On One Approach to the Design of Sustainable Construction Projects

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Abstract: The article presents an approach to the design of construction objects, according to which they should be developed on the model of dynamic natural ecosystems, which are sustainable communities of plants, animals and microorganisms. Construction projects should take account of the sustainable development principles. First, they should be environment-oriented. Secondly, attention must be paid to the well-being of both the individual and society as a whole. Third, it is necessary to ensure the resource and technological efficiency of the building throughout the life cycle. Fourth, projects should be financially feasible, both in the initial phase and throughout the life cycle of construction. Fifthly, greater attention should be given to the relationship between effective development and public policies.

1 INTRODUCTION

In the 21st century, most advanced countries have chosen transition to management by natural pattern as a guide for their development (Dorokhina & Kharchenko, 2017a). According to the prominent physicist and systems theorist Fritjof Capra, human consciousness is supposed to lead its way from an understanding of cell biology and its growth and development processes as the basic foundation of all living systems through the evidence of conditions of cognition and social interactions within all levels and elements of living systems (Capra, 2002). He exposes intriguing comparisons and relationships between the biological science of living systems and contemporary technologies, cultures, business organizations, and social systems. For instance, he writes, “In biology, the behavior of a living organism is shaped by its structure. As the structure changes (and they all do, constantly) during the organism’s development and during the evolution of its species, so does its behavior. A similar dynamic can be observed in social systems. The biological structure of an organism corresponds to the material infrastructure of a society, which embodies the society’s culture. As the culture evolves, so does its infra-structure – they co-evolve through continual mutual influences” (Capra, 2002).

Capra’s findings are important not only for addressing the current challenges of resource consumption and social processes, but also for the future development of technologies bound to achieve a higher level of social sustainability.

“Eco-design" should be modeled after dynamic natural ecosystems that represent sustainable communities of plants, animals and microorganisms. Sustainable human society must evolve so that its way of life, economy and technology do not destroy the intrinsic vitality of nature.

2 RESEARCH METHODOLOGY

The first step in building sustainable societies should be "understanding the organizing principles common to all living systems that ecosystems have developed to sustain life” (Kharchenko & Dorokhina, 2016). Such an understanding should be a crucial competence of politicians, businesspersons and professionals in all fields and should be part of education at all levels, from primary and secondary schools to colleges, universities, and further education and retraining. The six following

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ecological principles underpin "environmental literacy".

1. Networks. At all levels of nature, we find living systems located within other living systems - networks within networks. Their boundaries are not boundaries of separation or isolation, but boundaries of identity. All living systems interact with each other and exchange resources across their borders.
2. Cycles. All living organisms, in order to exist, must be constantly fed by the flow of water and energy from the environment, and all living organisms constantly produce waste. However, the ecosystem does not generate waste which is just waste (net waste) because the waste of one species is the food for another one (the other ones). Therefore, living matter circulates continuously within the biological system.
3. Solar energy. Solar energy, converted into chemical energy by photosynthesis, triggers ecological cycles.
4. Partnership. The exchange of energy and resources in the ecosystem is supported through comprehensive cooperation. Life has evolved on the planet not because of hostilities, but through cooperation, partnership and networking.
5. Diversity. Ecosystems achieve stability and resilience through the richness and complexity of their ecological networks. The more biodiversity they have, the more sustainable they will be.
6. Dynamic balance. The ecosystem is a flexible, constantly changing network. Its flexibility is a consequence of the numerous feedback loops that keep the system in dynamic equilibrium. Not one single variable is maximized, but all the variables fluctuate around their optimal values.

Connections (in our thinking, knowledge and information systems, within and between our organizations, in the systems we design, and between our built infrastructure and facilities, between people and cultures), connections that prevent producing net waste, - this is the goal of environmental sustainability, worthy of efforts to create a sustainable society.

Capra emphasizes that all living organisms, even the simplest cells, are interconnected, respond to the environment, are intelligent, communicate, thrive in the necessary diversity and do not produce clean waste (Capra, 2002). All organisms - except humans.

The process of providing for human needs and activities is perhaps the most wasteful one that takes place in peacetime.

There are axioms that people at their own risk ignore (Kharchenko & Dorokhina, 2017). The evolution of human needs seems inexhaustible. Technologies, institutions and policies are constantly changing. At the same time, nothing that is created from natural materials and substances disappears anywhere, as all natural materials evolve and eventually degrade. All the energy we use is stored solar energy that comes in free. All living systems are interconnected and highly dependent on each other to sustain life.

