RSP • No. 45 • 2015: 233-244

ORIGINAL PAPER

In Search of the Housing Supply: Determinants of the Construction Policy Empowerment in Europe

Alina-Maria Văduva-Şahhanoğlu *
Mădălina Xenia Călbureanu-Popescu**
Siemon Smid***

Abstract
The main objective of this Article is to show that there is an urgent need for using modern methods in the construction sector for more sustainable buildings. These modern methods include a high percentage of automation and robotisation in construction. To achieve this objective, it has been considered the necessity to build adaptive structures in order to respond efficiently to consumption of energy through all aspects included and an increased seismic safety. There is presented a comparative analyse of the current solutions in construction process and the ones which include automation and robotisation. The main accent was based upon using innovative technology with automatic removable formworks. This technology can be used to construct more easily high-rise buildings and in the same time provides the leads for green and sustainable buildings. A high percentage of automation and robotisation for the building processes will generate more sustainable buildings, green and durable technology, superior seismic performance, thermal efficiency, low emissions, waste reduction and, as whole, durable buildings.

Keywords: on-site manufacturing technology, affordable buildings, robotisation and automation building process

* PhD Ec., Project Expert, Romanian Association for Technology Transfer and Innovation, Phone: 40747507677, E-mail: alinavaduva@gmail.com.
** Associate Professor, PhD, University of Craiova, Faculty of Mechanics, Phone: 40722634340, E-mail: madalina.calbureanu@gmail.com.
*** Senior Manager, PricewaterhouseCoopers, Société cooperative, Phone: 352621334056, E-mail: siemon.smid@lu.pwc.com.

Challenges of the Construction Sector

In these days, more than two thirds of the European population lives in urban areas and this share continues to grow. In addition of this, the young population and a lot of disadvantage classes face the serious threat of economic stagnation or decline. Also, the green and healthy city is needed in these circumstances. It is estimated that around 70 % of the EU population – approximately 350 million people – live in urban agglomerations of more than 5 000 inhabitants. Although the speed of transformation has slowed down, the share of the urban population continues to grow (World Urbanisation Prospects: The 2009 Revision, United Nations, Department of Economic and Social Affairs, Population Division, 2010). So this demand for automation and robotisation in the construction sector appears as a result of: (1) The world faces a great tendency of urbanisation; (2) Future buildings have to be sustainable, eco - friendly, based on an efficient energy principles; (3) The construction sector has to improve its competitiveness and to reduce the initial cost and manage efficient the possible cost of maintenance during the life cycle structural monitoring of construction system.

The construction sector is of strategic importance to the EU as it delivers the buildings and infrastructure needed by the rest of the economy and society. It represents more than 10% of EU GDP and more than 50% of fixed capital formation. It is the largest single economic activity and it is the biggest industrial employer in Europe. The sector employs directly almost 20 million people (Lassale, 2013; Mayo, 2006: 1-5). In addition, construction is a key element for the implementation of the Single Market and other construction relevant EU Policies, e.g.: Environment and Energy. The total market size of the global construction segment was of 8,194 billion USD in 2013 (6,828 billion EUR), out of which: residential: 2,997 billion USD; infrastructure: 2,700 billion USD; non-residential structures: 2,497 billion USD. The European market size (according to FIEC annual statistical report, 2014), in terms of volumes of sales (total construction output) was in 2013 of 1,162 billion EUR (Communication from the commission – Europe 2020; European Commission, 2014a; European Commission, 2014b; European Commission, 2014c; European Union Regional Policy, 2011).

Construction by Robotization and Automatization as a New Scientific Domain and the Market Places within It

Construction automation and robotics involves three areas: mechanization, automation and robotics, encompassing a spectrum of technology application. At the low end of this spectrum is mechanization, which consists in equipping a pess with machinery. The mechanization process will evolve into an automation process, when the process is not only supported by machines, but the machines work in accordance with a program that regulates their behavior. At the high end of the technology application spectrum is robotics where task-specific or intelligent robots are used to execute parts (Mahbub, 2008: 23-27). The domain of this topic group refers to automation and robot technology based on-site manufacturing technology in the construction industry. It involves installing automatic/robotic machining or assembly centers on the construction site and transforming the construction site into a factory-like, structured, manufacturing environment (Linner, 2013: 1-2).

