SOME ASPECTS OF CONTEMPORARY TRENDS IN CIVIL ENGINEERING

M. DRAGOVIĆ[1], *Dr Sci, Assistant professor,*
M. SREĆKOVIĆ[1], *Dr Sci, Professor,*
A. ČUČAKOVIĆ[1], *Dr Sci, Associated professor,*
S.L. SHAMBINA[2], *PhD, Associated professor.*
[1]*University of Belgrade, Serbia*
[2]*Peoples' Friendship University of Russia, Moscow, Russia*

In this research several topics concerning contemporary civil engineering and architecture are introduced: problems regarding structural system choice (with respect to the geometric design of the building), suitable materials search (regarding durability, reliability, technical feasibility and optimal solutions), ecological aspect of the innovative materials and constructions, aspects of the strength of chosen materials, contemporary methods for the monitoring of the materials, shapes, and tracking of the stress in critical (crack) points of the structural system, composite materials role, facade solutions, geometric design shape with respect to energy efficiency and futurism in the building context.

KEY WORDS: civil engineering, structural systems, durability, composite materials, architecture, strength of materials, geometry, twisted structures.

Complexity of the building process regarding each civil engineering and architectural structure includes wide palette of tasks: from geometric design, via structural system, building technology, applied material, to a posteriori control – construction monitoring and material testing. These tasks concern the separate component as well as the whole. Contemporary life style and engineering necessity demanded energy efficiency analyses, as well (fig.1).

Simultaneously, the creation and the failure of the structures, through the history of the civilization both influenced on development of design, building materials and technologies. The failure analysis of civil engineering and architectural cultural heritage, with the deepest insight into the building practice and experience, consequently improved all the components of building process. Amongst the others, the famous historical document – Hammurabi's code of laws testified that tendency.

The strength of applied materials varied, depending on the place of its installation - critical points, joints, complex curved surfaces, etc. The influences of the temperature, wind and seismic disturbances, must have been predicted and included in calculations and design. Such kind of influences provoked the specific architectural trends (green architecture, seismic architecture, etc). Terrain observations during defined time period are unavoidable regarding the structure's function (residential buildings, multifunctional buildings, dams, airports, stadiums, oil platforms, satellite stations, power plants, etc.) and their reliability level.

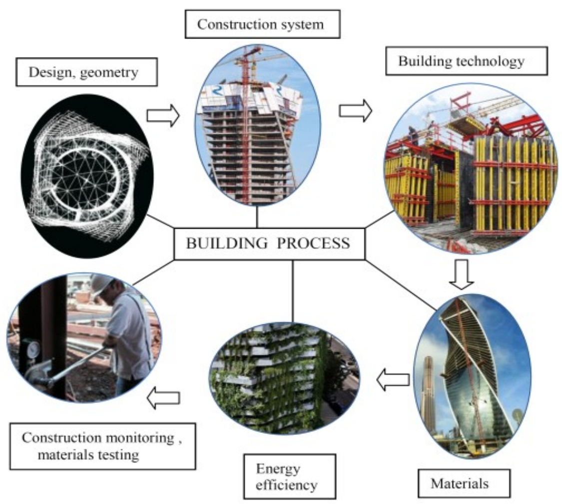

Fig.1 Necessary building process components

Civil engineering revolution in structural systems, at the begining of 21st century arisen along with diagrid, which adaptability enabled obtaining various shapes, both rectilinear and curvilinear, in the design of the most daring architectural creations [1]. The "diamond pattern" on the facades of the famous: Swiss Re building, Mary Axe in New York (arch. N. Foster), CCTV Headquarters building in Beijing, Seattle Public Library (both designed by OMA architects), Zaragosa Bridge Pavillion in Spain (arch. Zaha Hadid), etc. appeared in the variety of combinations of steel structural elements and glass surfaces, each one with the characteristic spatial shapes, building materials and technologies.

The forefather of diagrid's "geometry"- Buckminster Fuller, visionary engineer, proclaimed non collapsible essence of triangular structure with strong joints, and applied this principle to the tansegrity and geodesic constructions. Maybe more closer to the diagrid's "eyelets" reached engineer V. Shukov, with one sheeted hyperboloid shaped lightweight structures. Following the simple principles both entranced a new structural building approach supported by software analysis of various loads and influences. First direction, originated from Shukov's structure -

self supportive light weight lattice, brought up several innovative directions in building shapes: from horizontal lattice bridges (fig. 2, 3), to some other "twisted" civil engineering structures (fig. 4) [2, 3].

