The Design Characteristics of Innovative Nature-Inspired Architecture for Building Design

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Abstract: This paper analyses what is the concept of nature inspiration in relation to the innovative design of buildings, and the design characteristics of innovative design as well as the harmonious interactions of the past and the future in urban regeneration. This is with the aim of determining how to acquire inspirations from nature, and how to subsequently apply the visual or conceptual nature-inspired designs. Such nature-inspired designs seek to exploit the new concepts of biophilic design, such as bio-eco-friendly sustainable processes, creative designs, and systems which can be used to improve the urban environment. The goal of this research is to uncover out ways by which to apply new ideas inspired by nature for an innovative building design.

Key words: Nature inspiration, innovative design, nature-inspired biophilic design, urban environment.

1. Introduction

Humanity is facing serious environmental problems: climate change; pollution by various chemicals; loss of biodiversity; melting polar ice; rising sea levels; expanding oceanic dead zones; air pollution by fine dust; and, an explosive increase of plastic waste. The systems, processes, and organisms with nature have been extensively used for inspiration to solve human environmental problems from the past to the present. Nature-inspired sustainable and biophilic design is one of the methods that seek new design solutions for improving the human environment on the earth. Nature-inspired architecture can also help our yearning for totally harmonious interactions by the visual and conceptual inspirations aroused by nature. The basic concept of nature-inspired architecture is to acquire new design ideas from the pictures, shapes, mechanisms or organisms that occur and create in nature. Human life is surrounded by nature, and cannot therefore be separated from it. When planning and constructing for the urban generation of new cities, it is important to find how to satisfy our yearning for harmonious interactions with nature. With the onset of man-made environments, humans have attained inspiration from and by nature. Nature reveals unlimited adaptations and evolutions for the creation of new organisms and mechanisms. Nature-inspired designs and technologies inspire new ideas by observing the natural world and identifying new designs for shapes, and processes from it, that are sustainable vis-à-vis the natural ecosystem. Over 3.8 billion years of evolution, nature has been modifying for what is optimal and what is appropriate. When examining natural elements such as trees, flowers, animals, and ocean organisms, architects can obtain unusual perspectives, visually interesting ideas, notice special structures, creative details, and innovative mechanisms. Most modern cities are full of buildings akin to the shape of supermarkets and boxes, and if possible, architects should try to satisfy human emotions with beautiful scenery and a natural closeness through eco-friendly architecture. When planning for future cities and constructing new buildings, architects try to consider how to satisfy our
yearning for a harmonious interaction with nature and how the historic characteristics of buildings are shown to be present in the here and now. All of these considerations are related to our fundamental human feelings and emotions which yearn to improve interrelationships between architecture and nature for the good of human life [1-4].

This study will investigate and analyze the design and systems of existing buildings which include innovative nature-inspired designs, and propose a housing design characterized by a large spatial dome that can overcome air pollution and fine dust.

2. The Traditional Architecture Inspired by Nature

2.1 Korean Traditional Culture

Four plants, namely, plum, orchid, chrysanthemum, and bamboo, are recognized as natural objects associated with high quality and dignity. The people who love them have lived up to their character, standing firm and beautiful in environments of human life. People tried to represent the flower with poetry and painting. These four plants have been the objects of high art, singing poetry, and paintings which influenced later generations as shown in Fig. 1.

The blooming of plums can happen in the frost and snow, but they are merely fine flowers on the frozen ground which emit a clean scent. The plum is the first flower to bloom annually, and has been recognized as a symbol of high spirits. Orchids, however, have a very fragrant smell. The flowers are small, and their light colors and silky scent are their most recognizable qualities. Orchids which emit a fragrant aroma are likened to a woman with a high incision. Chrysanthemums bloom alone- in late autumn- in cold frosts. In this environment, the chrysanthemum was likened to those who kept their incision after left their world and lived their life. Bamboo has been recognized as a symbol of integrity and incision since bamboo, which is represented in poetry and painting, grows only straight. Bamboo has high quality, strength, and beauty. Hence, it is the symbol that is most likened to a man who keeps his patience and incision while suffering, and the man who keeps his integrity by refusing to compromise.

