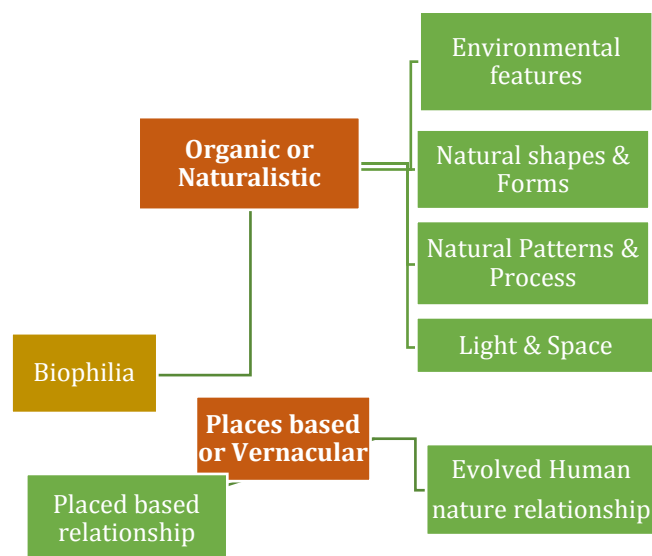


Fig 2. BD elements and attributes

(Modified from Kellert, 2008)

Organic or Natural dimension of Biophilic Design defines as shapes and Forms in the built environment that directly, indirectly or symbolically reflect the inherent human affinity for nature, While Places or Vernacular dimension defines buildings and landscaping which connects to existing ecology and geographic area. Using sunlight, air, water can make healthier and wellbeing, Forms can make space more workable and allow to take benefit of natural elements. (e.g. air ventilation and sunlight penetration angle can be depend on shape of roofing).Similarly existing ecology make space more beautiful (e.g. backdrop of mountains or waterfall in hilly areas, contours can be used as landscape element)

Moving ahead Kellert and Calabrese (2015) introduced revised framework for Biophilic design, it framed in 24 elements which were categories under 3 main heads(Table3). 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.

Table 3. Revised framework for BD by Kellert and Calabrese (2015)

Direct Experience of Nature	Indirect Experience of Nature	Experience of space and place
Light	Image of Nature	Prospect & Refuge
Air	Natural Material & Colour	Organized complexity
Plants	Natural Geometry	Transitional Spaces
Water	Naturalistic shapes and Forms	Mobility & Wayfinding
Natural Landscape	Simulating natural Light & air	Cultural & Ecological attachment to place
Weather	Biomimicry	Integration of parts to wholes
Animal	Age, Change, Patina of Time	
Fire	Information richness	
	Evoking Nature	

Biophilic design can reduce stress, enhance creativity and clarity of thought, improve our well-being and expedite healing. Theorists and researchers were working on this Biophilic design for years and years. In 2014 Browning, W.D., Ryan, C.O., Clancy, J.O. (2014) came up with 14 Patterns of Biophilic Design. These patterns cover interior as well as exterior applications with flexible design implementation(Table4)

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 4 : 14 Patterns of Biophilic Design by Terrapin Bright Green

(Note : Terrapin added a fifteenth pattern entitled "Awe" in 2020. which was absent in 2014),It Is not considered in category for green certification of USGBC.

Nature in the Space addresses the direct, physical and ephemeral presence of nature in a space or place .Example of elements are water, animal, Potted plants ,breezes, water feature ,Green walls, courtyards.

Nature Analogues man-made elements that mimic nature. Examples of organic analogues include affected plants, continued moss divider, graphic artwork, patterns, and structural designs that stimulate elements of character.

Nature of the Space: This idea refers to the physiologic hole or door in vessel which scope preparation and structural design influence our human reactions and feelings Quantifying Biophilic design

B. Quantifying Biophilic Design

Though there are no of patterns and elements of biophilic design to improve productivity of work it is always necessary to quantify BD with some measures to find out its impact. Let us see under which measures it can be simplified.

1. Biophilic Design Scorecard:

The Biophilic Design Scorecard is a tool developed by Terrapin Bright Green that quantifies the degree to which a building incorporates biophilic design features. It assesses seven categories of biophilic design: visual

connection with nature, non-visual connection with nature, natural shapes and forms, natural patterns and processes, light and space, biomorphic forms and patterns, and material connection with nature.

