Structural Innovations Inspired by Growth, Genetics, and Emergence Theory

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Summary

Understanding the process and greater context in which elements in nature are produced enables considerations for integrated solutions that can be mathematically described and applied to the built environment. These ideas are based on applying fundamental engineering principles to complex problems. Specific building examples will be used to illustrate the correlations of aesthetics, function, design, and efficiency by considering these methods in design.

Keywords: growth, systems, Pin-Fuse, genetics, emergence

1. Introduction

Observation of the natural environment reveals underlying patterns and intrinsic relationships that transcend individual species and have elemental relevance to the built environment. Explorations of the golden ratio, fractal geometry, and biomimicry have profiled these phenomena, but have not fully understood the depth of the processes from which they are yielded. The study of genetics has provided a fundamental understanding of the composition of life and how it changes over time. Nature's intrinsic rules and relationships govern how elementary components combine to create complex organisms and systems. These rules and relationships often orchestrate the growth of the higher-level system without any global oversight or guidance. This process is known as emergence. In this organic process, the whole becomes more than the sum of its parts.

2. Growth

Naturalists have long studied the growth of organisms of all scales to look for themes and patterns which transcend individual species. These principles can be applied to design to improve not only the efficiency of the structure, but to reveal aesthetically interesting built environments.

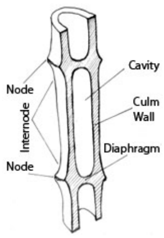

Fig.1: Bamboo cross section

For example, the natural formation of bamboo reveals unique structural characteristics. Long, narrow bamboo stems provide support for large foliage during its growing life while providing strong and predictable support for man-made structures after harvesting. Even when subjected to Tsunamis, bamboo behaves effectively and efficiently to lateral loads exhibiting the genius of natural structural properties and geometric proportioning. These growth characteristics are not random: diaphragm elements are not evenly spaced over the bamboo's height, but are mathematically predictable.

Bamboo consists of a culm, or stem, comprised of nodes and internodes as illustrated in Figure 1. Nodes mark the location of diaphragms and provide the location for new growth. A slight change in diameter exists at node locations. Internodes exist between nodes. Internodes are hollow creating an inner cavity surrounded by a culm wall. The diaphragms provide resistance to culm wall buckling over the height of the culm. Material in the culm is located at the farthest point from the stem's neutral axis, providing greatest bending resistance, allowing gravity loads to exist only in the outside skin which impedes uplift due to lateral loads and minimizes overall weight.

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