2.2 Korean Traditional House

The Korean traditional site plans are based on empirical knowledge that humans have learned, allowing them to live harmoniously with nature. Humans have analyzed natural phenomena such as rain, snow, wind, soil, water, topography, and a circulation patterns within an ecosystem. Oriental site plans start with a philosophical consideration of how to live harmoniously in the land where humans live. Harmonizing is attaining a feeling of the energy of the earth, and choosing a place that has a local energy, beneficial quality for people who live there. However, human beings gradually have moved away from nature by creating new forms of human civilization.

An indirect approach is to identify the shape conditions of a site by looking at it. This is the shape theory of the site. The land of a certain area is defined as a beast, a tiger, cattle, a plant such as plum, lotus flower, or other such objects. We then look for the place where the energy collects within the ecological characteristics of the plants and the animals.

If a harmonious feeling of the site energy with the surrounding environment is obtained, the site is also a good place for the construction of housing and a village. The form of philosophy based on the energy of the land has been popularizing the spirit of the site

Fig. 1  Traditional paints.
plan. The river is also to see its flow as an important element of a good site. Just as nature cannot see straight, site theory emphasizes harmony, and a soft environment. The flow of the mountain stem should be a twist curve with a soft and powerful shape, but the water is good for flows with various curves. And the flow of the river must be in harmony with the continuous flow of the mountain stem as shown in Fig. 2.

Natural phenomena have certain laws. The changes of spring, summer, autumn, and winter exemplify this, and the sun comes rises in the east and sets in the west. Therefore, depending on the orientation of the functions placed on the good site, the effect of energy will also vary considerably. The theory of site is the logic that the environment of the site should be good for people to live in, and we are looking for the survival of these elements both in harmony and balance. Basically, natural science and ecology are very well matched to the logic of site philosophy. Site philosophy is a comprehensive, scientific idea that can be a guiding ideology because site philosophy is an accumulation of knowledge regarding nature formed over a long period of time. Modern environmental issues are concerned with the destruction of the earth, and we are beginning to seriously worry about the continuation of human life itself. It is true that site theory has systematized and expanded the knowledge of nature, but it seems that traditional ideas based on organic world views such as natural science, epistemology and philosophy can also play crucial role.

Fig. 3 shows a traditional house built on a good site of the kind Koreans approve of. There is a mountain in the rear, a good view at the front, and the direction of the house is looking toward the south, which is sunny throughout the day. The important thing in urban regeneration of the past and the future is to reconstruct and preserve historical buildings as shown in Figs. 5 and 6. History is a continuous culture of past meshing with the present. The cultural characteristics which constitute the link in human life across generations, begins with ancient history and continues to the present. It is important to restore history and connect the ancestor’s culture with the present city. Fig. 4 is a view of Blue House and an ancient palace in Seoul, Korea. There is a high main mountain situated behind Blue House, and with the which the current president is responsible for the administration of the country. At the front, there is a palace where the ancient king ruled the country.
Korea’s traditional urban planning style, Blue House is not in harmony with the main mountain.

Modern cities raise their status through high-tech landmark buildings. High technologies are used to help create eco-friendly buildings, intelligent buildings, and “smart” cities. The aim is to apply information and communication technologies for buildings and cities so as to enhance the quality of human life and make the living environment more convenient. A smart city is a futuristic high-tech city that can connect the public functions of cities with computer networks and advanced IT technology. The goal of implementing a smart city is to improve the efficiency of services by using the information and technology of cities, and ultimately to improve the quality of life through meeting the needs of residents.

Smart cities focus on efficient management of facilities and services such as energy, transportation, environment, water and sewage, as well as administrative, medical, and educational functions.

The base technologies for creating a smart city include: the Internet of Things; Cloud; Big data; networking. These are combined strategically to create smart cities.

3. Innovative Architecture Inspired by Nature

3.1 Nature-Inspired Biophilic Design

Biophilic architecture takes into account the following elements of building design: a nature-friendly environment; nature-inspired concepts; healing facilities; and, the coexistence, interaction and balance of humans and nature. The main consideration of architecture and urban design is the creation of a good environment which generates positive feelings through the interaction of nature and human beings. The inner and outer spaces of buildings are designed to be a part of nature according to the changes of times and seasons and which create emotional stability and comfort through nature-friendly design. The temples in Korea create a healing environment for the promotion of harmony and balance and hence mental health via a synchronous coexistence of/with nature as shown in Fig. 7.