The functional landscape starts with the search for best value in homebuilding, which is not simply a question of finding the lowest cost. It is vital to maintain and enhance quality, including those aspects of quality that affect durability, lifetime running costs and overall performance in areas such as environmental sustainability, health and safety. In addition, the demand to increase housing supply requires more homes to be built in a shorter time, so value in homebuilding means building more quickly as well as more efficiently. The Construction Robots meet the three key quality requirements durability, performance and whole life costs. Major barriers, both technical and commercial, in the implementation of the construction robotics are: (1) Costs for R&D and innovation. Construction robots also imply an increase in capital intensity and higher workplace costs; (2) Costs for initial updating of a company and maintaining costs; (3) Difficulties in using and developing technologies; (4) Incompatibility with existing practices or current construction operations; (5) Low technology literacy among industry participants; (5) The necessary technologies are unavailable or difficult to acquire; (6) The technologies are not easily accepted. An interesting perspective of the expected future opportunities in the construction market is presented in Table 1 (Ranking from 1-most significant to 10-least significant).

Table 1. Future trends and opportunities

Ranking	Future trends and opportunities
1	Greater awareness of the technologies within the construction industry community
2	The number of construction companies using automation and robotics technology will increase significantly
3	Automation and robotics technology will be affordable for construction companies and easy to implement
4	There will be a larger range of automation and robotics technologies available for use in construction
5	There will be a greater standardization of the design and construction process
6	The use of automation and robotics technologies will enable companies to operate more efficiently and competitively
7	The technologies will be easily available across the world
8	The technologies will be accepted by the workers and they will be trained to use them
9	Automation and robotics will be easier to install and operate
10	The technologies will be easily available across the world

Source: Author's compilation after Mahbub, 2008: 238

Comparative Analysis of Current Solutions for Automatization and Robotization in Construction

The analyses of Automated/Robotic On-site Factories deployed so far reveal an interesting discrepancy between the technical state achieved and the improvements in productivity, economic performance and efficiency achieved. Whereas from a technical viewpoint the developed and deployed technologies (e.g. in terms of modularity, flexibility, variability, ROD) have reached an outstanding level, efficiency, productivity and economic performance stayed still behind the achievements in other comparable industries.

Like advanced manufacturing environments in the general manufacturing industry, Automated/Robotic On-site Factories were developed as sets of re-combinable subsystems with in-built (robotic) flexibility or with modular flexibility (e.g. end effector change) that can be fully synchronized with the buildings modular structure through ROD. Likewise, the analysis of the variability and of applied ROD methods shows that onsite factories can be adapted within a certain extent to various building projects and thus used to automate the subsequent construction of differently designed and shaped buildings. Although organizationally this capability was not yet fully used, technically speaking the analysis showed that the capability is embedded in the modular approach most systems followed (Linner, 2013). ROD is a strategy that aims at co-adaptation of both the construction products and automated/robotic manufacturing/assembly operations in order to enhance the efficiency of the total construction process.

Performing the analysis of identified and analyzed of all approaches to Automated/Robotic On-site Factories that have been conducted so far were identified 13 categories. Considering the analyzed systems and the fact that some of the systems were used several times (for example ABCS and SMART each up to ten times), that subsystem applications are frequently used (e.g. Obayashi) and that currently the application of the on-site factory approach for deconstruction is taking off in Japan, it can be said that the Automated/Robotic On-site Factory approach to date has been applied more than 60 times worldwide. On the basis of the technical analysis conducted, categorization into 13 categories shows that Automated/Robotic On-site Factories can be installed at various locations on the construction site (on the ground, on top of buildings) and can progress in various directions (for example vertically or horizontally) thus allowing solutions for almost any building typology (for example various high-rise building typologies, condominiums, point-block buildings, steel buildings, concrete buildings (see summaries in the Analysis and Categorization Matrix). Besides construction purposes, the on-site factory approach can also be used to deconstruct buildings of different typologies. This means that from a technical point of view, that Automated/Robotic On-site Factories based on the applied and analyzed technologies (subsystems, end-effectors, factory layouts) hold the potential to be developed for manufacturing any vertically or horizontally oriented building typology.

