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SCOPE AND AIMS

The review is concerned with a multi-disciplinary approach to spatial, regional and urban planning and architecture, as well as with various aspects of land use, including housing, environment and related themes and topics. It attempts to contribute to better theoretical understanding of a new spatial development processes and to improve the practice in the field.

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ADDRESS

Institute of Architecture and Urban & Spatial Planning of Serbia, IAUS
"Spatium"
Serbia, 11000 Belgrade, Bulevar kralja Aleksandra 73/II, tel: (381 11) 3370-091
fax: (381 11) 3370-203, e-mail: iaus@EUnet.rs, web address: www.iaus.ac.rs

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C O N T E N T S

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EDITORIAL

A new series of the international scientific journal SPATIUM has been launched. While this issue primarily covers a variety of topics that will be discussed at the International scientific conference „Regional development, spatial planning and strategic governance", to be organised by the Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) in December 2009 in Belgrade, Serbia, the following issues of the journal will be structured according to particular themes outlined in two or three year's editorial programme which will soon be communicated for collegial discussion.

Miodrag Vujošević
Jasna Petrić

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EVALUATION OF ENERGY EFFICIENCY MEASURES APPLIED IN PUBLIC BUILDINGS (SCHOOLS & HOSPITALS) IN SERBIA

Siniša Stanković [1], BDSP Partnership Ltd Summit House, London, UK
Neil Campbell, BDSP Partnership Ltd Summit House, London, UK
Duško Maksimović, BDSP (YU) d.o.o., Belgrade, Serbia
Tanja Cvjetković, BDSP (YU) d.o.o., Belgrade, Serbia

The Serbian Energy Efficiency Project 1 (SEEP1 – Design and Supervision Support for Implementation of the Energy Efficiency Improvements in Public Buildings in Serbia), funded by a credit from The World Bank, has involved the energy efficient refurbishment of 28 public buildings in Serbia (12 hospitals and 16 schools). The major goal of the project has been implementation of the energy efficiency improvements in public buildings in Serbia and the verification of the energy and cost savings as well as CO_2 emission reductions achieved through implementation of the energy efficiency measures. Significant energy consumption savings have been achieved for all refurbished buildings with annual savings in the range of 15% to 63% and an average of 40% over entire project. Associated annual CO_2 emission reductions vary between 15% to 64% with an average of 42%. The average specific space heating annual energy consumption for the hospitals monitored was ~339 kWh/m^2 and has been reduced down to ~205 kWh/m^2 after refurbishment. The average specific space heating annual energy consumption for the schools monitored was ~243 kWh/m^2 and has been reduced down to ~144 kWh/m^2 after refurbishment. The simple payback period (SPP) on investment across all buildings was found to be about 7.5 years. For hospitals, due to their 24/7 operation, the average SPP is 5.3 years and for schools is 12.8 years.

Key words: energy efficiency measures applications, buildings, energy consumption savings, CO_2 emission reduction, energy performance "before" and "after" monitoring and verification, simple payback period.

INTRODUCTION

Many schools and hospitals in Serbia are large energy consumers due to poor thermal characteristics of building fabric and inefficient heating equipment. For existing buildings, a set of energy efficiency measures was implemented to create environmentally friendly and energy conserving buildings while maintaining indoor thermal comfort. A joint venture (JV) between BDSP Partnership (London, UK), BDSP YU (Belgrade, Serbia) and Energoprojekt-Entel (Belgrade, Serbia) has been appointed by Serbian Energy Efficiency Agency (SEEA) to carry out energy efficiency improvements in public buildings across Serbia. This project lasted from 2005 to 2009. The objectives of this four-years project entitled Serbian Energy Efficiency Project 1 (SEEP 1) are listed below:

- Implementing energy saving measures on building envelope, heating system and interior lighting
- Increase in end-user satisfaction about energy efficiency and indoor comfort
- Awareness raising of the end users about energy efficiency and rational use of energy

This paper summarizes outcomes of SEEP 1 through energy and carbon savings as well as investment payback period. The results are presented in the following sections.