2. Green Building Certification:

Green building certifications, such as LEED (it incorporates biophilic design principles into their criteria. For these 14 patterns of BD developed by *Terrapin Bright Green and framework of Kellert's framework of elements and attributes is followed*) certifies Buildings that achieve higher levels of certification are more likely to have biophilic design elements.

3. User Surveys:

User surveys can be used to quantify the perceived benefits of biophilic design. Surveys can ask questions about user satisfaction, productivity, and health and well-being in spaces that incorporate biophilic design elements compared to those that do not.

C. Green Certification tools to asses Biophilic Design

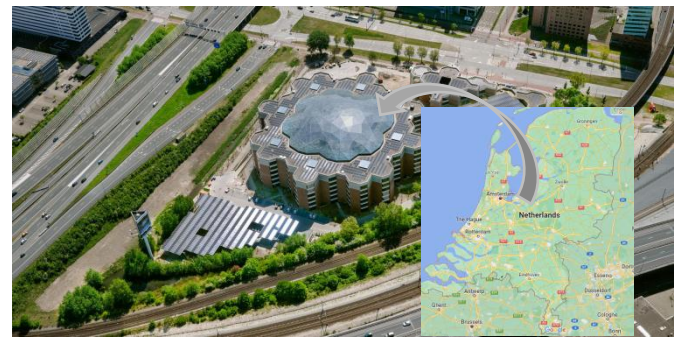
Earlier GBRTs tools were focusing only on Energy efficiency, whereas now it is incorporating health and well-being. Here is the comparative analysis to explain weightage of Quantitate and Qualitative evolution across the world's Green certification standards.

Building Standards	Qualitative Evaluation of Biophilic Design	Quantitative Evaluation of Biophilic Design
WELL V2	Mind - Biophilia I	Mind - Biophilia II
	1.Nature incorporation (Environmental elements, lighting, space layout)	1. Outdoor Biophilia 2. (25 % of the site area with landscaped grounds or rooftop gardens, and 70 % plantings including tree canopies)
	2.Pattern incorporation(Nature's pattern throughout the design)	2. Indoor Biophilia (potted plants or planted beds > 1 % of floor area per floor, and covering a wall area 2 % of the floor area)
	3.Nature interaction(within the building,	3. Water Feature (at least one water

	within the project boundary, external to the building)	feature for every 9290 m2 [100,000 ft2] in projects larger than 9290 m2 [100,000 ft2], each one >1.8m in height or 4 m2 in the area and with technology to address water safety)
Building Standards	Qualitative Evaluation of Biophilic Design	Quantitative Evaluation of Biophilic Design
BREEAM-NL V1.0 (NC)	- HEA 10 Biophilic Design: Browning et al.'s 14 patterns of biophilic design in 3 categories: 1. Direct Experience of Nature 2. Indirect Experience of Nature 3. Experience of Space and Place	Health - HEA 10 Biophilic Design (standard): From Browning et al.'s 3 categories and 14 patterns of biophilic design 1. Min 1 of the 3 categories are included 2. Min 7 of the 14 patterns are included 3. In 80 % of the living spaces, at least 2 patterns can be directly experienced while the other 5 patterns can be experienced on the same floors 4. No significant negative effect on the main health aspects 5. At least 3 measures (patterns) are not typical for the building and user function in which they are applied
GM (NRB and RB)	NRB 2015 4.2c Wellbeing - (i) Biophilic Design: 1. Accessible sky Gardens, sky Terrace, internal courtyards and rooftop gardens as areas for respite	NRB 2015 4.2c Wellbeing - (i) Biophilic Design: 3. 5 % of the common areas or functional spaces fix indoor planting 5. Images of nature for 5 % of common areas

	2. Biomimicry designs 4. Natural shapes and forms, or ecological attachment to the place	
	RB 2016 4.02 c Wellbeing - (i) Biophilic Design: 1. Nature in common areas 2. Indirect experience of nature 3. Experience of space and place 4. Space in common areas for lifestyle wellbeing	
LBC 4.0	Health D Happiness - Access to Nature: 1. Sufficient and frequent human-nature interactions in both the interior and the exterior 2. Post-occupancy evaluation regarding daylight, fresh air and access to nature Beauty - Beauty D Biophilia: 1. Environmental features, light and space, and natural shapes and forms 2. Natural patterns and processes and evolved human-nature Relationships 3. Place-based relationships (place, climate, and culture) 4. Human delight, and culture, spirit, and place	