The systemic analysis of subsystems and end-effector technology showed that Automated/Robotic On-site Factories were in most cases developed as modular kits which allowed, through a combination of in-built flexibility and modular flexibility, high variability. Each system could be broken down into multiple subsystems. The factors for comparative study of the Automated/Robotic On-site Factories are represented by: Factory Layout (Evolution Scheme, Elevation, Ground plan, Subsystems involved, Ed-Effectors, Robot Oriented design (ROD), Erection Speed, Configuration, Productivity, Resource Efficiency, Usability, Quality, Health and Safety. The invention belongs to category no. 8 “SkyFactory (moving up wards) for simple tower manufacturing” like Taisei and Shimizu technologies. These technologies use steel as building material of main structure. UMF uses concrete as building material of main structure (Linner, 2013: 1-2; Shimizu, 2012).

The following technologies represent the current solutions in robotization in construction on-site. There are presented the main working steps for every technology and the disadvantages which occur. Finally are presented the main working steps for UMF and the advantages of this technology.

Method of buildings execution in volumetric permutable formwork

Working steps: (a) Continuous consecutive concreting of transversal load-bearing walls and floor slabs in spatial sections of U-shaped formwork, which can be moved from one floor to another. The building concreting is carried out on floors; the floor is divided into sections whose dimensions are determined by the cycle of works within 24 hours; (b)

Formwork sections are installed in design position using a crane, taking separate blocks, which make possible to carry out the continuous concreting of walls and floor slab across the entire sector; (c) the walls and floor reinforcement is installed and concreting is carried out. So, it is achieved a fragment of the built-in-situ building with its vertical components (walls) and horizontal components (floor slab); (d) After the concrete achieve the durability of stripping, the formwork sections are taken to the scaffold in the console, installed in the floors throughout the building façade or removed through the gaps left in the floor slab, subsequently concreted.

Disadvantages: (a) the scaffold in the console must be installed in order to move the formwork, and that increases the workload and the amount of building materials; (b) If for the formwork moving there were left gaps in the floor and subsequently concreted, the integrity and the monolithism of the whole building floor slab disc are violated; stiffness decreases both for the floor slab and for the entire building, which has negative impact on building durability properties, especially for buildings in seismically active regions; (c) the limited character of technological possibilities – additional mounting should be performed as, for example, suspended panels mounting or brick up exterior self-supporting protective constructions, which leads to workforce consumption; (d) work undertaken on upper level is possible only after the formed floor slab has reached the designed durability because the equipment moving and the carrying out of reinforcement installation work are performed on the seated floor slab; (e) Period of time during which it is possible to transmit loads on built-in-situ formed buildings, in particular on the floor slab, exceeds the analogical period of time for loads transmitting on vertical buildings.

Method of execution of multi-storey monolithic buildings using mobile formwork

Working steps: (a) The foundation slab is installed, on which the jacking frames are placed along the vertical building elements axis and the formwork is mounted, then the vertical buildings reinforcement and concreting is carried out. Simultaneously, on the foundation slab it is concreted the floor slab, which is suspended on jacking frames columns with the help of special equipment; (b) After the concrete achieved the durability, the formwork panels are removed from formed vertical constructions, the jacks supporting on seated vertical constructions is performed again; jacking frames are lifted with the vertical formwork panels to the next floor with simultaneous lifting of the floor slab, suspended on jacking frames columns; (c) The floor slabs is installed in design position, the reinforcement mustache-bars of the vertical construction and of floor slabs are joined together and the joints built-in-situ is performed; (d) When hardening of the concrete ends it is performed again the supporting of jacking frames columns by the floor slab, the vertical formwork panels are installed in the design position, the vertical construction and the next floor slabs are reinforced, the vertical construction of the next floor is concreted concomitant with the next level floor slab concreting and their strengthening on the jacking frames columns; (e) further the construction execution cycle is repeated

Method of execution of multi-storey built-in-situ buildings using mobile formwork

Working steps: a) concomitant manufacturing of floor slab on the foundation slab in one package with their subsequent lifting; b) installation in design position and joints monolithisation; in this case the vertical formwork panels rests on closing plates built-in-situ in vertical constructions and jacking frames rests again on the panels through the latches strengthened on the frames longerons; c) there are mounted bars in the foundation of jacking frames columns, through which the floor slabs, are risen from foundation slab to the design landmarks.