METHODOLOGY

Overview

A total of 12 hospitals and 16 schools in various regions of Serbia have participated in the project. Breakdown of participating public buildings with respect to region, space heated area, heating plant and fuel type is presented in *Table 1*. All calculations are based on floor heated area. For all refurbished buildings, a fuel source remained the same as before retrofit except for Maternity Hospital in Belgrade. The heavy fuel oil fired boiler has been substituted with that of natural gas. The boiler room refurbishment has not been the part of SEEP 1.

There are four buildings where selected energy efficiency measures have not been fully

[1] 27 Sale Place, London W2 1YR, UK
sinisa.stankovic@bdsp.com

implemented and scheduled to be completed during summer 2009. These buildings include Belgrade Maternity Hospital, 'Dušan Jerković' school in Užice and schools in Arilje and Kraljevo. However, some measures have been applied and post retrofit monitored data have been collected and presented in this report. No construction work has undertaken at school in Arilje; and thus, excluded from analysis. Finally, hospital in Kraljevo has been excluded from investigation due to time schedule conflict (*Table 1)*.

Energy Efficiency Measures

Applied energy efficient measures have been focused on improving thermal performance of building's fabric and heating system by installing air tighter windows and doors with lower U values, improving roofs and external walls insulation as well as installing more efficient mechanical systems and controls. It should be noted that installation of efficient lighting system has been done not to reduce overall energy consumption but to improve occupants' comfort via higher illuminance levels. Extensive list of selected energy efficiency measures per building is presented in *Table 2*.

These measures have been used as an input to a 3D thermal building energy simulation model and evaluated based on carbon-energy savings and SPP per building. Assessment has been done by JV team and sent to SEEA for approval. The optimum set of measures has not only been selected based on the shortest payback period and lowest carbon emissions but also on suggestions of building's end-users. These measures included works with minimal influence on undisturbed operation of a building, priority works *e.g.* windows replacement over that of boiler replacement or effective low time consuming retrofits to be finished before beginning of the heating season in order to start monitoring process.

Simulations ('Predicted performance') and measurements ('Measured performance') have been done for pre and post retrofit ('Before' and 'After') stage of a building. The results have been analyzed on comparative basis (*Table 2)*.

Figure 1 illustrates breakdown of total investment per implemented energy efficiency measure. Installation of new windows has been extensively used across virtually all buildings due to poor thermal performance of existing windows and cold air infiltration causing draughts near fenestration.

While investment costs of window replacement accounted for 84% of the total project budget, boiler replacement investment costs accounted for 0.4%.

Building Energy Modelling

Transient building energy simulation software –TAS has been used for building thermal analysis. A 3D geometry model and thermal properties of the building envelope have been defined along with thermal zones where occupancy schedule is considered to take into account heat gains from occupants. Weather files for selected locations have been used as input to annual simulation with time step of an hour.

Annual energy consumption, properly adjusted for the purpose, has been used for carbon emissions and SPP calculations. System efficiency and heat distribution losses have been also accounted in calculations.

It should be noted that SPP has been calculated as ratio between total investment cost of implemented measure and annual cost saving through reduced fuel consumption.

Experimental Setup

Energy consumption has been measured by energy flow meters installed in heating substations as depicted in *Figure 3*. Monitoring process has been conducted before and after retrofits for entire heating season (referred as annual in the paper) *i.e.* from November to March pending on weather conditions.

As depicted in *Figure 4*, indoor air temperature and humidity in a zone have been measured by a sensor. Measurements have been used to determine annual heating energy consumption, whether indoor set point conditions have been achieved or additional adjustments have been required *e.g.* regulation of TRV valves. These parameters have been measured before and after implementation of energy saving measures in buildings. Three zones per building have been selected for measurements. Sensors have been decommissioned and reused in other buildings, afterwards. Thus, two months of recorded data during heating season have been obtained. Measured energy consumption for these corresponding months have been extrapolated over the whole heating season and used for comparison analysis.

RESULTS AND DISCUSSION

Energy Savings

Comparison of averaged specific energy consumption measured before and after retrofit is depicted in *Figure 5*. While average measured energy consumption for post retrofitted hospitals and schools is *cca.* 205 kWh/m^2 and 144 kWh/m^2 respectively, monitored pre retrofit building's energy consumption is found to be 339 kWh/m^2 and 243 kWh/m^2. Energy consumption reduction of around 40% has been achieved by implementing selected energy efficiency measures. Higher energy consumption of hospitals compared to that of schools was due to higher indoor set point temperatures and around the clock business hours. Detail breakdown of energy conserving measures applied per building along with energy consumed before and after refurbishments is presented in Appendix A.