3 RESULTS OF THE RESEARCH

Human society has come to believe that construction projects should be more deliberately and effectively take account of the principles of sustainable development. First, our efforts must focus on the environment. Secondly, attention must be paid to the well-being of individuals and society as a whole. Third, there is a need to ensure that construction projects are allocatively and technologically efficient throughout their life cycles. Fourth, projects should be financially feasible, both in the initial phase and throughout the life cycle of construction. Fifthly, more attention needs to be paid to the relationship between efficient development and public policy.

The design process is now under much greater pressure than before. Whereas since the beginning of the Industrial Revolution design schools have taught the development of the concept or form of expression, these are the integration strategies or dynamic relationships that should be taught nowadays as a key moment in design.

The challenges of designing, planning and providing sustainability of the society in the twenty-first century will be as follows:

- respect for all natural resources such as land, water, air, energy, and all their components;
- utilization of what is available (e.g., solar energy, reusable and recycled materials);
- involvement of all stakeholders in the design process (involving the team of experts and stakeholders in the design process at maximum from start to finish);
- use of the most appropriate and efficient, least cost technologies (applying the best world practices);
- linking long-term objectives of the sustainable development to human and natural capital, with

economic efficiency achieved through natural and human efficiency along with the efficient policies in maintenance, operation and financing;

- minimizing utilization of the electricity generated from the non-renewable sources and release of energy associated with the construction and operation of the constructed buildings;
- turning the facility into a net energy center (i.e. a center designed to produce and distribute more energy than it consumes);
- design with regard to dismantling and recycling (or re-use and modification in order to extend the life of materials and equipment) (Dorokhina & Kharchenko, 2017b).

According to Ken Yeang, an award-winning eco-architect in Kuala Lumpur (Malaysia), the design process will need to be transformed into an interdependent process which requires "whole systems thinking, gives much greater emphasis to the front-loading of design in the process, considers the end-use-least-cost (life-cycle) strategies, and facilitates a team of design minds" (Yeang, 1995). Given the abovementioned conditions are met, construction projects might become more connected to the planet's life systems, and they will be of greater value to human uses.

Up to now, construction mostly appears as making an isolated, disconnected, inanimate object of consumed natural materials rather than a design-build-recycle process connected to the evolutionary process of life. Still, such a strategy is currently emerging from the construction industry, namely, a circular renewal system (Lowe, 2001).

The circular renewal system is a combined approach to wastewater treatment, organic waste disposal and energy systems that is currently being tested in some hotels and apartment buildings. Let us shortly consider the way this system operates.

An internal system captures all organic residues from the building rather than using traditional municipal sewage lines and garbage collection.

Hygienic storage tanks and bins (with backup capacity) for the bio- materials feed into an anaerobic digester and an ethanol fermenter.

The resulting methane serves as a fuel supply to building boilers, kitchens, or electricity generating systems. (Part of the methane could supply a fuel cell for electricity generation order to test inclusion of this technology as it evolves to cost-competitive commercial operations).

The resulting ethanol provides fuel for vehicles for the building operations or possibly for electricity generation.

Solid residues from the processing are used as compost and fertilizer for the building's landscaping/gardening.

Liquid effluents from the system are treated and used on site as graywater, reducing overall water demand for the building.

Supplemental external power may be derived on site from wind generators, photovoltaic systems, or solar water heaters on the roof or other faces of the building envelope, depending on the climate.

Combined with passive cooling and heating, maximal usage of daytime lighting along with the energy monitoring and careful selection of the materials for low-energy recycling, a circular renewal system lets us consider a building as a kind of a biosystem. The very concept of a circular renewal system offers a real prospect of recovering the construction cost by saving energy over the life of the building, reducing the burden on the municipal infrastructure and on the environment, and increasing the market attractiveness of the construction projects, since such building may be regarded as a model in environmental protection.

Right now, there are at least two buildings equipped with such systems – a hotel in Delhi (India) and a commercial building in Tokyo (Japan).

4 DISCUSSION OF THE RESULTS

These examples show a discrepancy between how humans normally design their habitat and what nature supplies, develops, and recycles (Tsurkan, 2017). It is biology that shows the interdependence of natural systems in the sense that formation and consumption of waste are considered as the links of the same chain.

The most striking evidence of the lack of environmentally friendly management is the huge amount of waste generated by construction and demolition. Most of the materials used and discarded in construction and demolition do not find any useful secondary or residual use, mainly being disposed of in public landfills. The construction industry thus contributes significantly to one of the major environmental problems. This problem is landfills, which threaten human health and the environment, not to mention the loss of the economic value of waste. On average, construction industry is responsible for between 45 and 65% of the waste deposited in landfills (Lima et al., 2021).