3.2 Honeycomb-Inspired Domes with Hexagonal Structure

The Eden project is a botanical garden as shown in Fig. 9, and is designed with huge domes fabricated of hexagonal steel frames and geodesic spherical networks, inspired by nature. See Fig. 8. The Ethylene-Tetra-Fluoro-Ethylene (ETFE) foil cushion is a very lightweight and safe system in contrast to glass.
The ETFE film allows sunlight to pass into a dome while also providing good insulation. The weight and amount of steel used were minimized by the optimum design and ETFE film, and the cladding is also transparent re. sunlight. The lattice dome and the bubble-shaped appearance are attractive and display a high technical level of architectural design and structural systemic design. The ETFE surface has a self-cleaning function so that the dirt on the outer surface is washed off by reading for. The hexagonal-shaped cushions are easily attached onto the aluminum frame, and the pressure inside the cushion is about 300 Pa. In the design of the high wind suction, the outer surface is strengthened by using double layers of foil as shown in Fig. 10.

ETFE is conventionally used in greenhouses, or for the coating of solar cells and has since demonstrated its worth in the architectural buildings also. ETFE films can be highly transparent (from 90% to 95%) and allow for the passing of UV light which are added for the promotion of photosynthesis, thus facilitating plant growth. ETFE film systems can incorporate a number of tint patterns to control their solar performance, and the foil is printed with various patterns. Colors can be introduced in a variety of ways, providing a consistent tint in various tones from red to violet. ETFE film has approximately 70% acoustic transmission. Comparable to a glass system, increased thermal performance is possible with a multi-layered cushion system. For a double or triple layer pneumatic foil system, multiple layers of film are welded into panels that are inflated with low pressurized air to stabilize the film. A pneumatic ETFE cushion system is generally supplied by one or more inflation units. A pressure sensor will continuously monitor the internal pressure.

**Fig. 7** Biophilic temple architecture (Unju Temple in Korea).

**Fig. 8** Hexagonal shapes in nature.

**Fig. 9** Eden project.

Fig. 10  Eco-friendly ETFE film applications for architecture.

pressure of the ETFE cushions maintaining them. In case of high wind or snow loads, sensors can automatically and continuously adapt the pressure to resist external loading up to 30 PSF. The film melts away at around 500 °F.

Today, respiratory health has decreased markedly due to severe air pollution, as is shown in Fig. 11. We need to create a new concept of housing in order to live in this global environment. The author proposes a dome structure that can sustain life in this new global environment. The circular dome structure is surrounded by a natural circulation system that can live without and external environment and is surrounded by buildings where people can live. The house with such a dome structure is called a “bio house.” It is designed by mimicking the hexagonal honeycomb shape of the lattice structure of the dome as shown in Fig. 12. The diameter of dome is 200 m. It is a very effective system for installing ETFE cushions. Mechanically, it is a very safe and robust structural system. In order to evaluate the stability of the building during an earthquake, and analysis of the deformation and the strength and stress capacities was conducted with a time history analysis. A seismic isolation system was installed between the upper dome and the lower structure, and the dynamic response to the 3-dimensional ground motions of the El Centro earthquake (Peak Ground Acceleration = 0.3569 g) was analyzed. The LRB (lead rubber bearing) seismic isolation system can greatly reduce the internal forces and stresses upon the structural members, and the displacement response and acceleration response as shown in Figs. 13-22.

The maximum vertical displacement occurred at 3.45 sec and 3.60 sec respectively, in the results of the time history analysis for 3-dimensional ground motion of the El Centro earthquake (270 Deg. + 0.3 × 180 Deg. + UD, PGA = 0.3659 g). The maximum vertical displacement was reduced by 74% from 560 mm to 141 mm by the seismic isolation system; the horizontal displacement was increased by 23% from 215 mm to 264 mm. The maximum axial force decreased from 9,834 kN to 2,348 kN. The bending moment My decreased from 3,223 kN-m to 956 kN-m.

Fig. 11  Air pollution.
Source: https://t1.daumcdn.net/cfile/tistory/2605855057D187AA1D.