Figure 6 summarizes post retrofit total measured energy consumption over a heating season for all buildings and achieved savings. Amount of saved energy could cover heating needs of 15 refurbished schools for a 2 years period.

Figure 7 presents comparison of measured unit energy consumption before and after retrofit per building. While significant energy conservation in range of 45%-55% is achieved at hospitals in Aleksinac, Požarevac, Knjaževac, Prijepolje, the lowest energy savings by 17% is achieved in Valjevo hospital. Similar patterns are observed in schools. The school in Surdulica experienced the highest energy savings of cca.60%. Buildings located in cold mountainous regions of South-West Serbia have higher energy consumption than that in other parts of the country as can be concluded from *Figures 8* and *9*. *Figure 10* suggests that simulated and measured energy savings after implementation of energy efficiency measures are in excellent correlation.

Towards Serbian Energy Benchmarks

Presently, there are no detailed energy benchmarks available for Serbian schools and hospitals. The issue could be addressed in similar future projects by considering long term monitoring period and larger number of new/existing buildings. Therefore, obtained results should be used as a good trend indicator. Measured results for schools are compared with corresponding UK and Germany energy benchmarks as depicted in *Figure 11*. These measures could also be used as a part of operational energy ratings system that has been introduced to implement Energy Performance of Buildings Directive. They represent typical practice figures against which energy bills/metered data can be compared in order to assess performance on an A-G scale. It should be noted that UK and German figures are adjusted to account energy consumption for space heating only excluding electricity and heating for other purposes.

Carbon Emission Savings

Difference in average annual specific CO_2 emissions pre and post retrofit follow the same pattern as that of energy consumption. *Figure 12* indicates an average of 42% of carbon emission reductions for both schools and hospitals. Carbon emission savings are higher in hospitals than those in schools due to higher energy consumption savings.

Significant carbon emission reductions are achieved after retrofit and depicted in *Figure 13*. Amount of 4223t CO_2 is saved over a heating season for all buildings.

Figure 14 presents comparison of specific carbon emissions before and after retrofit per building. The savings are in the range of 20% to 50%. Carbon emissions are influenced by energy consumption and fuel type source. The highest CO_2 emission reductions from cca.175 kg/m^2 down to 100 kg/m^2 are achieved at Požarevac hospital. The hospital is heated by coal which has the highest CO_2 emission factor and has one of the highest energy consumption. Enhanced levels of carbon emissions are achieved at Belgrade Maternity Hospital due to substituting heavy fuel oil with natural gas fired boiler. For buildings with app. equal energy consumption, natural gas fired individual boilers yield lower CO_2 emissions then that of coal fired individual boilers due to lower carbon emission factors. In contrast, higher energy demanding buildings utilizing fuel oil/heavy fuel oil emit the app. the same amount of CO_2 as lower energy consuming building using coal as a heat source. Simulated and 'measured' carbon emissions savings are in excellent correlation as depicted in *Figure 15.*

Investment and Payback Period Analysis

Payback period for considered public buildings is depicted in *Figure 16*. While average SPP in hospitals is 5.3 years, SPP in schools is estimated to be *cca.* 12.8. On average, total investment for the entire project is to be paid off in 7.5 years.

Figure 17 indicates that unit investment in the building envelope upgrade is significantly higher than that of thermally improved mechanical system. The unit investment in building fabric improvements is the highest at Majdanpek school reaching *cca.*70 **€**/m^2 as opposed to that of Zajecar school with *cca.* 25 **€**/m^2. The most expensive retrofit of the heating system is found to be at Surdulica school and Priboj hospital. The average unit investment for hospitals is *cca.* 40 **€**/m^2 compared to that of schools with *cca.* 50 **€**/m^2.

Figure 18 depicts average unit window investment and difference in U value between replaced and new windows. The PVC windows have the best cost and U value improvement ratio.