LEED V4 (BDpC NC)	Pilot Credits EQpc123 - Designing with Nature, Biophilic Design for the Indoor Environment: 1. Nature in the space (or environmental features, light and space, natural patterns and processes) 2. Natural analogues (or natural shapes and forms) 3. Nature of the space (or evolved Human Nature relationships) 4. Place-based relationships 5. Opportunities for human-nature interactions	
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View of Building



Water body at Entrance

Table 5 . Green Certification tools to asses Biophilic design

D. Case studies to understand Biophilic Design elements in Green certified buildings

Case study 1 : The Edge, Amsterdam

EDGE Amsterdam West :48,000 sqm redevelopment of an office building

Designed by: former de Architekten Cie architect

key tenants : APG and Alliander .

Reviewing Dutch design projects from the ending of 1980 to 2000, the decision maybe tense that Biophilic design only easily begun coming into practice following in position or time the period 2000

In the Netherlands, Biophilic design in the 21st of one hundred years is principally executed on the city- and community scale, place large projects, design by political bodies, aim to support

Requirements for BREEAM Certification :

Qualitative Evaluation :

Measures have been included in the building for 14 patterns of biophilic design in 3 categories.

Quantitative Evaluation :

At least one component from all 3 categories of Biophilic Design is included in the building.

Measures relate to the entire building and in 80% of the occupied areas at least 2 components of Biophilic Design can be experienced directly, while the other 5 components can be experienced on the same floors.

The applied measures for Biophilic Design have no significant negative effect on the most important health aspects.

The Assessor uses his professional judgment to determine that:

The measures have been applied in line with the purpose of the credit.

At least 3 measures are not typical for the building and use function in which they are applied.

Measures included for BREEAM Certification :

The building has been upgraded to become an advanced and sustainable office space, meeting the highest requirements in terms of sustainability, technology and office health.

Design strategies for Qualitative Evaluation :

Fully glazed Atrium : Natural daylight to reaches the deep office floors.

To blow up the everyday dawn into the occupied spaces, the eight round shafts for establishments, situated everywhere the construction, are outside of and having another in one's place by new satisfied light shafts that reveal the floors from bottom to the roof.

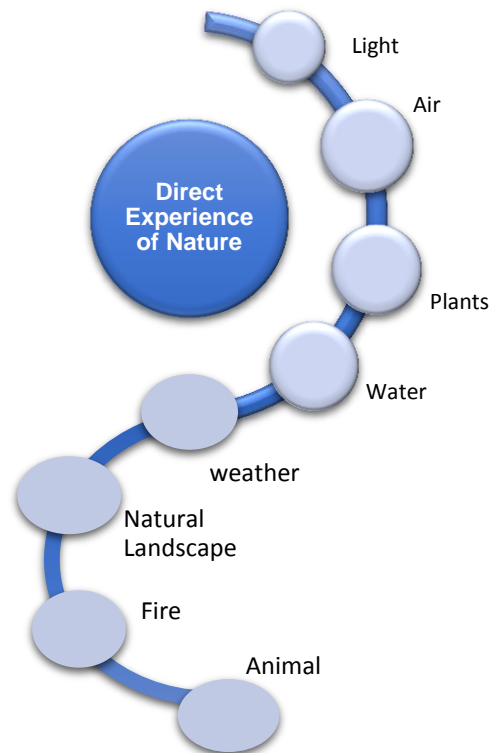
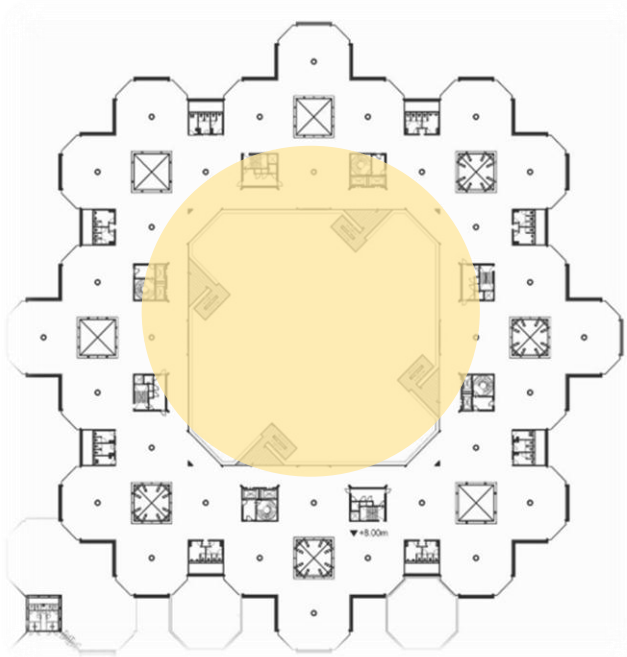


