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"Ant community": Community complex sustainable design based on design bionics—Case study of the Can Batlló community in Barcelona

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Abstract. Based on design bionics, this article attempts to explore a new community model that integrates the urban community life with the natural environment. This paper creatively proposes the concept of “Ant Community” and exploringly applies it to the design practice case of Barcelona Can Batlló textile mill. “Ant community”, the association of human community life with ant colony, emphasizes the study of the high socialization activities of ant colony and the shaping of their internal functional structure to construct a humanized community complex framework with high tolerance, and the study of the ecological structure of ant nest to research how to construct pleasant microclimate in high-density urban residential areas to optimize the urban community environment. The aim is to transform the Can Batlló textile mill into a vibrant and green community complex that provides both the ecological and urban care of the urban community environment.

1. Introduction
With the advancement of urbanization, urban boundary has gradually expanded outward and the boundary between city and nature is getting more and more infiltration. Design bionics, inspired by nature and viewed people and nature as a whole, plays a significant role in coordinating the living environment and the natural environment[1]. Applying design bionics to the design of human settlements has important practical significance for the sustainable development of human society[2].

How do cities and nature interweave? Most people's impressions of the city are bustling streets, towering glass walls, intensive population, congested traffic, and noisy community groups and almost self-enclosed city life. Based on such an era background, is there a possibility that the urban community life could be integrated with the natural environment to build a new type of sustainable green community?

“Ant Community” is a design attempt in this context. Based on the design ideas and design techniques of design bionics[3], this paper tries to learn from the social activities of ant community and their internal functional structure and ecological structure. Then, applying this community model to the Can Battle textile mill community complex design, aiming to transform the site into a dynamic green community complex, which have both the ecological function and the service function of human care.
2. Concept definition

2.1. Design bionics

“Natural selection, survival of the fittest”. Animals and plants in nature continue to improve themselves to adapt to the environment in the long years of competition, and thus their evolution is almost perfect. Learning from nature is an important development direction for the science of human settlements. The coordinated development of human society and the natural environment can be promoted by applying laws that learning from the natural world and ecosystems to the design of human settlements\[4].

What is the design bionics? The most direct interpretation is the design of imitation, simulation of natural creatures -- imitating the dominant features of natural objects and then using creatively\[5][6]. This coincides with the Taoist thoughts -- obeying nature, taking nature as a teacher, and learning the law of survival of all creatures in nature\[7][8]. Imitating the beautiful form, the novel structure and the unique living characteristics of natural objects not only can enrich the design method, but also can satisfy people's emotional needs of pursuing nature, reflecting respect and aspiration for nature\[9][10]. From the simple morphological imitation to the complex function and structure imitation of natural objects, design bionics has gradually become a systematic and scientific design theory in the design field, and has gradually become one of the most important development trends in the design of human settlements\[11][12].

2.2. “Ant community”

This article creatively proposes the new type of community complex “ant community” based on the study of the characteristics of “Ant Colony”. “Ant community” emphasizes that each space of the community complex is organized and integrated on the basis of satisfying different functions, making each space closely link and mutually integrate, which reflects the relationship of connection, integration and symbiosis (Figure 1).

![Figure 1. "Ant community" network.](image-url)

“Ant community”, inspired by ants, emphasizes to compare the life of ant colony with the human social community and to explore their internal relevance by using naturalistic design concept and bionic design method\[13]. The connotation of the concept of “ant community” is that “ant” expresses the orderly assembly of a large number of things, which can be extended to the process of assembling new things into pieces, and that to construct a symbiotic ecological community system that connects diversified residential areas into a whole through the method of bionic form, structure and feature.

3. Barcelona Can Batlló community complex

3.1. Overview

3.1.1. Status Quo. The Can Batlló community is located in the La Bordeta district of Northern Sants-Montjuïc, in Barcelona, Spain. The site covers an area of approximately 11 hectares, and it is adjacent
to the educational exhibition area, political center and harbor industrial zone, where is an important position in the intersection of polity-economy axis and culture-ecology axis. The surrounding area is dominated by residential district with fragmented green space, disorderly distributed entertainment space, sports space (Figure 2).

Figure 2. Site location.

3.1.2. Major Issues. Through field research and data analysis, the following five problems to be solved are summarized: the site lacks space for social public activities; the increasing aging society bring the increasing demand for suitable space; how to use industrial heritage to stimulate the vibrancy of the site; how to reuse rainwater in the context of Mediterranean climate; the site lacks green space.

3.2. Design idea: the integration of function, culture and ecology

Focused on the sustainability of the living environment, this case uses design bionics approach to attempt to create a new community model – “Ant Community”, in which the concept of sustainable development is applied. Combined the policy of "Smart City "with "Superblocks" of Barcelona, the plan integrates function, culture and ecology as design strategies. Functionally, it encourages public participation, promotes green trip mode, and pays attention to the improvement of the vitality within the community and of the harmony with the external environment. The case retains a shared community workshop and public event space with local characteristics, while adding more cultural and ecological public space. Culturally, it considers a cultural landscape axis hoping the participants can better understand the historical significance of the site and look back at the industrial cultural landscape and the agricultural landscape with the site memory. Ecologically, it considers the compound greening, ecological buffer corridors, energy recycling and the creation of microclimate of the site. It hopes to achieve a balanced symbiosis between human beings and nature, and to create a livable community living environment. The designed master plan is as follows (Figure 3).
3.3 Design Strategies
From the three perspectives of function reconstruction, culture inheritance and eco-build, this case forms a symbiotic eco-community system that is integrated by diversified areas and, on this basis, makes full use of the advantages of design bionics to carry out ecological design, expecting to make a closer community life and a more united community. Firstly, the high sociality of the ant colony is used as a highly inclusive and humanized community framework in the design of the Can Batlló community complex. Secondly, combined the survival characteristics of the ant community with the history and culture of the site, the historical culture of the site is connected into a cultural axis consisting of feature spots. Thirdly, combined with the ecological structure of ant nest, the internal microclimate system in the high-density urban residential areas is constructed to optimize the urban community environment.