CONCLUSIONS

Energy conserving measures implemented on building envelope and heating system in 28 retrofitted public buildings in Serbia have been analyzed and presented. Replacement of existing windows has been the most frequent measure applied into buildings. Significant energy and carbon emission savings of *cca.* 40% have been achieved. While measured average unit energy consumption for hospitals and schools has been found to be *cca.* 205 kWh/m^2 and 144 kWh/m^2 respectively "after" refurbishment, monitored energy consumption has been found to be 339 kWh/m^2 and 243 kWh/m^2 respectively "before" refurbishment. These results might be used to give an idication of energy performance and typical space heating energy benchmarks in Serbian schools and hospitals but further investigation is recommended. Carbon emissions are influenced by energy consumption and fuel type. The simple payback period on investment is found to be 5.3/12.8 years for hospitals/schools, respectively. For the entire project, the average payback period has been found to be 7.5 years. In most cases, depending on the financing options, we expect this SPP to be considered favourable.

Acknowledgement

Financial support for this work has been provided by The World Bank via Serbian Government.

Nomenclature

SEEA	*Serbian Energy Efficiency Agency*
SEEP	*Serbian Energy Efficiency Project*
SPP	*Simple Payback Period*
TRV	*Thermostatic radiator valves*
U	*Overall heat transfer coefficient (W/m^{2}K)*

References

The Chartered Institution of Building Services Engineers (CIBSE), 2008, Energy Benchmarks TM46, UK

EnEv (2007), Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden-Die Energieeinsparverordnung, Government of Germany, Germany

Table 1: Breakdown of buildings, regions, space heating area, heating plant and fuel type

(Note: Highlighted buildings were partially or not fully retrofitted)

GENERAL INFORMATION						
No.	Building Name	Town	Region	Area [m²]	Heating Plant	Fuel Type
1	Vranje Hospital	Vranje	S	2,075	Local	Fuel Oil
2	Senta Hospital	Senta	N	3,656	District	Heavy Fuel Oil
3	Aleksinac Hospital	Aleksinac	S	3,620	Local	Fuel Oil
4	Knjaževac Hospital	Knjazevac	S	5,780	Local	Fuel Oil
5	Leskovac School	Leskovac	S	1,216	District	Heavy Fuel Oil
6	Vranje School	Vranje	S	3,432	Local	Fuel Oil
7	Surdulica School	Surdulica	S	4,080	Local	Fuel Oil
8	Bačka Palanka School	Bačka Pal.	N	4,521	District	Natural Gas
9	Čonoplja School	Čonoplja	N	2,066	Local	Coal
10	Odžaci School	Odžaci	N	2,102	Local	Heavy Fuel Oil
11	Belgrade Maternity Hospital	Belgrade	C	20,000	Local	Natural Gas
12	Kladovo Hospital	Kladovo	E	4,810	District	Heavy Fuel Oil
13	Kraljevo Hospital	Kraljevo	C	1,840	Local	Natural Gas
14	Požarevac Hospital	Požarevac	E	4,770	District	Coal
15	Priboj Hospital	Priboj	SW	4,510	Local	Heavy Fuel Oil
16	Prijepolje Hospital	Prijepolje	SW	6,350	Local	Fuel Oil
17	Šabac Hospital	Šabac	W	2,926	Local	Natural Gas
18	Valjevo Hospital	Valjevo	W	9,240	Local	Coal
19	Arilje School	Arilje	SW	3,330	Local	Fuel Oil
20	Ivanjica School	Ivanjica	SW	4,740	Local	Wood
21	Kraljevo School	Kraljevo	C	3,996	Local	Coal
22	Majdanpek School	Majdanpek	E	3,256	District	Heavy Fuel Oil
23	Priboj School	Priboj	SW	4,140	District	Heavy Fuel Oil
24	Uljma School	Uljma	N	1,189	Individual rooms heating	Natural Gas
25	Užice "Stari Grad" School	Užice	SW	3,580	Local	Coal
26	Užice "Dušan Jerković" School	Užice	SW	3,896	Local	Coal
27	Višac School	Višac	N	2,542	Local	Natural Gas
28	Zaječar School	Zaječar	E	3,503	District	Heavy Fuel Oil