Fig.4.Direct Experience of Nature



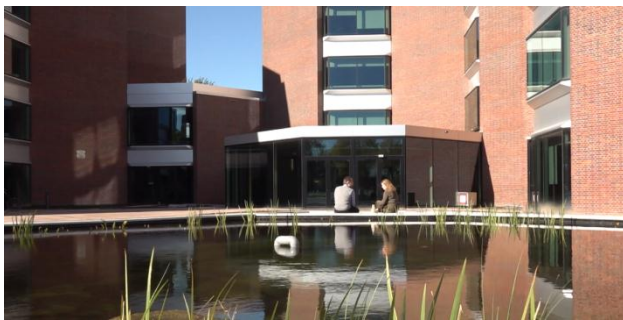
Typical Floor Plan-Atrium at the center



Light , Air, plants



Weather



Water



Section

Indirect Experience of nature :

This Attribute is nothing but Natural Analogues, which are **materials and patterns that evoke nature** and are characterized by four broad types: representational artwork, ornamentation, biomorphic forms, and the use of natural materials.

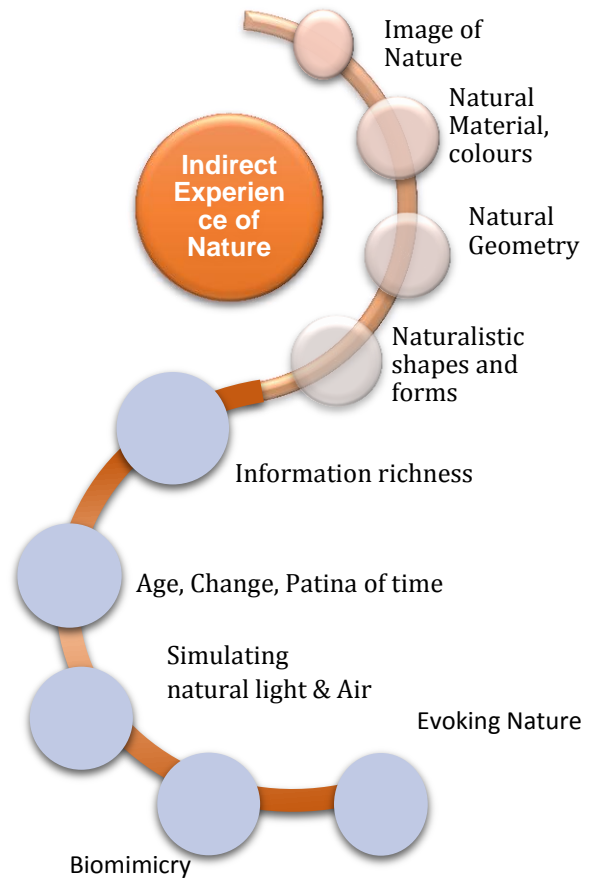
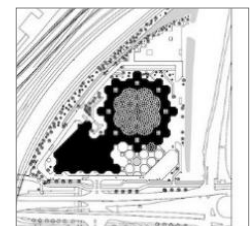


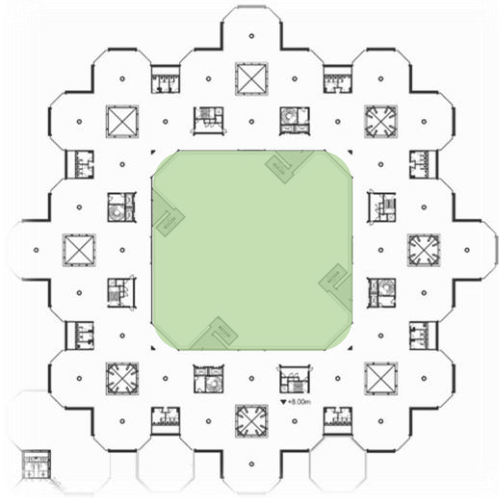
Fig.5. Indirect Experience of Nature



Natural Colour
Forms(Flower)