Disadvantages: a) because the floor slab is concreted apart of vertical constructions and their joint and joints monolithisation are subsequently performed, it cannot be ensured the formation of the floor monolithic rigid disk of the whole construction connected with the vertical constructions, which has negative impact on the building durability properties, in particular for buildings from seismic active regions; b) in addition, according to the basic version of the method, for the concreting of vertical construction the jacking frames and the entire formwork rest on floor slab close to the horizontal junction node of the vertical construction with the building floor slab. The next level/floor slab is concreted on the same floor slab. In order to execute this concreting work it is necessary that the concrete of the joining node achieves the designed durability, which requires time-consuming, exceeding, for example, the time when vertical construction concrete reaches durability values, approved for supporting the formwork panels and, also, jacking frames by seated vertical construction. The time limits of the building are increasing; c) Since the latches for supporting the jacking frames panels are stationary strengthened on the frames lingering, it is impossible to modify their width in the execution process of the vertical constructions, otherwise latches and panels will sit in different planes and other support will be impossible to get. Thickness of vertical construction of the building with many floors virtually always decreases in the direction from the foundation slab to coverage; d) Using known solutions lead to excessive consumption of building materials (RU 2078884 C1 1997.05.10).

New technology relates to construction and can be used in the erection of multi-storey cast- in-situ buildings

Working steps: a) erection of the floor slab of the stage/floor of the building; b) concrete-filling of vertical structures of the next stage/floor of the entire building after setting of concrete floor slab of this stage/floor; c) erection of another floor slab after time curing of the poured concrete up to the attainment of the working strength.

Advantages: a) The result is to increase the strength properties of the erected buildings; b) Reduce the period of construction; c) Building materials saving; d) The possibility of mechanization and automation of technological processes (MD 4161 C1 2012.10.31).

Seismic performance. The new technology based upon automation and robotization can be used in the erection of multi-storey cast-in-situ buildings.

The process for erection of cast-in-situ building includes the erection of cast-in-situ piece of the building: floor slab of the entire building - vertical structures of the overlying stage/floor of the entire building. The basic principle of the process: erection of the floor slab of the stage/floor of the building and, after setting of concrete floor slab of this stage/floor, concrete-filling of vertical structures of the next stage/floor of the entire building – time curing of the poured concrete up to the attainment of the working strength – erection of another floor slab, etc. In the execution of works the formwork is based on the stacked vertical structures of the building.

Technological operations can be carried out in parallel or can be exchanged places respecting the basic principle: performance floor level/floor the entire construction and where the concrete slab that level/floor concrete filling is performed vertical construction of the next level/floor of the entire building, while maintaining the durability of concrete poured until it reaches calculated, the execution of the next floor etc.

As a bridge to maneuver the floor can be used some air mattresses or hydraulic flexible elastic material, while after removing the formwork slab mattresses are collected in rolls and moves to the next level/floor by vertical gaps. Besides walls, intended for lifting beams formwork telescopic floor.

After removing formwork floor next level/floor in rooms formats and places determined according to the calculations can be installed pillars, supports individual who rests on the floor level/lower floor until you reach the floor sat resistance calculated/projected.

1. Setting the pillars mobile trolley jacks frames in the transverse direction vertical construction executed, which are suspended formwork panels, gives the possibility to adjust the thickness of the wall, including wall thickness to decrease the upper floors, which helps to reduce consumption building materials and reducing the mass of the building and inertia forces associated masses at the upper storeys with important effects above the dynamic characteristics of the entire structure which is subjected at wind and seismic loads. Installing the cassette jacks frames with longitudinal reinforcement and longitudinal reinforcement device for binding carcass reinforcement concrete construction makes it possible to automate the process, as opposed to linking the armature with hand tools. The automation of the process improves significantly the accuracy of the binding reinforcement so the strength, stiffness and ductility will have good values in order to perform raised seismic behavior.