Fig. 12  200 m spanned lattice dome inspired by a honeycomb.
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### Fig. 13  Eigenvalue mode analysis.

<table>
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<th>with isolation(σc)</th>
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</tr>
<tr>
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<td>0.7329</td>
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<td>100</td>
<td>0.1201</td>
<td>0.1580</td>
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</tbody>
</table>

### Fig. 14  Seismic response analysis with and without LRB seismic isolation system.

<table>
<thead>
<tr>
<th>Time</th>
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<th>with isolation</th>
</tr>
</thead>
<tbody>
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<td>3.45 sec</td>
<td>y=214, z=560</td>
<td>y=69, z=141</td>
</tr>
<tr>
<td>3.60 sec</td>
<td>-9.536−9.634</td>
<td>-1.958−2.348</td>
</tr>
<tr>
<td></td>
<td>-3.223−3.182</td>
<td>-949−956</td>
</tr>
</tbody>
</table>

### Fig. 15  Horizontal displacement.

### Fig. 16  Vertical displacement.

### Fig. 17  Horizontal acceleration.

### Fig. 18  Vertical acceleration.
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Fig. 19  Horizontal displacement (LRB).

Fig. 20  Vertical displacement (LRB).

Fig. 21  Horizontal acceleration (LRB).

Fig. 22  Vertical acceleration (LRB).

Fig. 23  300 m spanned lattice dome inspired by a honeycomb.

Fig. 24  Eigenvalue analysis.

Fig. 25  Seismic response analysis with and without LRB seismic isolation system.

The horizontal acceleration decreased 73% from 1,221 gal to 325 gal; the vertical acceleration decreased 68% from 3,942 gal to 1,261 gal. The stress decreased 71% from 730 MPa to 212 MPa.
Time history analysis of the 300 m honeycomb lattice dome is shown in Fig. 12 for 3-dimensional ground motion of the El Centro earthquake (270 Deg. + 0.3 × 180 Deg. + UD). This was performed to analyze displacement response and acceleration response up to 50 sec. Fig. 25–33 sure the results of the time history analysis. The vertical displacement decreased by 35.9% from 418 mm to 268 mm. Compressive force decreased by 31.3% from 9,783 kN to 6,727 kN. The bending moment My was decreased by 30.9% from 4,827 kN-m to 3,336 kN-m and the bending moment Mz decreased by 25.8% from 3,465 kN-m to 2,571 kN-m. The stress decreased 32.5% from 456 MPa to 308 MPa. Figs. 26 and 27 are time histories of horizontal displacement and vertical displacement responses, respectively. Figs. 28 and 29 are horizontal and vertical acceleration response curves. Horizontal displacement was large response before 15 seconds, and vertical displacement response was large until 25 seconds. The horizontal acceleration response showed a large response before 10 seconds, and the vertical acceleration response increased until 15 seconds ago. Figs. 30 and 31 are the horizontal and vertical displacement response curves for the dome equipped with an isolation device, and Figs. 32 and 33 are horizontal and vertical acceleration response curves. The horizontal acceleration decreased by 51.2% from 1,245 gal to 608 gal and the vertical acceleration decreased by 33.9% from 4,175 gal to 2,761 gal.

3.3 Beijing National Swimming Center

The Beijing National Swimming Center as shown
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Fig. 32  Horizontal acceleration (LRB).

Fig. 33  Vertical acceleration (LRB).

Fig. 34  Beijing National Swimming Center.

In Fig. 34 was designed to act as the function of a greenhouse while also remaining a dramatic and exciting sporting venue with the innovative design of high technology biomimicry. The ETFE cushions allow the high levels of natural daylight into the building. The structural design was based on the most effective arrangement of organic cells, and also the natural formation of soap bubbles. The iterative procedure of structural optimization was carried out by finding the optimized size of steel members which satisfied all design constraints and resulted in the minimum self-weight. The arrangement pattern of the roof has seven different patterns of bubbles and the wall has a combination of 15 repeated bubble patterns. The ETFE is a tough and durable plastic material that transmits more UV light than glass and can clean itself via natural rain. All pillows are permanently inflated by a pump for an internal pressure with 0.2 mm film thickness. The ETFE cladding allows more heat penetration than traditional glass, resulting in a 30% decrease in energy costs. Flames do not spread when a fire occurs. The tensile strength is very good, and the strain is very large, so it does not tear easily. Ecofriendly ETFE has a long service life and is 100% recyclable.