Biomorphic



Evoking Nature



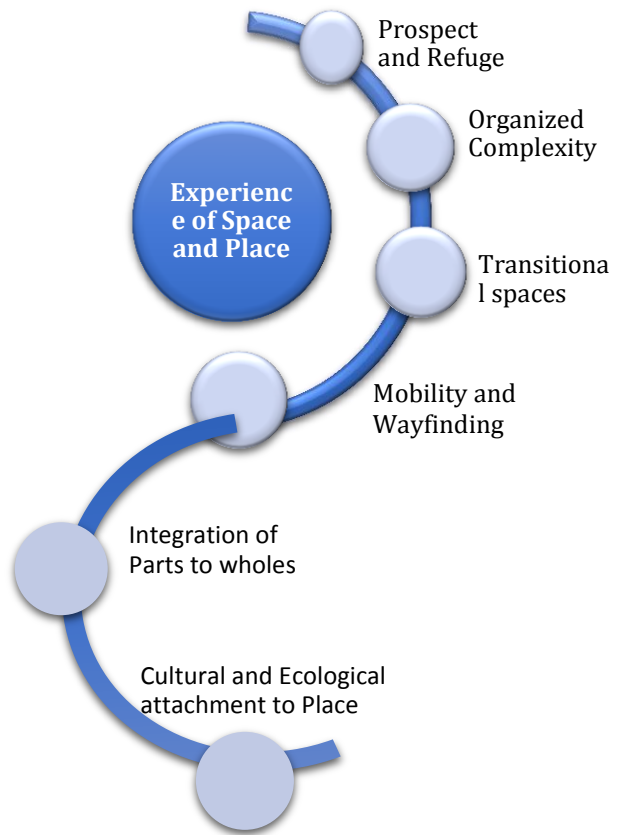
Transitional Spaces-Overlooking Terraces



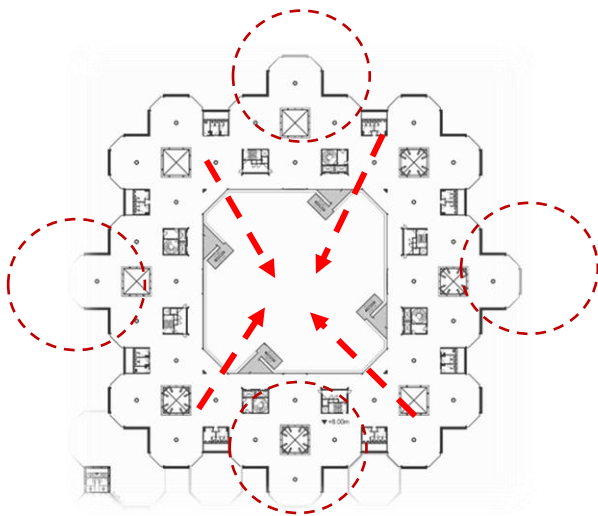
Natural shape-Curves



Nature in atrium

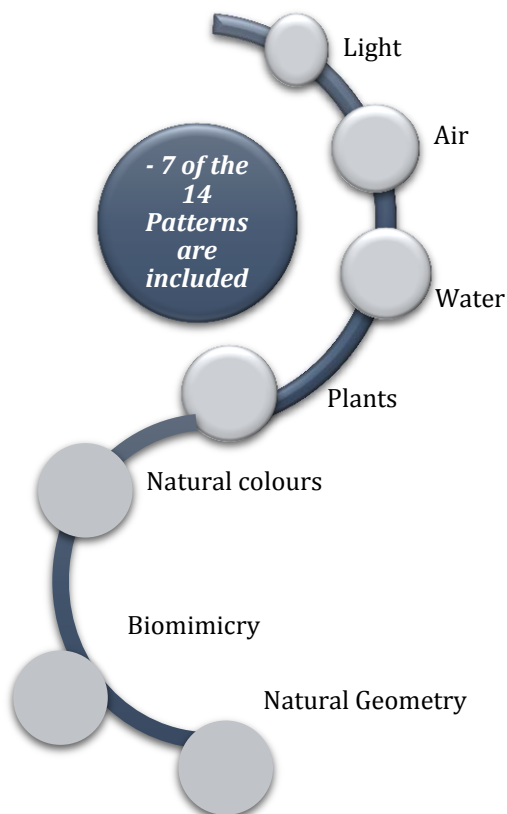


Organized Complexity



Mobility & wayfinding

Sequential and successional linking of spaces/integration of space can be enhanced by a central focal point that occurs either functionally or thematically



