Budownictwo o Zoptymalizowanym Potencjale Energetycznym 2(20) 2017, s. 43-50
DOI: 10.17512/bozpe.2017.2.06

Krystyna JANUSZKIEWICZ
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie, Wydział Budownictwa i Architektury

THE HEALTH PROTECTIVE AND ENERGY SAVING URBAN ENVIRONMENT AT THE TIME OF CLIMATE CHANGE

With the use of parametric and multi-criteria optimization digital tools, buildings can be designed to respond to various requirements. Recently, an expanded understanding of building performance acknowledges that all factors acting on buildings (climate, energies, information, human agents) are not static and fixed, but rather mutable and transient. This paper explores the possibilities of architectural design to benefit human condition, which encompasses physical and mental well-being, environmental quality of life during the Climate Change era. The first part of the paper defines the main factors (such as: lack of green nature and sunlight, noise and pollution) which are influencing the formation of psychological disorder in big cities. The negative impact of these factors is constantly increasing in the time of Climate Change progressing. The second part presents results of the research program undertaken at West Pomeranian University of Technology in Szczecin by author. The program (Climate Change Adapted Architecture and Structure) goes on to attempt to solve the problem through architectural design. This study highlights a social problem, such as mental well-being, resulting from urbanization or effects of the climate change, and serves as a useful background for further research on the possibilities of redefining sustainable and human friendly design).

Keywords: urban design, energy saving, human heath, climate change, protectivity, climate change

INTRODUCTION

Global climate change is expected to pose increasing challenges for cities in the following decades, placing greater stress and impacts on multiple social and biophysical systems, including population health, coastal development, urban infrastructure, energy demand, and water supplies. In the past decade, there has been growing evidence that activities to mitigate climate change can have beneficial impacts on public health as a result of changes to environmental pollutants and health-related behaviours. Understanding the interrelation between these impacts and the built environment put forth to architects and engineers to develop innovative materials, components and systems, with the goal of designing to building more active i.e. responsive, adaptive as well as protective to variable and extreme climate conditions [1]. Future building should be active to both internal and external conditions as well as should be act as a protector of human health.

1. A PSYCHOLOGICAL DISORDER IN THE URBAN ENVIRONMENT

The process of urbanization could be described as one of the major global environmental changes directly affecting human health today. People spend more than 90% of their lives within buildings [2]. Advanced urbanization brings a lot of advantages society, but also far-reaching side consequences. One of the fastest growing diseases in recent years with a global reach is depression, a psychological disorder.

While the physical health impacts of climate change are well known, the impact on mental health has only begun to be recognized. At the time of Climate Change the number of people suffering from depression is constantly growing. There are 350 million people that live with depression today. It affects people of all nationalities and ages, regardless of social status. The World Health Organization estimates that in 2030 it could be the most widespread disease in the world. This increasing number is harmful to humanity, declines economic activity, increases social costs and suicides [3].

Depressive disorders appear for different reasons: genetic, neurobiological or environmental. Today, most neuroscientists agree that the biological determinants of this disease are associated with disorders of the brain or nervous system. Neurotransmitters whose disorders especially affect proper working of human endocrine are serotonin (hormone of happiness), melatonin, and norepinephrine [4]. Despite scientific knowledge and self-awareness about depression, therapies used by doctors are short-lived and not effective. They heal only the human body but do not affect the environment in which we live, which significantly contributes to disorders of human endocrine. The right level of hormones mentioned above is dependent on the inputs that the organism is getting from environment. The urban environment requires a fast pace of life, causing stress and chemicals responsible for the endocrine balance in the body are not fully metabolized. Restoration of normal hormonal balance can be achieved the creation of a friendly environment and developing structures that will have a positive impact on occupants.