3.4 Cable Structures Inspired by a Spider Web

Spiders seem able to vary their natural behavior in order to construct an optimal network structure for the adaptation of the surrounding environmental conditions. Spiders’ webs represent complex animal architecture. The construction rules of spider webs provide a useful tool for the construction method of a typical web. The spider tightens the first strand, then walks along it while simultaneously strengthening it with a second thread. This process is repeated until the thread is strong enough to support the web, and the spider continues to make an overall web network. Natural spider webs have a structure analogous to that of a radial cable network, even though spider nets have no rigidity. Such a network can be applied to the system of cable structures for a large span space and a lightweight roof. The cable truss roof system as shown in Fig. 35, has both upper and lower cables that are connected by bracing cables to resist the up and down loads acting upon the roof. The cable roof system consists of an outer compression ring, a center hub post, and continuous radial cables. The outer circular ring acting compression forces is in equilibrium with the tensile forces of inner radial cables. The upper ridge cables and lower valley cables—with a large prestress—are connected to each other by a bracing cable to ensure structural stability and rigidity. The ridge cables and the valley cables are resiliently prestressed and the curvature in the reverse direction cables is maintained in the stable shape. In the cable systems, various cables have strong mechanical
properties and high tensile strength, enabling the design of large space lightweight roofs of sizes 100–300 m. The cables have very strong tensile forces but are also very flexible and offer no bending resistance. The retractable roof system opens and closes the part of a roof required to maintain the optimum environment of the stadium so as to overcome extreme outside climate. It is possible to play in cold weather and hot weather, and it creates good environment conditions for the healthy exercise of athletes. Figs. 36 and 37 are the results of geometrical nonlinear analysis for light weight roofs designed with cable and fabric membrane.

3.5 Innovative Buildings with Inspired by Flowers

Lotus flowers are known to be associated with purity, spiritual awakening, and sincerity among Buddhist saints. Lotus leaves and flowers have a waxlike surface on each epidermal cell. As a result, raindrops carry away dust particles and keep the surface clean. The cleaning surface properties in such plant leaves have opened up the possibility of manufacturing various ultra-hydrophobic products, such as paints, glass, and windows. The large-scale Lotus Conference center in Fig. 38 is a government initiative center in the Wujin district, and resembles the pink lotus flower. The structure is characterized by a combination of sculpture, and a powerful, sensuous and feminine biological form. The building becomes one of the most famous icons in the city. The design is striking and inspired by the blooming of lotus flowers, as shown in Fig. 38. The Qizhong Forest Sports City Arena is also a tennis arena in Shanghai, as shown in Fig. 39. It has a steel roof with eight sliding petal-shaped pieces which resemble a blooming magnolia, the flower of Shanghai city.

Architect Tsvetan Toshkov proposed an imaginary oasis building where one can escape from the everyday noise, stress and dirt. The visual design is a towering structures that resembles a lotus flower. The design concept was inspired by the lotus flower which is known for its pure and clean image. Symbolically, the building represents a sort of utopia, as shown in Fig. 40. The open expanse on each structure even appears to have the ideal balance of a beautiful natural landscape in combination with aesthetically pleasing architecture.

Lotus Temple is a notable piece of architecture famous for its lotus structure, as shown in Fig. 41. The temple has won design awards for its style and design concept which combines and embodies religious function with the beauty of nature. This is a modern style, non-religion-oriented temple. The temple has 27 “petals,” mimicking the lotus. There are nine openings to the temple—mirroring the nine anatomical openings of a human body. The temple is surrounded by nine ponds and gardens covering a total of 26 acres. The temple aims to spread humanity, peace, affection, truth and courage.
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Fig. 36 A circular curved roof (diameter = 100 m, sag ratio = 0.05).

(a) Deflection status (0~0.246 m, load = 0.5 kN/m²)
(b) Deflection status (0~0.565 m, load = 1.0 kN/m²)
(c) Deflection status (0~0.864 m, load = 1.5 kN/m²)
(d) Tensile forces of bearing cables

Fig. 37 A rectangular curved roof (span = 100 m, sag ratio = 0.05).