3.3.1 Function Reconstruction. Under the premise of consideration of most people’s needs, the corresponding function sections are designed for the potential needs, and then the aerial greenway is used to connect the functional partitions in the venue (Figure 4). The aerial greenway is a highlight in this case. It is like the pulse of the community with the functions of connecting, passing, resting and viewing. Using the method of bionic form, the plan is to metaphorize the site as a “miniature version of Barcelona” and the base of site as a vast and varied ocean. The form of the aerial greenway is inspired by the harbor in the marine culture of Barcelona, and then extracts four types of strip-connected, single-cut, multilateral angle, and edge-extending (Figure 5). Then, the airway links the various community groups, which not only builds a combined community activity space but integrates the site with urban culture, allowing the entering crowd to reach the designated harbor space according to their own choices.

Figure 4. Function and space reconstruction process in the site.

Figure 5. Four forms of aerial greenways.

The airway is connected to each feature spot of the site, and the form of it changes according to the different needs of each spot. Details are as follows. In the industrial cultural square where the gathering is held, this greenway adopts multilateral angle shape, which is convenient for the crowd to watch the celebration on it. In front of the school and the community farm, a wide hanging garden is set up on the greenway, which makes people feel surprised and cheerful, while making full use of the bottom space under the sky garden including setting up waiting space for parents and activity space for children.
especially a farmer's market to facilitate the economic benefits of the community. Linked to the main buildings, it directly accesses to the roof garden. Crossing the main city road in front of the site, it is convenient for the community population to lead to the Muntjac Mountain.

3.3.2. Culture Inheritance. The venue has gone through a long history. It can be roughly divided into four periods: the canal period, the agricultural period, the industrial period, and the post-industrial period. The plan constructs a cultural landscape structure -- one-axis and multi-branches. The one-axis is the main tour axis consisting of the water culture landscape, the agricultural culture landscape and the industrial cultural landscape that were generated based on the historical development of the site, which is the main landscape axis in the community complex. The multi-branches are composed of a variety of community cultural landscapes that are divided by the main axis. This article focuses on one-axis.

In the water culture landscape, the fountain called Della Princess is the main feature spot. This interactive dryland fountain is located at the entrance to the community site, symbolizing the beginning of the canal culture. In the agricultural culture landscape, the community farm is the main feature spots. Its location corresponds to the location of the farmland in the historical period, designed to shape the farming memory of the venue. In the industrial culture landscape, the industrial culture square and the textile culture corridor are the main view spots. Ad for the industrial culture square, the wave shape inspired by sea waves is adapted through the method of bionic form, which echoes the harbor space of the greenway. In regard to the textile culture corridor, the linear winding structure of the textile car is applied through the method of bionic structure, and the plaza area in the center of the corridor is equipped with an exhibition hall that combines concrete and weathering steel, showing the cultural timeline of the site and giving the public a better understanding of the site history.

3.3.3. Eco-build. First of all, adhering to the principle of environmental protection, this case is designed to increase greening area on the facade and top surface as much as possible to form a compound greening system within the site. There are four kinds of measures for compound greening: vertical greening of building facades, column structure greening of the aerial greenway, greening of the industrial chimney and roof garden (Figure 6). Through compound greening, the green coverage ratio of the site will be improved, and consequently the site can play a transitional role for birds from the Montjuic Mountain area to enter urban communities.

Figure 6. Four kinds of measures for compound greening.

Furthermore, the program learns the survival characteristics of the ant colony to build a community agricultural production system that can achieve public participation and group collaboration. Community farm provides green and fresh melons and vegetables for the community fairs, and the economic incomes from market transactions is used for the operation and management of the community farm. Community farm are divided into two types: shared and harvested. In shared farmland, residents can participate in the process of planting, maintaining and harvesting, which not only enhances the public's sense of participation, but also meets their spiritual needs in contact with agricultural work. In harvested farmland, it brings economic benefits to the community, while provides food and living
environment for local people (Figure 7). In addition, water recycling system is designed in community farm to make full use of precipitation for domestic water, farmland irrigation and other use, promoting the sustainable development of the community (Figure 8).

Last but not least, the case also takes the creation of the site microclimate into consideration. Microclimate affects all aspects of people's production, life and health, and determines the quality of people's quality of life to a large extent\[14\]. In this design, using the method of bionic structure to learn the ant hole ventilation performance that energy can be provided through the ups and downs of the wind in ant nest and the undulating motion of the wind can be promoted by multi-level spatial structure. Through the compound greening, rainwater harvesting and ecological corridor, the heat island effect in the site can be effectively alleviate and a pleasant microclimate environment can be made (Figure 9).

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**Figure 7.** Self-sufficient agricultural production system.

**Figure 8.** Water recycling system.

**Figure 9.** Microclimate creation process diagram.
4. Conclusion
This project applies design bionics to the Can Batlló community complex design in Barcelona, aiming to create a new community complex model with sustainable development. The article creatively proposes a new model -- “ant community” and points out that it is the result of a combination of design bionics and sustainable development. “Ant community”, inspired by ants, emphasizes the improvement of community function, the care of vulnerable groups, the pursuit of place memory, the formation of community solidarity and the creation of community ecosystem.

The ant is a kind of highly social specie. Ants were born on earth earlier than humans, so naturally may have a better way to survive. The ant spirit of group collaboration, caring for the weak and clear division of labor is worthy of attention and consideration by human society.

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