Table 2: Breakdown of energy efficiency measures implemented into buildings

(Note: Highlighted buildings were partially or not fully retrofitted)

No.	Building Name	Town	Implemented Measures
1	Vranje Hospital	Vranje	Thermal insulation of outside walls, windows and doors replacement on the south and west wing with stairs glazing replacement, variable flow pump installation, old radiator valves replacement with thermostatic ones and pipe insulation
2	Senta Hospital	Senta	Windows replacement, installation of heat exchanger and 3-port valve, installation of thermostatic valves on radiators, variable flow pumps installation and pipe insulation
3	Aleksinac Hospital	Aleksinac	Windows and doors replacement, burners replacement, 3-port valve installation, old radiator valves replacement with thermostatic ones and variable flow pumps installation
4	Knjaževac Hospital	Knjazevac	Windows and doors replacement, burners reparation, 3-port valve installation, old radiator valves replacement with thermostatic ones and old pumps replacement
5	Leskovac School	Leskovac	Windows and doors replacement, 3-port valve installation, old radiator valves replacement with thermostatic ones and variable flow pumps installation
6	Vranje School	Vranje	Roof insulation, windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pump installation
7	Surdulica School	Surdulica	Windows and doors replacement, boilers and burners replacement, variable flow pump installation, 3-port valve instalalltion, pipe insulation and old radiator valves replacement with thermostatic ones
8	Bačka Palanka School	Bačka Pal.	Windows and doors replacement, variable flow pump installation, pipe insulation, old radiator valves replacement with thermostatic ones
9	Čonoplja School	Čonoplja	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones
10	Odžaci School	Odžaci	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones
11	Belgrade Maternity Hospital	Belgrade	Windows and doors replacement
12	Kladovo Hospital	Kladovo	Windows and doors replacement, pipe insulation and old radiator valves replacement with thermostatic ones
13	Kraljevo Hospital	Kraljevo	Replacement of old radiator valves with the thermostatic valves and variable flow pumps installation
14	Požarevac Hospital	Požarevac	Roof insulation, outside windows and doors replacement,old radiator valves replacement with thermostatic ones and variable flow pumps installation
15	Priboj Hospital	Priboj	Reparation of existing windows, replacement of single pane glazing, installation of 3-port valve, burners replacement, old radiator valves replacement with thermostatic ones, variable flow pumps and water softener installation
16	Prijepolje Hospital	Prijepolje	Outside windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pumps installation
17	Šabac Hospital	Šabac	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones
18	Valjevo Hospital	Valjevo	Windows and doors replacement, replacement of old radiator valves with the thermostatic ones, by-pass valve installation
19	Arilje School	Arilje	
20	Ivanjica School	Ivanjica	Outside windows and doors replacement, old radiator valves replacement with thermostatic ones, pipe insulation and water softener installation
21	Kraljevo School	Kraljevo	Windows replacement and old radiator valves replacement with thermostatic ones
22	Majdanpek School	Majdanpek	Windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pumps installation
23	Priboj School	Priboj	Replacement of existing windows and doors, heat exchanger and pipe insulation and replacement of old radiator valves with thermostatic ones
24	Uljma School	Uljma	Windows and doors replacement, old radiator valves replacement with thermostatic ones
25	Užice "Stari Grad" School	Užice	Replacement of windows and doors, pipe insulation, replacement of old radiator valves with thermostatic ones and water softener installation
26	Užice "Dušan Jerković" School	Užice	Windows and doors replacement, old radiator valves replacement with thermostatic ones
27	Vršac School	Vršac	Replacement of windows and doors, variable flow pumps installation, pipe insulation and old radiator valves replacement with thermostatic ones
28	Zaječar School	Zaječar	Windows and doors replacement, pipe insulation and old radiator valves replacement with thermostatic ones

