ПРОЕКТИРОВАНИЕ И СТРОИТЕЛЬСТВО ГРАЖДАНСКИХ, ПРОМЫШЛЕННЫХ И СПЕЦИАЛЬНЫХ СООРУЖЕНИЙ, КОНСТРУКЦИЙ И ТЕХНИКИ

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THE INFLUENCE OF THE NEW GENERATION OF SMART-MATERIALS AND TECHNOLOGIES IN THE DEVELOPMENT OF INNOVATIVE ARCHITECTURE — A PROGNOSTIC OVERVIEW

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It envisages the prognostic overview of some smart building-materials and technologies that may have far-reaching influences on the development of architectural environment as sub-systems of Nature, as well as, on the innovative model of development of the post-industrial society as a whole.

Key words: prognostic overview, building-materials and technologies, innovative model of architectural.

1. **Preamble.** The architecture, as an innovative synthesizing means of humanizing the fruits of the NTP-II (with its 7th-Technological Cycle until 2040) in the service of the mankind; and, it is to play a vital role in the improvement of the quality of life of the majority with a systems future vision of the living environment and the society as a whole; at present, its 3 main aims in the spirit of the Post-industrial era of the XXI century: (i) improvement of Economy (for higher economic growth and productivity). (ii) improvement of the Human Resources (mainly for the purpose of innovative-intellectual labors), (iii) improvement of the Ecological Environment; these aims can be fulfilled with the help of high-tech and innovative architectural designs.

The mainline theoretical concept in architecture, at present, is based on multidisciplinary synergic-systems approach: it includes various allied fields of sciences and technologies, including human-sciences that deal with man-environment relations, (namely, Cultural Anthropology, Human Ecology, Ethology, Urban Sociology, Environmental Psychology, Proxemics, and various others); hence, the Architectural Environment, in essence, is phylogenetical in content, and as a sub-systems of Nature, with all its complexities; hence, at present, the Architectural Design is basically identified as the Environmental Design in its totality; in other word, it is the process of development of the Nooshere, as envisioned by Vernadski in the early decade of the XX century.

Such a concept of the innovative model of development is justified on the basis of the following indices: (i) the high-tech share in GNP (> 50%), (ii) the sustainable rate of economic growth (> 8%), (iii) the higher value of population resources with its intellectual potentials, as the national wealth, (iv) the higher environmental quality and standard of living, (v) the higher share of recycling energy in the energy supply system, (vi) the favorable Gin-factor for income distribution in the civil-society, (vii) the higher level of longevity with disease-free active-life, and similar others.

2. **Smart Materials.** In the past few decades, a large numbers high-tech based smart materials, have been developed, that are suitable both for advanced building materials and construction and that have made possible, along with the use of information technology (viz., the CAD), revolutionary changes in the architectural design, its formation of fractal or non-linear aesthetic order, the light-weight large-span construction systems; some of them may be indentified.

2.1. ***Some of high-tech Materials*** as are frequently used in Architectural Building Construction: High-tensile Steel (HTS > 10 times than ordinary steel), various categories of Light wt. high-tensile Steel-Aluminum-Titanium alloys (Lt. wt. HT Metal-Alloy), multi-layered composite-materials (both transparent and non-transparent), mainly from the aero-cosmic sphere, light-weight carbon-fiber composites; Light wt. (floating) plasmas-concrete, High Performance Concrete (6—8 times higher compressive strength than the conventional one), Ductal Concrete (incorporated fiber-reinforced, highly resistant to bending), Ferro-concrete, Light- transmitting (transparent/translucent) concrete, and various others [1].

2.2. ***Sensor-implanted Materials*** and its impact on Architecture (i.e. micro-chips sensors implanted building materials for automatic monitoring of the structure-conditions). Adding sensors and other devices to bridges, tunnels and buildings can turn into "smart structures" cable of sensing, monitoring their own conditions, to issue warning when a problem starts to emerge, thus, responding to problems, even in cases can take action to prevent or mitigate a problem; it is achieved by employing a suitable array of wireless sensors, that measure physical conditions around the structures such as temperature, vibration and strain, producing a stream of data that can be analyzed by a computer to provide continuous monitoring of the structural integrity; for example, in 2009, a smart sensor system is installed to monitor the Jindo Bridge with suspension cables in South Korea that has 113 nodes of sensors, each with six sensors and uses cleaver programming to control the data while minimizing energy consumption; the sensors detect wind loading and vibration above certain threshold; the nodes are powered by small wind turbines and solar cells, which may power them indefinitely; the computer even send text-messages to engineers about the status about the bridge.