(a) Deflection status (0~1.605 m, load = 0.5 kN/m²)
(b) Deflection status (0~1.777 m, load = 1.0 kN/m²)
(c) Deflection status (0~2.976 m, load = 1.5 kN/m²)
(d) Tensile forces of bearing cables
3.6 Stadium Inspired by Bird’s Nest

Beijing stadium—inspired by a bird’s nest—was designed for a specific event, but went on to be an icon, as shown in Fig. 42. The Bird’s Nest has become a mega-icon because at night, it actually depicts the sun. In China, circles symbolically represent the sun. The bird’s nest design therefore strives to embrace the world. The stadium was designed to celebrate the Olympic games held here.

3.7 Remarkable Building Inspired by DNA

Agora garden, the unusual twisting tower in Taipei City was inspired by the double helix of a DNA molecule, as shown in Fig. 43. One of the purposes of this form is to create open-air gardens. Inevitably this arrangement greatly increases the building’s surface area for thermal performance. The building will also include building-integrated photovoltaic power, apparently placed in the intersection of giant horizontal shades that sit at the very top of the building. The building will also apparently be provided with hot and cold air throughout. A light well will pass through the building, curving to adapt to the route of the core, and which will inevitably increase the rate of light absorption. Blinds will be...
integrated into the facades to prevent heat gain, and double glazing will be used to prevent heat loss.

3.8 Remarkable Building Inspired by Cobra

The Kuwait Cobra Tower (or Burj Cobra), as shown in Fig. 44, is a concept generated by a CGI (CDI Gulf International) firm. The tower is supposed to rotate to give an edgy spiral effect. The building manifests a new-age design, a creative image and is without doubt a fascinating building.

The design of the cobra-shaped building in Fig. 45 is a futuristic structure that rises from a circular base, widening to a cobra head-shaped pinnacle, complete with red eyes and a fanged sneer. The building rises up as a landmark structure looking over cities or standing alone in the landscape. The snake tower would most likely entice developers in cities in the Middle East and Asia, where snakes are seen as a sign of wisdom. The diamond-shaped pattern on the back of the snake is the symbol for reunification of the sun and the moon.

3.9 Iconic Stadium Inspired by Female

The stadium in Fig. 46 was designed using waves on the roof cover to resemble the structure of traditional boats. The stadium has main roof arches of 230 m on two tiers. The stadium ensures comfortable temperatures with fans and shade, and aerodynamics and mechanical ventilation systems are used to minimize the impact of heat. It is inspired by a dhow and a female, a traditional Qatari fishing boat. On the one hand, its flowing white outer form resembles sails moved by wind. Furthermore, the inner side of the roof—with strong use of engineered timber—strongly resembles the dhow’s hull. Finally, the visual liquidity of its form and retractable cable-membrane system have become famous for globally.

![Agora garden](https://www.google.co.kr/search?source=hp&ei=E4nfXIfZM4Te8wW1sKK4Bw&q=Agora+garden&oq=Agora+garden&gs_l=)

![Cobra tower in Kuwait](https://www.google.co.kr/search?q=cobra+tower+in+kuwait&tbm.)

![Asian cobra tower](https://www.alux.com/concept-skyscraper-shaped-like-cobra/)
is entirely enclosed, offering no natural ventilation. The retractable sliding roof provides an aerodynamic form which protects audiences from hot winds.

3.10 Residential Housing Inspired by Hills

Nature has always provided new sources of inspiration for humans, and to solve complex architectural design problems, architects examine objects from nature, such as trees, plants, hills, etc. Mad Architects was inspired by the shape of hills, and designed to be part of the city of Beihei, as shown in Fig. 47. The buildings have undulated roofs that maximize the view of those who dwell there. The shape of the building allows automatic cleaning by the air and rainfall. Sunlight naturally filters through the structural shape, making the building energy efficient without the use of electricity.