Fig.2
Hyperboloid bridge in Manchester

Fig.3
Horizontal "twisted" bridge in Netherlands

On the other hand, resisting even the gravitation laws diagrid overcame the vertical eccentricity of the objects (fig.5). In order to obtain rigidity of the stucture "Ring beams at the floor edges are normally tied into the diagrid to integrate the structural action into a coherent tube and connect the same to the floors, and back to the core" [1]. Hence the geometric shape of the building became artistically almost free of limitations. Although the seismic rules prefer simpler shapes, due to structural stability, likewise symmetry and uniformity, the present projects of architectural buildings are often struggling against it [4].

Fig. 4
Capital gate in Abu Dhabi

Fig. 5
Tod's building in Tokyo

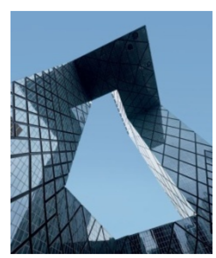

Fig.6
CCTV in Bejing

The interesting examples of such efforts are designs of Tod's building in Omotesando area - Tokyo (arch. T. Ito & Assoc.), where the facade construction succesfully imitates the nature: tree trunks with branches leaning on the street (fig. 6), likewise CCTV Headquarters - Beijing (OMA, R. Koolhas and O. Scheeren arch.), with diagrid as exosceleton of unusual eccentric object's geometry (fig. 7).

Earthquake architecture become challenging for the towns with seismic areas. One of the adopted concepts is of seismic insulation (object's reliance on series of flexible seismic insulators or dampers) [4]. K. Moon studied diagrid's optimization on very tall buildings, concerning angle of diagrid with respect to the object's dimensions [5]. Present digital design techniques, like parametric modeling, or building information modeling - BIM enable optimization and parametric control of the structural design.

Fig. 7
Al Bahr towers

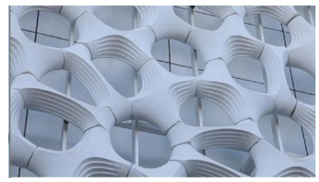

Fig. 8
Mexico City's hospital

In order to achieve creativity in direction of energy efficiency and ecology, regarding insulation and air streaming, some amazing facade tessellation elements (inspired by tradition - mashrabiyas) were designed on high Abu Dhabi tower, where traditional mud, clay and wood were replaced with the "smart"- dynamic facade solution (fig.7). The air purification process in Mexico City's hospital upholds ornate "double skin" with carbon air filters (fig.8).

"Construction monitoring and materials testing are the bridge between design and safe, economical, high quality, completed project" [6]. Contemporary methods overview for the estimation of structural system stability, stress distribution and critical point are numerous. Elion techniques (contactless and distant methods) progressively replaced more classical. The other methodologies incorporate fiber optic's elements with lasers [7].

Fracture theory can be treated on microscopic (atomic) and macroscopic levels [8]. The first one is connected to material structure, for performances linked to the crystal lattice (or adequate characteristics of amorphous materials). Macroscopic consideration refers to defined magnitudes (elastic moduli, crack threshold, etc) according to limited (critical) engineering regulations, based on theory and long term experience in civil engineering and architecture areas. Adequate safety coefficients are macroscopic ones, but their essence is linked to the prediction knowledge of initial cracks and whole kinetics. This is connected to the type of applied material: mono-crystal, poly-crystal, metal, glass, composites (aluminium panels PEFR), PCM materials, polymer cement, etc. [9]. However, these questions are always present in the fracture theory with multi-disciplinary approach, supported by software simulations.

The latest constant development of experimental techniques of model proto-typing and testing by optical/laser methods (polarimetry, holography, tomography, holographic interferometry, or methods with incorporated fibers) [10]. Two types of devices are developing in CW or pulse regimes. The principal difference is linked to parasite mechanical vibrations which should be avoided during measurements.

Conclusion: Creative ideas grew through the time, according to the "taste" and courage of the designers, but the building realization is faster and more reliable, considering contemporary civil engineering equipment and previous investigations of the seismic stability, climate, surroundings (underground, air, or water), etc.