2. Using telescopic stabilizers pillars-of formwork panels enables correct spatial position of the panels. The panels are arranged so strictly in vertical position and perform leveling and installing panels (the lower end of the panels) on horizontal landmark design. This affects the quality of joints between vertical and horizontal elements of construction in order to raising the stiffness of the hinges.

3. Install panels in strict vertical position preclude the occurrence eccentricity annexation vertical load on the foundation construction, which improves the durability properties of the construction.

4. The telescopic construction of the (tightening) chuck gives the possibility to perform gathering panels where the wall thickness changes that are running. The floor beam formwork construction gives the possibility of carrying out concreting where, in the solutions according to the architectural concrete and planning changing a spacing between the walls of the building. It provides compactness not only for mounted the beam, but the entire main building.

5. Just ensure the installation of all items under massive bearing formwork (deck) in a plan, which increases the quality of construction. It prevents, for example, excessive leveling concrete floors with effects above the mass of the structure. Making process of the basic variant claimed using technological equipment gives the possibility to perform disk monolithic floors of the entire construction, which improves the durability properties of the construction. As technological equipment rests vertical constructions executed, it reduces the time to build compared to nearest solution.

a) Floors play a key role in taking seismic forces by: overtake the inertia forces and their transmission to the vertical elements of the structure; horizontal rigid diaphragm. To ensure the effect of diaphragm floors of structures must possess adequate strength and stiffness.

b) Connecting floor side structure elements. Connecting floor side structure elements will be done so as to be able to transmit shear forces resulting from horizontal diaphragm action. This connection is achieved by adequate anchoring for the perpendicular reinforcement to the interface slab – wall (or beam) in reinforced concrete floors.

6. Composition walled design of reinforced concrete structures will be reconciled with execution processes considered in design. In addition to the above, for dissipative zones can form stable plastic hinges, should ensure good adhesion and anchorage of longitudinal reinforcement on supports. This leads in most cases to anchor lengths greater than gravity when the requested beam, particularly at the lower reinforcement.

7. Running constructive technological equipment provides the possibility of its use in the construction of buildings with different thickness of vertical construction (walls) and the change (decrease) wall thickness as it approaches the slab of the top. Inventions consisting in this technology offer the possibility to reduce the time of construction, to mechanize and automate work. Based on execution of building monolithic fragment, the slab floor the whole building – the vertical elements of vertical level/top floor, the technology increases the stiffness and durability properties of buildings, which determines the effective use of inventions in building in seismic active regions (Penelis, 2014: 118-124).

Thermal efficiency

The components of the new technology involved in thermal energy efficiency by thermal resistance of the building envelope are represented through the possibility of installing masonry with many layers. The component is: 1) the possibility to adjust the thickness of the wall, including wall thickness decreasing for the upper floors, which helps to reduce building materials consumption; 2) In addition, there is the possibility of installing masonry with many layers, which increases significantly the thermal resistance of the envelope and offers the opportunity of using a wide variety of insulation materials. The second aspect involved in thermal efficiency is about thermal bridging. Thermal bridging in buildings can contribute to a multitude of problems, including, but not limited to, added energy use during heating and cooling seasons and interior surface condensation problems. A thermal bridge is an area localized on the building envelope where the heat flows is different (usually increased) in comparison with adjacent areas (if there is a difference in temperature between the inside and the outside). The effects of thermal bridges are: altered, usually decreased, interior surface temperatures, in the worst case this can lead to moisture penetration in building components and mould growth and altered, usually increased, heat losses (Dieter, 2013: 1-6).

Both effects of thermal bridges can be avoided: the interior surface temperatures are then so high everywhere that critical levels of moisture cannot occur any longer – and the additional heat losses become insignificant. If the thermal bridge losses are smaller than a limit value (set at 0.01 W/(mK)), the detail meets the criteria for "thermal bridge free design". Thermal bridge free design leads to substantially improved details; the durability of the construction is increased and heating energy is saved. A building envelope is considered to be thermal bridge free if the transmission losses under consideration of all thermal bridges are not greater than the result calculated using the external surfaces and regular U-values of the standard building elements alone. It's a good idea to include the 'regularly occurring structures' in standard building elements within the regular U-values (Totten, 2014: 1-3).