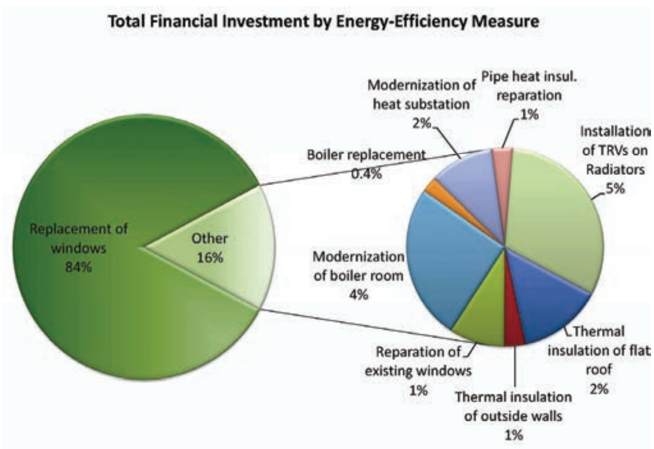

Figure 1: Total investment per implemented energy efficiency measure breakdown

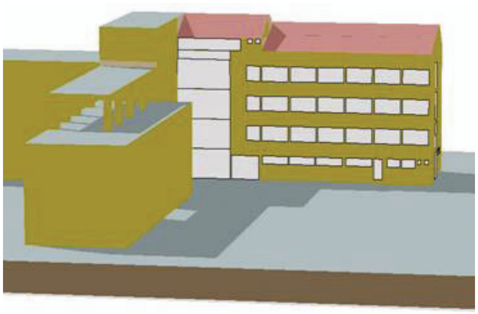

Figure 2: 3D thermal building model of Vranje Hospital

Figure 3: Photo of variable speed pump and heat flow meter in heating substation

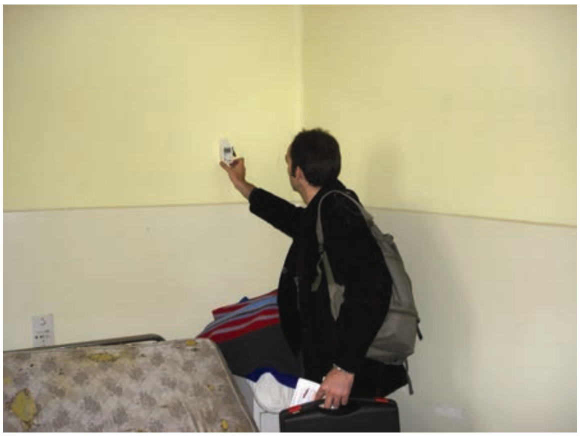

Figure 4: Photo of temperature and humidity sensor measurement

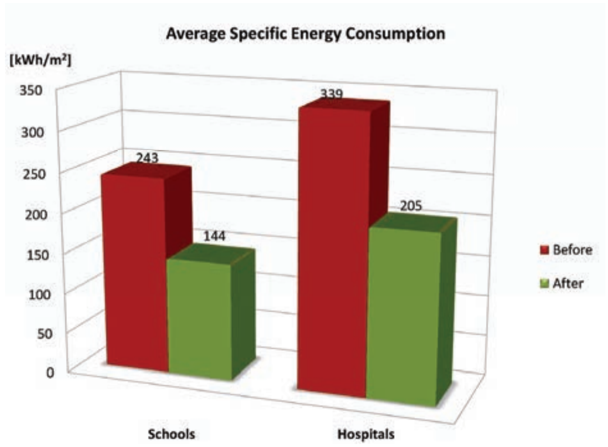

Figure 5: Comparison of average annual unit energy consumption before and after retrofit