2. RESEARCH AND DESIGNING OF ANTIDEPRESSANT BUILDING IN THE URBAN ENVIRONMENT

The dictionary explanation of 'protective' is intended to protect someone or something or adapted to afford protection of some kind: “protective covering”; “protective coatings”. While the protectivity in contemporary architecture can be defined as a system’s ability to giving protection of users to the build environment. Recently, at the time of global climate change the terms redefine form not as the shape of a material object alone, but as the multitude of effects, the milieu of conditions, modulation and microclimates that emanate from the exchange with its specific environment - as a dynamic relationship that is both perceived and interacted with by subject [5]. As defined in climate change literature “adaptive capacity” is the property of a system to adjust its characteristics to expand its coping

range [6]. In practical terms, adaptive capacity is the ability to implement effective adaptation strategies, or to react to stresses to reduce any likelihood of harmful outcomes. The ability for a building to change and adapt its configuration relative to the main factors (such as: lack of green nature and sunlight, noise and pollution) which are influencing the formation of depression in big cities should be a source of formal and technological innovations.

Last year these issues were addressed by Krystyna Januszkiewicz (Leader of Digitally Designed Architecture Lab) and faculty member at the WPUT (West Pomeranian University of Technology) in Szczecin. The research program (Climate Change Adapted Architecture and Structure) is focused on protective envelopes designed for modern buildings in cities experiencing recent rapid development. The envelopes designed to have adaptation and protection strategies to anticipate exterior environmental variations as well as interior interaction with inhabitants. With the use of parametric and multi-censor optimization tools, envelopes are programmed to respond to the certain criteria. Cities produce lot of energy e.g. sound, smell, friction, that is not used again, so it is worth widening the range of storage inputs.

2.1. Research

In the first part of the research project, the main negative and positive factors affecting mental health are in large metropolises are defined. The impact negative effects of climate change along with their correlation with depression are discussed (Fig.1).

Fig. 1. Environmental factors influencing depression and principles of building working. Climate Adapted Architecture and Structure Research Program, WPUT Szczecin, 2015

The second part of the research program goes on to attempt to solve this problem through architectural design, using the latest technology and methods [7]. The intention of this design was to not only to minimise but to eliminate any negative environmental impact completely. This was possible by using intelligent and sensitive design conceptualization. The working principle was inspired through the basic principle of how natural neuron networks works.

An artificial neuron is a mathematical function conceived as a model of biological neurons. Artificial neurons are the constitutive units in an artificial neural network. The artificial neuron receives one or more inputs (representing dendrites) and sums them to produce an output (representing a neuron's axon). The entry gets input signals. This is information that describes a task that the neuron has to solve. Each of the instruments has a certain value. The signals are multiplied by the weight values, the results of this multiplication are added together in a summing block. In this way, a specific number is defined as membrane potential. It is sent to the activation block where it can be processed in the future. The activation blocks receive an answer with a new value of the input signal [8].

Similarly, the stages of information processing through the building can take place by using three elements: the external envelope, which wraps the building and spreads to the streets of the city, collecting inputs from the environment. Gathering of the information - mostly negatives are processed in summing blocks located at the building base and released as positives into the interior by outer envelope.

2.2. Processing external negatives into internal positives

Each of the environmental factors could be collected or processed by a personalized system. Inputs gathered from surroundings would be processed and released to the building interior with a new value. The intensity of released outputs could be controlled or manipulated by internal needs. It also could be combined in various ways to create the best expected microclimate (Fig. 2). The following basic principles of building working have been considered:

- *Smell*: dirty air would be collected by the pores in facade. Odor from the surroundings is cleaned in a summing block using an air ionizer. Plasma discharge generates and emits the same positive and negative ions that occur in released into the air simultaneously would be used. These positive and negative ions instantly recombine on nature. Ion air purification technology in which positive ions [$H^{+}(H_2O)$ n] and negative ions [$O^{2-}(H_2O)$ m] are the surface of bacteria, mold fungus, viruses and allergens floating in the air to form hydroxyl (OH) radicals, which have extremely high oxidation ability, and this chemical reaction decomposes proteins on the surface of bacteria and other pathogens, thereby inhibiting their activity [9]. This combination creates water which returns to the air. Cleaned air is transformed back to the interior of the building. Some of the pores in the facade contain selected natural, essential oils that are sprayed in the air in selected parts of the buildings in order to create a particular mood. For example: graveolens - a strong antidepressant, helps with emotional problems; grapefruit - improves mood and relieves nervous tension; peppermint - inhibits hyperactivity and lessens fatigue.
- *Sound:* A system of microphones could be mounted to the façade. Microphones are divided into 3 groups. Each group has a special membrane catching specific tones: low, medium and high. Particular vibrations go to the synthesizer that works like the sampler, recording sounds (the noise of the city) and then manipulating them in various ways by changing the sound settings into more