At present, building owners, contractors, designers have few options and even fewer incentives to recycle construction waste. However, fortunately for both the future of human health and the environment, the construction industry is on the verge of significant change. Especially in large cities, an increasing number of non-profit organizations are emerging to clean up and redress the existing imbalances. Based on a lot of relevant literature, large cities publish their own toolkits that help the stakeholders like developers and contractors recycle construction and demolition waste. For instance, the Metro Oregon government publishes the "Metro's Construction, Salvage and Recycling Toolkit" (https://www.oregonmetro.gov/tools-working/guide-construction-salvage-and-recycling)). Portland, the largest city of the Oregon state, is one of the leaders in developing the policies and practices in treating the construction and demolition debris.

With a goal of preventing waste from construction activities, the Toolkit provides sample record keeping forms and detailed model instructions. It advises:

- Set waste prevention goals and include them in specifications.
- Require specific waste prevention activities in the waste management plan, including reuse and salvage practices.
- Design with standard sizes for all building materials.
- Specify green building materials such as certified wood or low VOC paint.
- Specify materials and assemblies that can be easily disassembled at the end of their useful life (design for deconstruction).
- Choose flexible interior finishes or materials, such as carpet tiles, that can be easily removed, recycled, and replaced when worn or damaged.
- Design spaces to be flexible for and adaptable to changing uses.
- Communicate your waste prevention plan at meetings, post it at the job site, monitor the program, and promote the results.
- Require vendors to ship materials to the job site in recyclable or reusable packaging.
- Re-evaluate estimating procedures to make sure the correct amount of each material is delivered to the site.
- Maintain an up-to-date material ordering and delivery schedule to minimize the amount of time the materials are on site and to reduce the chance of damage.
- Ask suppliers to deliver supplies using sturdy, returnable pallets and containers. Have them pick up the empty containers when delivering new supplies. Also, require suppliers to take back or buy back substandard, rejected, or unused items.

With a goal of saving materials from demolition activities, the recommendations might be as follows: "There are two ways to recover materials for salvage and reuse: Deconstruct the building or conduct a selective salvage operation prior to demolition. Deconstruction involves the careful dismantling of a whole structure in reverse order of assembly, usually by hand, to re-harvest materials for reuse. Salvage is the removal of certain valuable reusable building materials before demolition" (Couto & Couto, 2010).

The so-called Eco-Stores are an example of an alternative to landfilling construction and demolition wastes, since these are the places where materials can be donated, not thrown away. Used materials for construction and reconstruction can be sold at a discount from 50% to 90% of the retail price of new materials. The Eco-store will accept donations in almost any material suitable for construction or renovation. Typical donations are windows of various sizes and types, tiles, bricks, stone, roofs, cabinets, toilets, bathtubs, doors, as well as wooden floors, finishes and lumber. For example, such store is operating in the city of Lincoln, Nebraska, USA (www.ecostoresnebraska.org).

It is therefore possible to address the serious problem of construction and demolition wastes and their impact on the environment by removing usable items from the landfill and from a larger waste stream.

It is common knowledge that traditional methods of construction and reconstruction use many natural resources, and the standard construction process results in significant waste. This waste consists of unused construction materials containing valuable, often non-renewable resources and embodied energy from their production and transportation to the site of work. Once building materials have been landfilled, these resources are practically impossible to recover.

According to a study conducted by the National Association of Home Builders (USA), when building a house of 2,000 square foot (180 m^2), up to 8,000 pounds (3,600 kg) of waste are usually disposed of at the landfills (Johnson, 2015). In addition to increasing needs for the capacity of landfills and growing operation costs, waste from paints, solvents and chemically treated wood can lead to soil and water contamination. In addition, the energy originally used to produce these materials, both by natural and human processes, is wasted when the materials are landfilled. On the other hand, the reuse of materials prolongs the life of local landfills, conserves natural resources, reduces pollution and saves energy.

5 CONCLUSIONS

In general, the design of sustainable construction projects has a significant impact on the practice and public policies with respect to the construction industry. The changes we are witnessing may bring us closer to the model of natural management, design following the concepts of sustainable development and to the maximal reuse of natural materials. Due to economic and social pressure requiring greater energy efficiency in construction (especially in housing markets), we are beginning to look for and to apply important innovations and best practices in the construction industry.

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