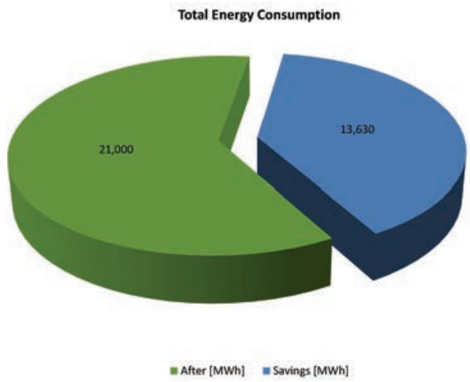

Figure 6: Total measured energy consumption and achieved savings after retrofit

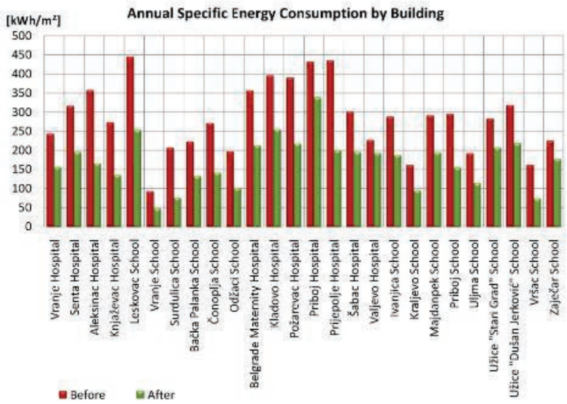

Figure 7: Comparison of measured unit energy consumption before and after retrofit breakdown

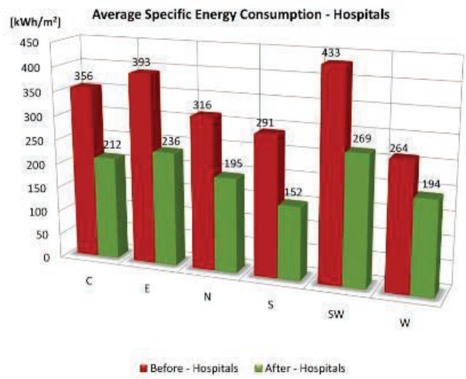

Figure 8: Average unit energy consumption in hospitals per region breakdown

(Note: C-Central, E-East, N-North, S-South, SW-South-West, W-West)

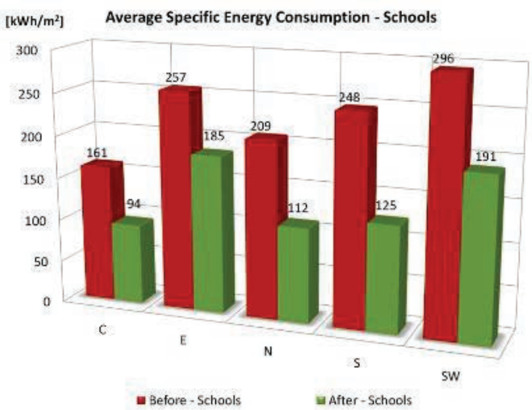

Figure 9: Average unit energy consumption in schools per region breakdown

(Note: C-Central, E-East, N-North, S-South, SW-South-West, W-West)

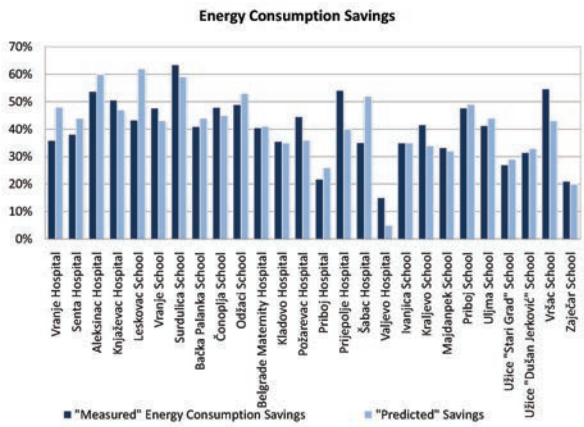

Figure 10: Comparison of measured and simulated energy consumption savings breakdown

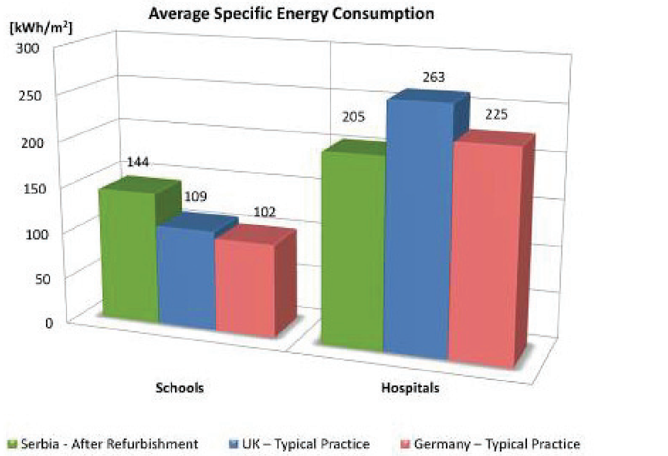

Figure 11: Comparison of building energy benchmarks in Serbia, UK and Germany (CIBSE TM 46, 2008), (EnEv, 2007)