Buildings in windy and earthquake-prone areas are equipped with active smart-systems (not the passive ones), with the active dampers that use sensors to monitor the building's movement and powered actuators to respond accordingly by moving weights placed on the upper floors, that act as tight-rope walker, to counteract to keep balance; such system can cope with a far wide range of conditions; both the sensors and the shock absorbers can be powered by emergency standby power-systems; for example, the World Financial Centre in Shanghai, built in 2004, uses an active damper. At present, the smart sensors are penetrating almost all sphere of life, including, for example, the used it to improve the way buildings control their heating and cooling systems, manage renewable-energy systems such as wind-turbines and solar panels.

3. **3-D Printer as Production Technology.** (3-Dimentional Printer Technology for Construction-joints and Lego-Construction System): It is the digital 3-dimentional automatic, or semi-automatic, labor-extensive Production Systems for monolithic joints of structural-components of buildings; the 3D Printer or manufacturing technology makes it as cheap to create a single item or more; it undermines the economies of large scale of products.

3.1. ***Production technology principles:*** as per the design drawing and specification the end-product is built-up by progressively adding material one layer at a time, with a precision of a tenths of a millimeter; (0.02—0.03 mm) the layers are defined by software; the techniques of putting the layer are diversified: that include liquid blinder, titanium or other metal-powder-layering, laser or particle beam, and others; thus the process uses less materials, and less energy compared to conventional ones; even the construction of building of any shape can be made with additive layers of materials or concrete with computer-guided nozzles; a small item can be made by a machine like a desk-top printer, hence the name it adopts; for a large construction joint-part it may need a bit more space; each item is created individually, and each item can be made slightly differently at almost no extra cost; it also promote innovation— e.g., if you change the shape of a product in computer, you can turn it into an object; it is becoming an open-source innovative programming, designing and manufacturing system — its long-term impact is highly optimistic and with revolutionary perspectives, like the invention of transistor in the 1950's; the 3D Printer as manufacturing machine is developing fast as the technology improves and as its cost of manufacturing falls [2].

3.2. ***Impact on Architecture:*** the economic-efficient medium or large-span construction systems with new light-weight composite-materials (e.g., the transparent multi-layered thermo-plastic) with implanted net-work systems of light-weight high-strength reinforcements-components (e.g., various high-strength lt.-wt. steel-al-titanium alloys) with monolithic-joints for self-supported structure, short or large-span, of any shape or form.

4. **Recycling Energy Sources and Green Technology**: e.g., cheap recycling sources of energy, vertical farming, sea farming, formation of nooshere with the help of "energy-efficient waste-free closed-cycle cluster industries" and "bio-geo-engineering" and similar others.

4.1. ***Cheap recycling sources of energy.*** New technological developments: (i) Module Cutter for Silicon-Crystals for the full-cycle hard-panel Solar Battery, (ii) the film-form solar-battery, (iii) the present cost-effectiveness, under the solar-condition of Germany: for the CIGS (Silenit with Copper, Indium and Gallium) Battery is 2 (two) years; for the CdTe (Telluride of Cadmium) Battery is 1 (one) year only; accordingly, the prognosis claims that within a couple of years the basic cost of production of electricity from the solar-battery on the roof-top becomes most cheapest source of energy; (iv) the excess amount of electricity from the solar or wind sources may be transmitted to general supply-net; (v) by 2050, as per the official plan, 100% of the electricity will be produced from recycling sources, more than 50% of that from off-shore wind-generators and solar-panel-battery sources; eco-clean bio-gas based thermal-power station;

4.2. ***Vertical Farming Technology:*** Growing crops/ vegetables (including, root-crops to melon and serials like maize in vertical farms in cities (on urban roof-top, or vertically in high-rise structure; plants indoors or on roof tops, with the help of controlled environment (namely, the control of temperature, humidity, lighting, air-flow, water, nutrients, pesticides, erosion of soil, and so on) and the automated recycling hydroponic high-tech method, that can produce 20 times more agro-products on a unit area during a year-period, than with the conventional method [3]. Analogical projects with high-tech implications, like highly profitable "Fish-Farming" — for the artificial cultivation of fishes and sea-products along the sea-coast-lines of the world.