friendly tones. Processed vibrations are released into the building through the different speakers as harmonic sounds of specific frequencies, which are friendly for the organism. For example, sounds with level of 136,6 Hz are relaxing for body, frequencies of 400÷480 Hz decrease stress and are free from physical pain and raising vitality.

- *Natural environment:* rainwater could collect on the facade by a system of gutters with bowl-shaped heads. Single gutters would be connected to a main one hidden in facade that would direct water to the summing block for future cleaning and recycling processes. Recycled water is pumped back to the interior of the building and used for hydrating the plants that create a beneficial, natural environment.
- *Sunlight*: in the external façade a system could be mounted that basically uses a glass ball that is filled with water to concentrate the sun's energy onto a PV panel. In this way the sun's energy is concentrated by up to 10,000 times [10]. The ball can also be rotated and would include a tracking system, meaning that energy collection is maximized throughout the day. The PV panels transport collected energy to the battery, which converts DC power into AC power with the frequency and voltage corresponding to the requirements of electricity grid. The collected power could be used to charge the whole building and to operate lamps, which are physically similar to sunlight. It has a resemblance to the wavelength of light, the light intensity (about 10 000 lux) and color. Lamps are turned on when there is no sunlight outside which would provide the right balance of melatonin to the organism.

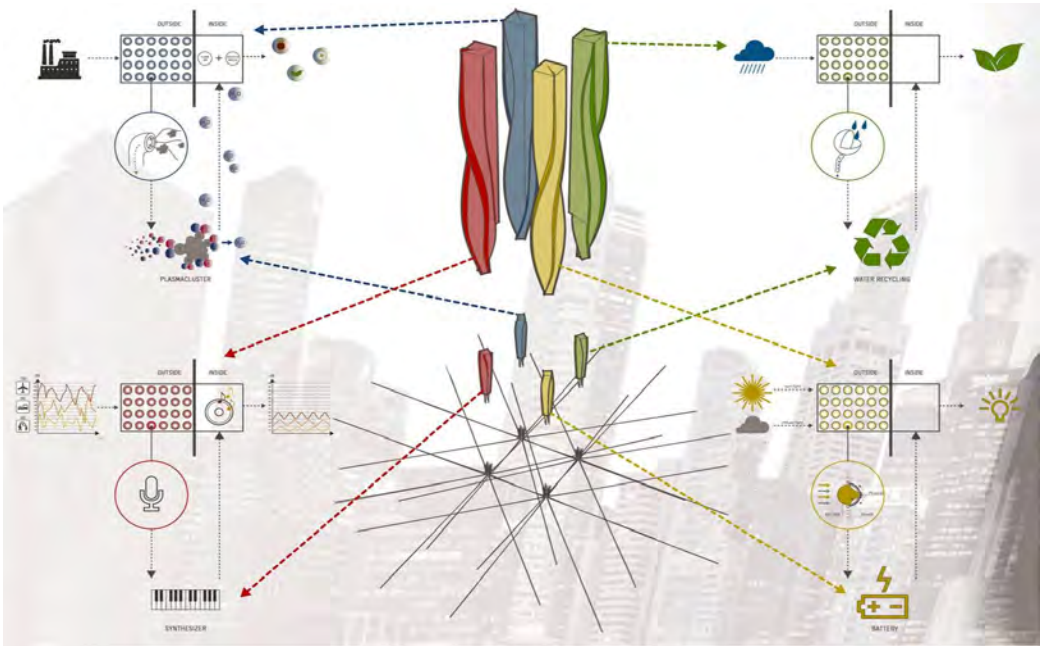

Fig. 2. Processing external negatives into internal positives - Stimuli division. Climate Adapted Architecture and Structure Research Program, WPUT Szczecin, 2015 [7]

This is a proposal for a protective and adaptive building envelope. This is an idea of a first level operational framework for present and future investigations towards performance based responsive architectures through a set of responsive typologies. A mock-up concept of a secondary environmental system to a primary structural system joint into a collective behavioural system equipment with an artificial neuron network system is presented above (Fig. 2).