Quantitative Evaluation

- (1) 1 out of 3 Categories are included
 - Experience of Space and Place
- (2) 7 Patterns included
 - Light, Air, Water, Plants, Biomimicry, Natural Colours, Natural Geometry
- (3) Light & Air-2 Patterns is experienced 80% on Ground Floor
 - 5 Patterns on the same floor are :
 - 1.Plant
 - 2.Biomimicry
 - 3.Natural colours
 - 4.Natural Geometry
 - 5.Water

(4) No significance negative effect on the main health aspect

(5) 3 patterns which are not typical

- Prospect
- Refuge
- Risk & Peril



Prospect-Enclosure by furniture



Refuge-Large area



Risk & Peril- Balcony

Case study 2 : The Titan Integrity Plus, Bengaluru.

Area : 390000 sq.ft.

Designed by: Mindscape Architects

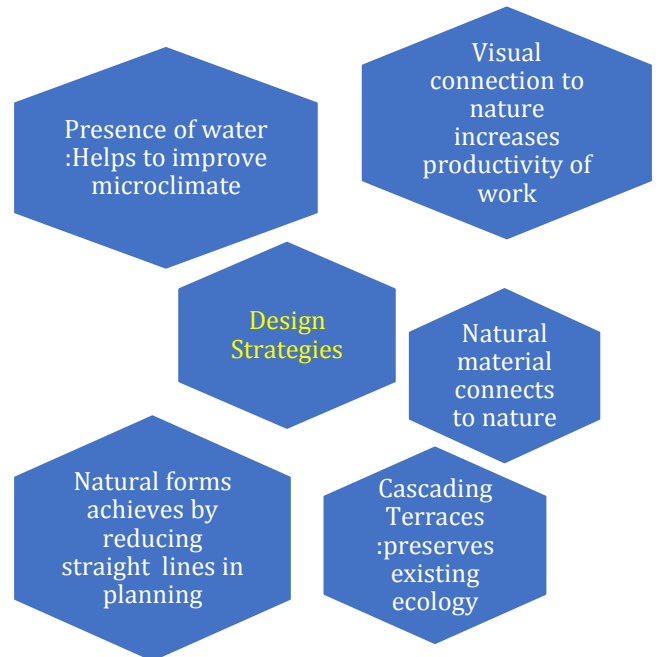
Building that integrates with nature : Enhancing Productivity of Employees in Workplaces through Biophilic Design Strategies

Introduction :

Corporate commission construction is situated on a 6.5acre section which has a reservoir on the eastward side and expressway towards northward.

The design has a very special connect with the site and the adjoining lake. The plan is of exploiting each view likely to the lakeside form some user a observer concerning this serene background.

Additionally, design procedures can involve fostering human-character interplays, or providing adequate opportunities for human-character interplays inside the building and inside the project borderline, extrinsic to the building, constituting an atmosphere that ties the landscape and interior environments together.

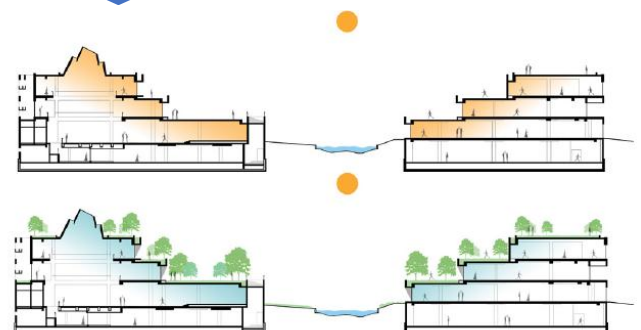


Location plan of Titan Integrity Plus, Bangalore

Requirements for LEED Certification:

Engage in the exploration of the biophilic design potential for the project and implement a minimum of five design strategies which incorporate biophilic design elements.