3.11 Ecology Center Inspired by the Evolving Erosion of a Meandering River

The design concept of Ecology Center in Korea was inspired by the form of an oxbow lake, an aquatic body created by the evolving erosion of a meandering river, as shown in Fig. 48. The master plan guides the visitor flow through a series of botanical gardens via five biomes i.e., seeing, hearing, smelling and touching flora and fauna from the tropical rainforest, cloud forest, dry tropics, cool temperate and Antarctic regions. The master plan was consciously designed as a continuous series, utilizing climatic zones while maintaining the connections between regions presented in nature. Ecorium is unique in its physical form and design characteristics, and is a model of efficient green and eco-friendly design. Steel arches delineate the ridgeline of each arch dome, and support a lightweight glazing system to maximize passing daylight. This design promotes vigorous plant growth and eliminates the need for electrical lighting.

3.12 Eastgate Shopping Center Inspired by Terminate

The Eastgate Centre, Zimbabwe, typifies the best of green and ecological architecture inspired by termites, as shown in Figs. 49 and 50. Termites build gigantic mounds inside of which they farm a fungus that is their primary food source. The termites constantly dig new vents and plug up old ones in order to regulate the temperature. The massive protruding stones of the Eastgate not only protect the small windows from the sun, but also increase the external surface area of the building to improve heat loss to space.
The Eastgate is designed to exploit more passive and energy efficient mechanisms of temperature control in buildings. The building’s materials have a high thermal capacity, which enables it to store and release heat gained from the surrounding environment. This process is facilitated by fans that operate on a cycle timed to enhance heat storage during the warm daytime, and enable heat release during the cool nighttime. Internal heat generated by the building’s occupants and appliances helps to drive airflow within the building and internal open spaces as it rises from lower floors toward an open rooftop chimneys. Various openings throughout the building enable internal airflow driven by outside winds. These designs work to minimize temperature changes within the building interior as outside temperatures fluctuate.

3.13 Bio-Intelligent Algae House

Situated in Hamburg, Germany, the bio-intelligent
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building is the first algae powered building in the world. See Fig. 51. The sides of the building that face the sun have a second outer shell that is set into the facade itself. Microalgae are produced within this shell, enabling the building to supply its own energy. The algae draw all of the energy needed to generate electricity and heat from renewable sources. Apart from generating energy using the algae biomass harvested from its own facade, the facade then collects energy by absorbing the light that is not used by the algae and generates heat, in the same way a solar thermal unit does, which is then either used directly for hot water and heating, or cached in the ground using borehole heat exchangers. The state-of-the-art bioreactor façade is pointing the way ahead for the future of facades and low energy engineering for green buildings. The conversion of light to heat is a well-known physical process used in solar thermal design. The conversion of light to biomass is a biochemical process facilitated by microscopic microalgae. Microalgae use sunlight for the photosynthetic process and this is linked to the process of conversion of CO2 to organic matter. This fact leads to reducing CO2 emissions through building facades. The energy concept is the combination of different energy sources so that they will work together. The energy concept is capable of bringing together, in one circuit, solar energy, geothermal energy, a condensing boiler, district heating, and the production of biomass in the bioreactor facade.

3.14 Future Architecture

Future buildings require new design strategies, not only by architects but also urban planners, landscape architects, designers, artists, and any other professionals who explore our living environment. The future architecture platform is looking for aspiring individuals from various disciplines to apply new ideas to what should expect from architecture in the near future. The platform builds on the social mission of European architecture to improve the quality of life of humans. Paris-based architect Vincent Callebaut, proposed a concept of a self-sufficient amphibious city for the year 2100 that will provide shelter for future climate change refugees. Called “Lilypad,” the city will travel across oceans, from the equator to the poles, following sea streams. In Lilypad a half aquatic and half terrestrial floating city, would be able to accommodate 50,000 inhabitants and instigate the development of its biodiversity i.e., its fauna and flora around a central lagoon of soft water, while collecting and purifying the rain waters. The double skin is made of polyester fiber covered by a layer of ETFE membrane which by reacts to the ultraviolet rays enabling it to absorb the atmospheric pollution, as shown in Fig. 52.

Vincent Callebaut Architectures has proposed a new design for a new eco-tourism resort in The

Fig. 51  Bio-intelligent algae house.
Source: https://www.google.co.kr/search?q=Intelligent+Algae+house&tbm.

