

## The Application of Bionics Ideas in Bridge Design

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### Summary

Based on the classification of bionics as well as application goals, the present paper attempts to address existing problems in bridge design through incorporating bionic or biomimetics thinking. Meanwhile, it provides some new ideas into innovative design and future bridges. From macroscopic aspect, the appearance and structure in biosystem can be utilized in type-selection or innovative bridge design. From microscopic aspect, the mechanism and behavior in biosystem can also be applied in design optimization or improvement. With the discussions of bionics idea in bridge, it is likely to establish the conception of “living bridge” as well as the biological thinking in bridge design. From unconscious to conscious, the application of bionics idea may push the bridge engineering back to the future. This philosophy would help us to build more sustainable, energy-efficient, environmental friendly bridges, if we learned from Nature endlessly.

**Keywords:** Bionics; Bridge design; Design optimization; Innovative design; Sustainable design.

It is well known that after millions of years of evolution, the biological world has formed quite reasonable life structure, whose merits, such as small size, exquisiteness, high efficiency and reliability and so on, are very amazing. The advent of bionics is a beginning for human being to learn from the Nature. This discipline, which has incorporated multi subjects, sees the Nature as an inexhaustible source of knowledge and technical solutions.

Engineering of today still needs great improvements in design, construction, monitoring, etc. The application of bionics ideas provides some new solutions to these problems. Sustainability and innovation are the world's subjects today, so did engineering fields. Innovational, reasonable, material-saving structures are goals pursued by engineers. The ecological coordinating system, which has come into being after millions of years' evolution, is a very precious textbook for our current society to coordinate ecological environment and develop sustainable technologies. In addition, the biological world is even a rare reference for studying how to make the structure of non-living organisms more vital so as to become self-adaptive and self-regulative organisms.

Bionics falls into different categories from different perspectives. On basis of other categorization, this paper attempts to divide Bionics studies into two categories, which are macro-bionics and micro-bionics. The paper below attempts to discuss applications of bionics concepts to bridge design from both macro and micro aspects. No matters in macro-bionic or micro-bionic design or the realization of comprehensive bionic design, the main body of research is organisms and project design. It is an important turning point in bridge development, since they shift bridges from inanimate to vital objects.

The macro-bionic design refers mainly to the appearance as well as the structure of the natural world. In this paper, the bridge design will be discussed from three aspect of macro-bionic which is morphological intimated, mechanical intimated as well as emotional-intimated. Whether it is the overall design or detailed design, the optimal designs, Nature will provide an important and fresh resource for the engineers. Thus, designers can blend the bionic idea everywhere in a bridge, including the superstructure and substructure, as well as in the option of the bridge floor system and the affiliated infrastructure. For instance, in the scheme design for the appearance of the bridge,

designers can take the static or dynamic appearance of animals or plants for reference in order to build more composite and innovative bridges. While in aesthetic design optimization, designers can imitate the visual images in Nature.

Since the macro aspect of natural world can inspire engineers during the design process, in micro aspect, the function and mechanism within the organism can also be a great source of bridge design and optimization. The micro-bionic design means the blending of inner system of living creature into bridge design. In this paper, the bridge design will be discussed from three aspect of micro-bionic which is the material, function and mechanism as well as neural system of the natural world. The adaptive and self-regulatory ability of the living organisms is the natural blueprint for bridge engineering, which is characterized by wind resistant, seismic design and sustainable design. For example, the wind-resist and earthquake-resist ability of plants can be used for bridge design; the dynamic performance of birds and insects gives us stimulus in addressing the wind resistance of the bridge. As for the matter of improving the hydrological studies, we can gain insight from hydromechanics of fish. Both whole and specific structure of a bridge may also be designed and optimized based on some functions in the biotic community.

The third part is about ecological perspective in bridge design. Although there is no need for bridge to carry out “photosynthesis” as eco-architecture, the ecological status of bridge cannot be ignored whether in cities or suburbs. The ecological view of protecting the environment and saving resources should be deeply-rooted in the mind of each bridge engineers. A successful scheme should be supportive for future site planning and environmental conservation; otherwise it will cause unnecessary waste of resources. During the bridge construction, we should use as much as possible local materials, recyclable materials and even materials remaining in the process of building. We also should give priority to the use and transformation of existing bridges rather than demolition and reconstruction. In the whole life cycle, energy-saving measures should be taken into account. In bridge drainage ventilation and lighting, For example, solar energy and wind power should be fully utilized so that a lot of resources will be saved. This idea should not only embody in the period of construction, but extend to the whole life-cycle, even out of service. As a result, the one hundred years is no longer the target of bridge design

Given all the bionic idea discussed above, these concepts can be applied not only in bridge design, but also in all aspects of today’s bridge engineering, such as planning, implementation, monitoring, disaster prevention and mitigation, etc. The problem now engineers facing is: What is going to be done with all this knowledge? As mentioned before, no matter what the bionic concept is, our ultimate aim is to solve existing problems as well as to study on the future trend of intelligent bridge. Despite difficulties in the future, with the development of technology as well as the corporation of different specialist, all these difficulties will be overcome.

Nature is an excellent teacher, who has inexhaustible mysteries for mankind to probe, as we can hardly find a scientific research learning nothing from Nature. From unconscious to conscious, future engineers will be in a unique position when they come to build bridge of next century, promoting the bridge engineering into a new stage. With the fusion of bionics, a great breakthrough will be made, for bridge could then be not only a dead structure but a vital one. Although it’s essential to imitate our predecessors, the sustainable goal will be achieved if we learn from Nature.

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