There have been positive experiences with numerous construction systems in which the principle of "thermal bridge free design" has already been applied. There are complete catalogues of thermal bridge free details now available for constructions using formwork elements. Using new technology the materials involved for building main elements (walls, slabs) can be chosen as efficient materials in thermic way and can be very easily changeable. Similar building materials use for the main elements can reduce the percent of thermal bridges which improve significantly the thermal efficiency of the building.

Energy Efficiency

The construction industry is a large contributor to CO_2 emissions, with buildings responsible for 40% of the total European energy consumption and a third of CO_2 emissions. To help address climate change the European Commission has set specific targets to be achieved by 2020, known as the 20/20 targets. These targets are to reduce energy consumption by 20%, reduce CO_2 emissions by 20% and provide 20% of the total energy share with renewable energy. All components are involved in automation, mechanization, low consumption building materials, reducing the time for building, reducing amount of work, reducing the consumption of manpower and time of operations execution, reducing unproductive expenditure of time, including technological breaks leads to rising energy efficiency.

Results

Following these purposes we determined couple of solutions that can be solved using our invention, such as: reducing the efforts made by workers; decreasing the amount of waste materials; increasing the speed of construction process; lower price for dwellings. The comparative analyses and the results say that the same workload, using the same numbers of workers, can be done 23 times faster using modern technology with automation of the formworks. Also, using classical methods in construction we need to multiply the number of workers by 20 to achieve it in the same amount of time as modern automation and robotization technology.

Figure 1. The comparison of the total construction time between MTC - modern technology in construction and the traditional one

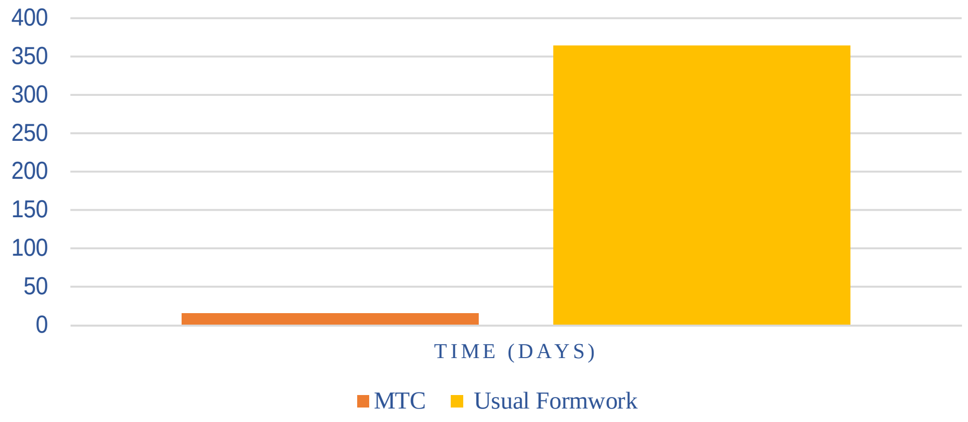
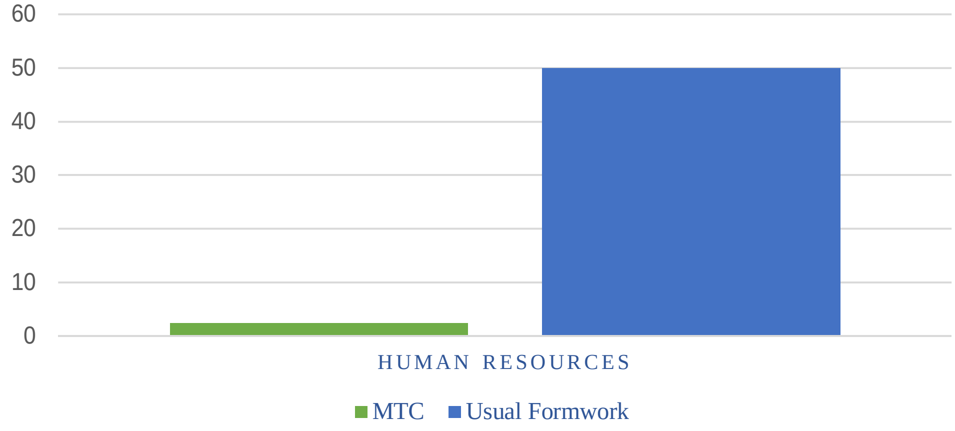