2.3. Results

The presented proposal of building envelope prepared by the Digitally Designed Architecture Lab (2015) at WPUT in Szczecin shows the possibilities of how to use elements of existing environments and to then process them into a friendly habitat using the latest building envelope technology. In this design a building is treated as 'environmental valves' regulating the transmissions of energy, light, air, moisture, and information between interior and exterior.

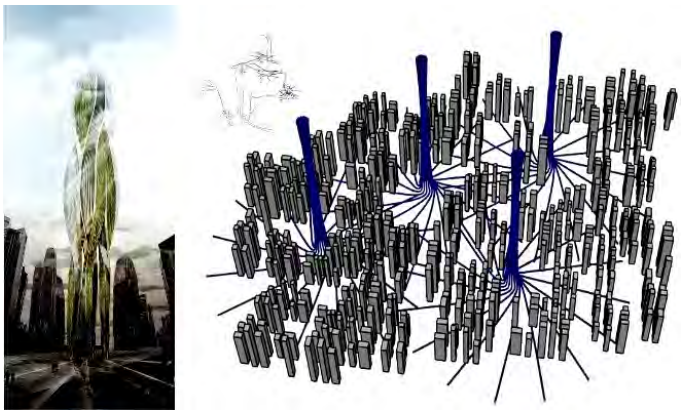

Fig. 3. Protective human health envelope for a smart city under rapid development, 2015. Climate Adapted Architecture and Structure Research Program, WPUT Szczecin [7]

Cities that focus on smart development have to seek innovative solutions and wisely manage resources in order to become a forces for economic development. Depending on the location and needs, the building (this could be a public or residential space) function could be combined for private and public functions. Buildings also could create networks with each other, such as a neuron network. In a big metropolis environment, stimuli can be very different in each part of the city. Some of the buildings could collect more water or sunlight for others that need it. In that case, buildings could contact each other by sending Wi-Fi information about the state of collected energy. Buildings, which would save more energy, could transmit it to those that need it, assuring a sustainable balance in the network (Fig. 3). It would become a living part of the city, processing the external factors such as light, noise, smell and give it back into the building, creating different atmospheres of sounds, smells and other inputs, that the city creates every day.

This design task can only be tackled by means of an integrated approach to planning, i.e. interdisciplinary collaboration between architects, facade and environmental engineers.

DISCUSSION AND CONCLUSION

This research highlights the impact of architecture on the psychological state of man and sensitize designers to re-define sustainable and human friendly design. The "vein-like" structure of the building would be connected with the surroundings, unlike it is today, where most of the buildings aim to protect human health from external factors. Scientists should take more research into the improvement of building envelopes in terms of impact on the urban environment of their users. The capacity for building skin to actively support building function is critical to the future of building envelopes design. Every environmental factor would be collected and processed through a customized computing system. Input gathered from the building exterior would then be processed and recalculated with a new value to the building's interior. The intensity of released outputs could be controlled according to internal needs. This could also be combined in various ways to create the optimum microclimate. Climate change policy is often presented as a choice between mitigation and adaptation, where "mitigation" refers to efforts toward reducing the accumulation of greenhouse gases in the atmosphere and "adaptation" refers to adjusting to the impacts of a warming world through enhancing an ecosystem's resilience. This is a false dichotomy, and to address climate change we need to begin the process of writing both mitigation and adaptation strategies into our building codes and standards. inputs, that the city creates every day.

Acknowledgements

The author would like to thank WPUT Szczecin students (Master Program): Sylwia Gudaczewska, Piotr Orłowski and PhD students: Natalia E. Paszkowska, Konrad Zaremba for their contributions to this work as well as for their efforts and enthusiasm throughout the WPUT Szczecin workshop.