Each design planning must address not completely individual particular biophilic design idea as assign to source from either 14 Patterns of Biophilic Design, from Terrapin Bright Green (visualize Table 1), 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 Material

Natural Geometry (Curves)



Natural Material (above) Water body (below)



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

- individual built space opens up onto a greened terrace
- A green divider on the west side of the construction shields the available scopes from the rough situated or toward the west sunlight.
- Presence of water : balances microclimate by evaporating cooling

Selected Category to comply Green Certification:
Nature Analogue



Natural Analogues encompasses Following three patterns of biophilic design:

1. Biomorphic Forms & Patterns

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

2. Material Connection with Nature Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place

3. Complexity & Order

Rich aural facts that adheres to a relating to space ranking identical to those encountered in type

Five Design strategies to comply Green Certification

2.Complexity and order and Pattern



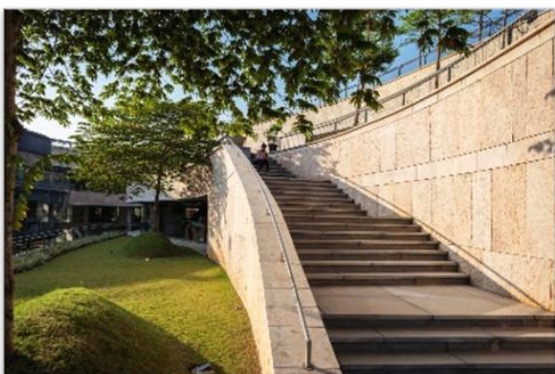
3.Material Connection with Nature



4.Presence of Water



1.Biomorphic Forms



5. Visual Connection with Nature

Bringing nature inside through design strategies:

The lengthier parts of the building face northward, that acquires glare-free instinctive light

To interrupt the situated or toward the west sun, green obstruction and green safeguard rooms are created for a non-hindering system

Porosity in preparation and form admits constant activity of breeze accompanying wind tunnels constructing venturi effect.

Free abounding Cascading green plateaus that is redolent of edible grain fields, is related through outside staircases gives an impression of inflated ground at each of these floors.

Voluminous atriums admit light and escape hot air. Also forms sense of individual community, affection and bright interaction between various areas.

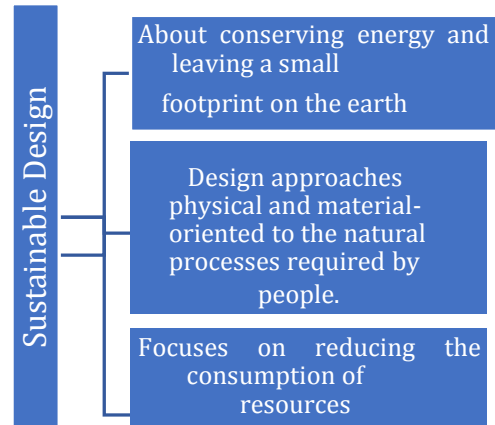
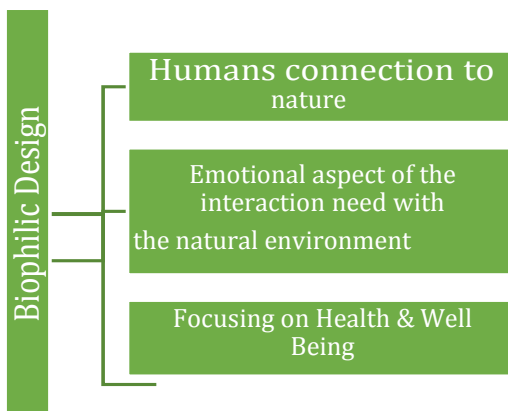
Every campaign of the water’s beat can be visualized on the maximum. The landscaped terraces covered in grass, insulate the building, thereby reducing the heat load and creating comfortable conditions, in the immediate atmosphere, and large trees provide natural shading, which make the outdoors suitable for usage, even during the hot Indian summers.

E. Biophilic design for sustainable architecture

It is necessary to reduce energy consumption by adopting sustainability in planning. Though we follow Passive techniques to achieving this, there are various challenges are observed. Implementation of Biophilic design helps to minimize such challenges by using natural element in effective way. Here we can see comparison of sustainable and Biophilic Design that how both can be beneficial in their own way.

Difference between sustainable design and Biophilic Design

Biophilic design offers any of approaches for upholding sustainability in construction



Conclusion :

The tenable facet of biophilic design is a important aspect for living houses and atmospheres. Creating green spaces, water features, plants and natural materials brings a range of benefits such as reducing carbon footprint and regulating temperatures of buildings.

Results :

Kellert and Calabrese (2008) Elements & Attributes specifies a healthy list of potential methods across design affairs and scales. while Terrapin’s (2014)14/15 Patterns supplies a curated list of biophilic materials that are abandoned to the creator to define

Conclusion:

The study of Biophilic design focuses on human reworking to the things as they are that over mutative occasion have progressive people’s strength, appropriateness and well-being.

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