Table 2. The comparison of the number of workers between MTC - modern technology in construction and the traditional one



Although the total costs for realising the new technology based upon automation and robotization in construction can be high the construction cost per level results after a certain number of cycles much cheaper. This technology is saving total time of construction with at least 7 times than traditional ones. In the same time can be saved material to 30% and the environmental protecting can be raised up to 35%. Using reduced human resources the economy resulted from resources payroll can be minimized by 85%. Overall the capital cost for the same building can be reduced with 40%. The entire technology can be used for applying multiple layers for the envelope of the building so the energy efficiency can be raised with at least 40%. In order to build in a traditional way there are necessary a lot of sub-contractors which can introduce a lot of errors in the technological flux. The robotization and automation in construction technology remove a significant number of these sub-contractors and as a result it is obtained a reduced number of errors in the technological flux.

Conclusions

Using new modern technology of robotization and automation in construction major challenges in this sector can be developed. The other important issue in all these technology is that the buildings can be adaptive ones to the certain conditions of thermal zonation, seismic zonation and of course the architectural.

One of the most important results of the new modern methods based upon automation and robotization is to increase the strength properties of the erected buildings, reduce the time for construction, building materials saving, the possibility of mechanization and automation of technological processes. The buildings made in this way have the advantage of increase bearing capacity, stiffness and seismic stability. The modern technology offer the possibility to reduce the time of construction, to mechanize and automate work which determines good energetic efficiency for buildings and a diminution of CO_2 emissions. Based on the possibility of installing masonry with many layers, the technology increases the thermal efficiency of buildings which determines the effective use of the new technology in the future.

References:

Balaguer, C., Abderrahim M. (2008), Trends in Robotics and Automation in Construction Construction, Robotics and Automation in Construction. In Carlos Balaguer and Mohamed Abderrahim (Eds.), *InTech*. Retrieved from: http://www.intechopen.com/books/robotics_and_automation_in_construction/trends_in_robotics_and_automati on_in_construction.

Belyakova, T., Rogova, E., (2013). On the specific of formation and evaluation of Intellectual Capital in the Information Economy. In *Eurasia Business and Economics Society 2012 Anthology*. Retrieved from: http://www.ebesweb.org/Publications/EBES-Anthology/Archive/EBES-2012-Anthology.aspx.

Communication from the commission – Europe 2020. *A strategy for smart, sustainable and inclusive growth Europe 2020 Strategy*, Brussels, 3.3.2010, COM (2010) 2020 final. Retrieved from http://ec.europa.eu/ europe2020/documents/related-document-type/index_en.htm.

Dieter, H., Roppel P. (2013). The Effects of Thermal Bridging at Interface Conditions. *CTBU Research Paper*, issue IV. Retrieved from: http://www.ctbuh.org/LinkClick.aspx?fileticket=QTHEtdBy72I%3d&tabid=749&language=en-US.

European Commission (2014a). *Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions on Resource Efficiency opportunities in the Building Sector, Brussels, 1.7.2014, COM (2014) 445 final*. Retrieved from: http://ec.europa.eu/environment/eussd/pdf/ Sustainable BuildingsCommunication.pdf.

European Commission (2014b). *Key employment and social trends in the face of a long delayed and fragile recovery*. Retrieved from: http://ec.europa. eu/social/keyDocuments.jsp?advSearchKey=human+capital&mode=advancedSubmit&langId=en&policyArea=&type=0&country=0&year=0.

European Commission (2014c), *Key employment and social trends in the face of a long delayed and fragile recovery*, 2014. Retrieved from: http://ec. europa.eu/social/keyDocuments.jsp?advSearchKey=human+capital&mode=advancedSubmit&langId=en&policyArea=&type=0&country=0&year=0.