REFERENCES

[1] Velikov G., Thün K., Responsive Building Envelopes: Characteristics and Evolving Paradigms. In Design and Construction of High Performance Homes, Routledge Press, London 2012, 75-91.

[2] Confalonieri U., Menne B., Akhtar R., Ebi K.L., Hauengue M., Kovats R.S., Revich B., Woodward A., Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge UK, 2007, 391-431.

[3] Ebi K.L., Sussman F.G., Wilbanks T.J., Reid C.E., Hayhoe K., Thomas J.V., Weaver C.P., Analyses of the effects of global change on human health and welfare and human system, Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, U.S. Environmental Protection Agency, Washington DC 2008, 1-11.

[4] Nemeroff C.B., Vale W.W., The neurobiology of depression: inroads to treatment and new drug discovery, J. Clin Psychiatry 2005, 66(7), 5-13.

[5] Hensel M., Menges A., Inclusive Performance; Efficiency Versus Effectiveness. Toward Morfo-Ecological Approach for Design, AD 2-3 (78) 2008, 54-63.

[6] Wigginton M., Harris J., Intelligent Skins, Elsevier Architectural Press, Oxford 2006.

[7] Januszkiewicz K., Gudaczewska S., Orlowski P., Antidepressant infrastructure for vertical cities. Experimental approach to investigate antidepressant structures for regions for regions in rapid development, 4th Annual International Conference on Architecture and Civil Engineering (ACE) 2016, Singapore, GSTF 2016, 323-329.

[8] Beesley P., Hirosue S., Ruxton J., Responsive Architectures. Subtle Technologies 06, Riverside Architectural Press, Cambridge 2006, 3-11.

[9] Sharp, Hihger concentration of plasmacluser ions Higher Concentrations of Plasmacluster Ions®*1 Boost Virus Inactivation and Elimination, Inhibit 99.9% of Airborne H5N1 Avian Influenza ("Bird Flu") Virus, Verified in Collaboration with Retroscreen Virology Ltd. of the UK, August 2008, in press.

[10] Goia F., Perino M., Serra V., Zanghirella F., Towards an active, responsive, and solar building envelope, Journal of Green Building 2010, 4(5), 121-136.

ŚRODOWISKO MIEJSKIE CHRONIĄCE ZDROWIE I OSZCZĘDZAJĄCE ENERGIĘ W CZASIE ZMIANY KLIMATU

Cyfrowe narzędzia parametryczne oraz wielokryterialne narzędzia optymalizacyjne sprawiają, że budynki mogą być projektowane w odpowiedzi na różne żądania. Obecnie, w rozszerzonym rozumieniu performance-u budowli przyjmuje się, że czynniki oddziałujące na budynek (klimat, energia, informacja, czynnik ludzki) nie są statyczne i stałe, lecz zmienne i przejściowe. Artykuł przedstawia możliwości projektowania miast z uwzględnieniem tych czynników i wynikające z tego korzyści dla człowieka, zwłaszcza jego zdrowia psychicznego podczas postępującej zmiany klimatu. W pierwszej części artykułu przedstawia się główne czynniki (takie jak: brak zieleni i nasłonecznienia, hałas i zanieczyszczenia), które występują w dużych miastach, a które mają wpływ na stany psychiczne. Wpływ tych czynników nieustannie wzrasta podczas postępujących zmian klimatu. W drugiej części przedstawia się próbę rozwiązania tego problemu przez projektowanie architektoniczne w ramach programu naukowego (Adaptacja architektury i konstrukcji do zmian klimatu) kierowanego przez autorkę w Zachodniopomorskim Uniwersytecie Technologicznym w Szczecinie. Wyniki tych studiów rzucają nowe światło na problem socjalny, a zwłaszcza zapewniania dobrego samopoczucia w środowisku zurbanizowanym w czasie zmian klimatycznych. Otwierają także drogę do dalszych badań nad i w zakresie projektowania przyjaznego człowiekowi miejskiego środowiska zrównoważonego.

Słowa kluczowe: projektowanie miast, energia, zdrowie, zmiana klimatu, ochrona