Classical buildings were rather limited by materials and technologies, while contemporary design is almost free in expression: the shapes are double curved (2nd or 3rd order surfaces), or free form; structural systems overcame heights and eccentricity, while modern materials improved in mechanical properties gravitate to composites obtaining energy efficiency and ecology; adequate software solutions and simulations offer faster predictions for static and dynamic behavior of structure and its components. All these improvements promise miraculous futuristic creations.

References:

1. *Boake T. M*. Diagrids the new stability system: combining architecture with engineering/ Building solutions for Architectural Engineering, 2013. - pp. 574 - 583.
2. *Dragović M*., PhD thesis - Constructive procedures in spatial transformation of the surface - EHOS, Belgrade University, Faculty of Architecture, 2013.
3. *Шамбина С. Л.* Многогранные коробчатые поверхности и их применение в архитектуре / Строительная механика инженерных конструкций и сооружений. 2014, №1 - М.: Изд-во РУДН, 2014. - С. 18 – 24.
4. *Charleson A., Tayler M.,* Earthquake architecture explorations. 13th World Conf. on Earthquake Engineering, Vancouver, Canada, Aug 1-6, 2004, No 596.
5. *Moon S. K*, et al. Diagrid structural systems for tall buildings-characteristics and methodology for preliminary design./ Structural Design of Tall and Special Buildings, Vol.6, No 2, 2007. - pp. 205 - 230.
6. Citation from http://www.geostructures.net/services.php
7. *Kirić M., Srećković M.* Modern approach to control and nondestructive testing methods. Fundamentals of fracture mechanics and structural integrity. – Belgrade, 2009. - pp. 237 - 260.
8. *Finkel V. M.* Fracture Physics. – Metallurgya, Moscow, 1970. (in Russian)
9. *Шамбина С. Л.* Анизотропные материалы и особенности расчета конструкций из них/ Строительная механика инженерных конструкций и сооружений, 2005, №1. – М.: Изд-во РУДН, 2005. - С. 113 – 118.

10. *Nestorović M. et al*. Rapid prototyping: constructing physical models of architectural geometry/ Int. conf. Geometrical and computer simulation: safe energy, ecology, design. Crimea, Simferopol, Ukraine, 7 - 10 oct. 2013. - pp.187 - 192.

Figures:

Fig.1 http://www.bi-constructionnews.com/en_article_Evolution_Tower_Moscow.news; http://www.geostructures.net/images/construction_1.jpg; http://www.pinterest.com/pin/8444318025193886/

Fig. 2 http://www.mathematik.unibiefeld.de/~sek/la2/material/einschalig.htm

Fig. 3 http://www.west8.nl/projects/bridge_vlaardingse_vaart/`

Fig. 4 http://worldamazinginformation.blogspot.com/2011/04/world-furthest-leaning-man-made-tower.html

Fig. 5 http://www.arcspace.com/CropUp/-/media/57291/5tod.jpg

Fig. 6 http://www.phaidon.com/resource/buildingmillennium-p148-01.jpg

Fig. 7 http://www.archdaily.com/270592/al-bahar-towers-responsive-facade-aedas/.

Fig. 8 http://www.inform.kz/eng/article/2593501

НЕКОТОРЫЕ АСПЕКТЫ СОВРЕМЕННЫХ ТЕНДЕНЦИЙ В СТРОИТЕЛЬСТВЕ

М. ДРАГОВИЧ[1] (Сербия), *Dr Sci, Assistant professor,*
М. СРЕЧКОВИЧ[1] (Сербия), *Dr Sci, Professor,*
А. ЧУЧАКОВИЧ[1] (Сербия), *Dr Sci, Associated professor,*
С.Л. ШАМБИНА[2] (Россия), к.т.н., доцент.
[1]Белградский университет, Сербия
[2]Российский университет дружбы народов,

В этом исследовании рассматриваются несколько тем, касающихся современного строительства и архитектуры. Это вопросы, связанные с выбором конструктивной схемы (с точки зрения геометрической структуры здания), поиском подходящих материалов (с точки зрения их прочности, долговечности, надежности, технического обоснования и оптимального решения), экологический аспект инновационных материалов и конструкций. Также рассматривается роль современных методов мониторинга конструкций, использования композитные материалы в так называемых «умных» домах, современные фасадные решения, зависимость энергоэффективности здания от геометрическая конструкции его формы.

КЛЮЧЕВЫЕ СЛОВА: строительство, структурные системы, долговечность, композитные материалы, архитектура, прочность материалов, геометрия, скрученные конструкции.