European Regional Development Fund (2014). *URBACT III, Operational Programme, CCI 2014TC16RFIR003*. Retrieved from: http://www.agentschapondernemen.be/sites/default/files/documenten/urbact_definitief.pdf.

European Union Regional Policy (2011). *Cities of Tomorrow: challenges, visions, ways forward*. Retrieved from: http://ec.europa.eu/regional _policy/sources/docgener/studies/pdf/citiesoftomorrow/citiesoftomorrow_final.pdf.

The Framework of the Hungarian Presidency of the Council of the European Union (2011), *The Impact of European Demographic Trends on Regional and Urban Development, Synthesis Report*, Budapest. Retrieved from: https://www.mir.gov.pl/rozwoj_regionalny/Polityka_regionalna/rozwoj_miast/rozwoj_miast_w_UE/Documents/Demography.pdf.

Global Construction 2025 (2013). A global forecast for the construction industry to 2025, London: Global Construction Perspectives and Oxford Economic, 1-11. Retrieved from: http://www.arcadis.com/Content/ArcadisGlobal/docs/publications/Research/Global_

Perspectives_2025_Exec_Summary.pdf.
Hardock, D., Roppel P. (2013). The Effects of Thermal Bridging at Interface Conditions. *CTBU Research Paper*, issue IV. Retrieved from: http://global.ctbuh.org/resources/papers/download/907-thermal-breaks-and-energy-performance-in-high-rise-concrete-balconies.pdf.
Herczeg M. et al., (2014). Resource efficiency in the building sector. Rotterdam: Ecorys and Copenhagen Resource Institute. REtrieved from: http://ec.europa.eu/environment/eussd/pdf/Resource%20efficiency%20in%20the%20building%20sector.pdf.
Jones Lang Lasalle (2013). *The new geography of office demand. 1. The Urban Tendency*. The Increasing Appeal of City Centers. Retrieved from: http://www.jll.co.uk/united-kingdom/en-gb/Research/JLL%20Urban%20Tendency%20Report.pdf.
JRC European Comission (2012). *Eurocode 8: Seismic Design of Buildings. Worked examples*. Retrieved from: http://eurocodes.jrc.ec.europa.eu/doc/WS_335/report/EC8_Seismic_Design_of_BuildingsWorked_examples.pdf.
Linner, T. (2013). *Automation and Robotic Construction: Integrated Automated Construction Sites*, Munchen: Technische Universitat Munchen. Retrieved from: http://d-nb.info/1037198409/34.
Mahbub, R. (2008). *An investigation into the barriers to the implementation of automation and robotics technologies in the construction industry*, School of Urban Development, Faculty of Built Environment and Engineering, Queensland: Queensland University of Technology. Retrieved from: http://eprints.qut.edu.au/26377/.
Mayo, A. (2006). *The Human Value of the Enterprise, Valuing PEOPLE as Assets. Monitoring, Measuring, Managing*, London: Nicholas Brealey International.
Penelis, G. G., Penelis, G. (2014). *Concrete Buildings in Seismic Regions*, Boca Raton, FL: CRC Press.
Totten, P. E., O'Brien, P. E., Sean M., Pazera, P. E., Marcin (2014). *The Effects of Thermal Bridging at Interface Conditions*. Retrieved from: http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/BEST/BEST1_034.pdf
United Nations Environment Programme (2014). *Sustainable Building and Construction*, Division of Technology, Industry and Economics, Singapore. Retrieved from: http://www.unep.org/10yfp/Portals/50150/downloads/Singapore%2010YFP%20Workshop%20Report-JSH.pdf.
Shimizu Corporation (2000). *The Tower Smart Application*. Retrieved from: http://www.shimz.co.jp/english/index.html.
U.S. Department of Energy (2008), *High performance and Sustainable Building Guidance*. Retrieved from: http://www.wbdg.org/pdfs/hpsb_guidance.pdf.
United Nations Indicators of Sustainable Development (2012). Retrieved from: https://sustainabledevelopment.un.org/index.php?menu=920.

Book review Info

Received: January 15 2015
Accepted: March 2 2015