Impact on Architecture: By 2050, it is expected that 70% of world population is expected to live in urban areas; so it is convenient and economic to produce food at a "multi-functional self-dependent work-cum-living centers", with its own self-sufficient systems of producing basic-foods, and the cheap-energy from the recycling-sources) with the help of new technology and new management know-how.

5. **High-speed Mass-Transport System** (Rapid Transit Systems, RTS): The high-tech development of high-speed mass-transport system (viz., on rails up to 450 km/hr., on mag-lev up to 850 km/hr.) have far reaching consequences and changes on the systems of urbanization (more specifically on the process of rurbanization) on the National, as well as, Continental (Global) Scale; it new system involves high-intensity development of Grid-Systems of high-tech-based global urban-infrastructures (viz. the information and power-grids, and fuel-transport pipes, RTS, National High-ways and Free-ways, New Types of Work-cum-living Settlements, Cluster-Industries, etc.) that connects the large Urban-centers and its effective and active Zone of Influence (within 30-min. of travel time between suburban settlements and urban centers, i.e. the phylo-genetic basis of the "home-range" distance limit, as the psycho-somatic perception of convenience as the regular travel-time scale; within the urban area 5—10-min travel time from place of living to place of work).

6. **Conclusions.** The direct effects of the fast development of high-tech building materials and construction systems and its impact on the innovative development of architectural environment, from National to Local Scales, have some definite trends:

— the formation of "New Systems of Rurbanization": the Megapolis, as the "Global Center" with its central services and infrastructure; it is surrounded by "high-tech based work-cum-living centers (< 50,000 popu., viz. Techno-park, Free-Econ. Zone, etc.) and connected by high-speed RTS (> 250 km/hr);

— the architectural complexes are becoming multi-functional sub-centers (viz., the Hub, the Node with transport-intersections, the work-cum-living complex, business-centers, information-community centers, etc.) with high-tech high-intensity land-use formation (with FAR > 1.5), extending both vertically up (mainly for long-term human-use, with natural environment, greeneries, winter-garden, etc.), and vertically down (mainly for the automatic machine-space, car-parking, transport, services, infrastructures, etc.), while the ground-level is kept free mainly for the pedestrian-movement, landscapes, greeneries, with the low Ground Coverage (< 15%) by buildings;

— the design of architectural environment, with the help of high-tech, is progressively becoming the complex multi-disciplinary process, as the sub-systems of Nature:

the synthesis of natural and made-made environments, at the interior or the exterior levels (with the integration of natural light, landscape-elements, greeneries, etc.) with the help of high-tech large-span, light-wt.-transparent construction systems, flexible planning, and other diversified spatial means (like, atrium, roof-garden, vertical-garden, winter-garden, terrace, lodge, etc.),

it is becoming sustainable in qualitative terms: it is becoming energy-saving (> 90%) with self-recycling waste-free sources of energy, water, and other resources; becoming self-dependent, self-organizing, self-financing (with the help of NE and NM); automatic-control of the interior environment from pollutions (> 18 items) with recycling energy-sources,

the control of the psycho-somatic comfort for its users,

the architecture is becoming the effective means to minimize the gap between the fruits of the NTR-II and the qualitative process of life, to minimize the social-deviants, and thereby to develop the human resources in general.

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ВЛИЯНИЕ НОВЫХ ПОКОЛЕНИЙ УМНЫХ МАТЕРИАЛОВ И ТЕХНОЛОГИЙ В РАЗВИТИИ ИННОВАЦИОННОЙ АРХИТЕКТУРЫ

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Рассматриваются прогностические отчеты некоторых современных умных строительных материалов и технологий, которые имеют долгосрочное глубокое влияние на развитие архитектурной среды как субсистемы природы и также на инновационные модели развития постиндустриального общества в целом.

Ключевые слова: прогностические методы, строительные материалы и технологии, инновационная архитектура.