Fig. 52  Future city inspired by Lily pad.
Source: https://www.google.co.kr/search?q=Vincent+Callebaut&source.
Philippines, inspired by natural coastline forms. Making extensive use of sustainable design principles, the resort features spiraling apartment buildings and shell-shaped hotel buildings. At the center of the ensemble, a mountainlike complex combines a school, recreational swimming pools, sports halls, and a suite of laboratories for environmental scientists, as shown in Fig. 53.

4. The Design Concept of Future Architecture Inspired by Nature

4.1 The Design Concepts

The design concepts of future architecture have greenhouse, sustainable, intelligent, smart, and health monitoring designs, as shown Figs. 54-59. “Green architecture” is an approach to building that minimizes harmful elements on human health and the environment to attempt for safeguarding of the air, water, and uses eco-friendly materials. Green architecture seeks optimal locations on land, maximizing sunlight, winds, and natural sheltering. To achieve carbon-neutral and net-zero energy design, buildings must be responsive to their local climates. The entire building approach will consider the following design objectives in order to create high performance homes: accessibility; aesthetics; functionality; history; safety; security; and, sustainability. Aesthetics applies to the external architecture, the interior design, the surrounding landscape, and the neighboring buildings. Green building design should attempt to apply the guidelines of Leadership in Energy and Environmental Design, Building Research Establishment Environment Assessment Method and Green Building Certification Criteria.

An optimal site has to consider existing buildings, the orientation of streets and homes for passive and active solar features, potential hazards, and high priority resources that should be conserved such as trees, waterways, and animal habitats. Flexible design requires understanding of future adaptations needed to extend a building’s useful life. The intelligent building has a building automation system and intelligent technologies integrated within it. Building automation systems are networks of micro-process controls i.e., the control of climate, the control of heating, ventilation and air-conditioning equipment, the facility management, the energy management, telecommunications, IT infrastructures, community infrastructures, etc.

There is a need for automated intelligent facility systems that can maintain an optimal environment for
Fig. 56  Green home design.

Fig. 57  Sustainability.
indoor spaces. Depending on the exterior climate, an open/close system is needed to actively control with the indoor environment. Intelligent structural systems that can ensure structural stability, against events such as earthquakes, typhoons and heavy snow, are also important considerations. It is also necessary to apply an integrated management system that manages and operates the entire building with intelligent smart systems based on big data and deep running.

In order for a sustainable environment and sustainable architecture to coexist successfully, it is necessary to also realize a sustainable social environment. Buildings which are currently being built have a short life. The life cycle of a typical building is around 50 years. It is necessary to design buildings with a lifetime of more than 100 years. It is necessary to design buildings that have variable space inside. The structure of these buildings should be easy to replace. As the global environment changes, e.g., winds are becoming stronger and the possibility of huge earthquakes is increasing, and hence buildings should be constructed more strongly than current design guidelines or standards. Sustainability is indispensable for the future of humankind. Sustainability science has emerged as an effort to tackle the complex problems that the world is facing today. The holistic issues it tackles include sustainability, industrial pollution, an aging society, the human-natural world connection, urban planning, and development for long term sustainability.

5. Conclusion

This study proposed ways through which to acquire inspiration from the natural world, and how to apply sustainable design for harmonious interactions in relation to the connections between the past and the future. Nature-inspired design seeks to exploit design concepts such as bio- and eco-friendly sustainable
The Design Characteristics of Innovative Nature-Inspired Architecture for Building Design

Design, creative design, and complex system design. The historically harmonious design is used to reconstruct and preserve buildings because history is a continuously-being-forged culture of past and present. Nature-inspired biophilic architecture tries to create healing environments that provide comfort, increased happiness, and improved perception. In order for a sustainable environment and architecture to coexist fruitfully, it is also necessary to realize a sustainable social environment.

Some exciting recent architectural trends are giving us much justification for getting excited about the future of built environments right here on earth. There is a focus on the importance of green infrastructure and energy efficiency. Architecture as we currently know it is likely to disappear and, in the future, the role of architects may be very different to how we recognize it today. Environmental Science and Social Anthropology will become active co-participants in architectural design strategies, working on complex projects that require knowledge from across different fields.

Acknowledgments

This research was supported by a grant (19AUDP-B100343-05) from Architecture & Urban Development Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

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