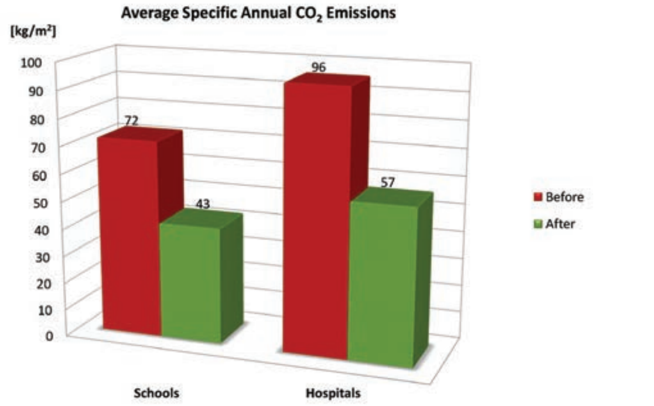

Figure 12: Comparison of average annual unit carbon emissions before and after retrofit

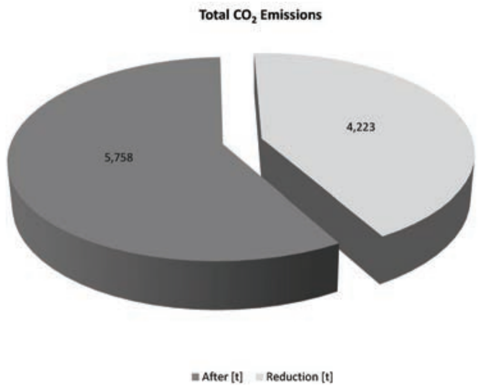

Figure 13: Total carbon emission and achieved savings after retrofit

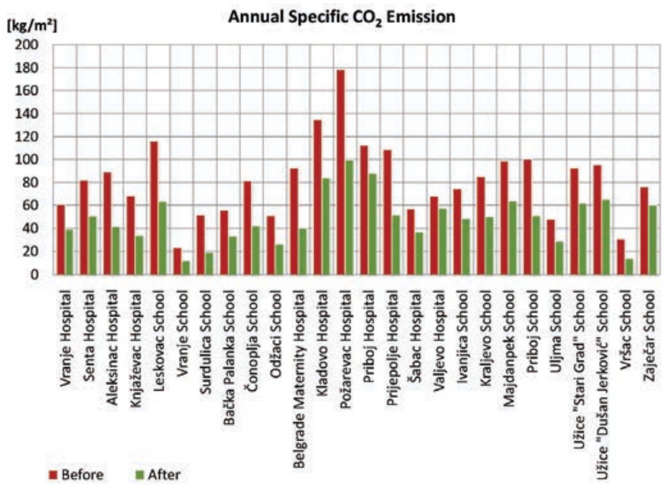

Figure 14: Comparison of unit carbon emissions before and after retrofit breakdown

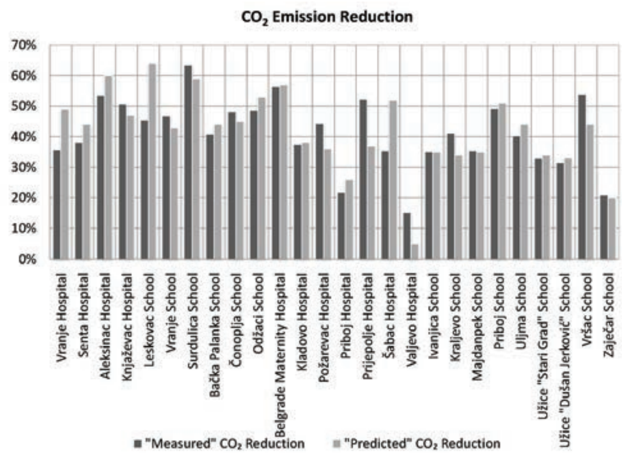

Figure 15: Comparison of measured and simulated carbon emission savings breakdown

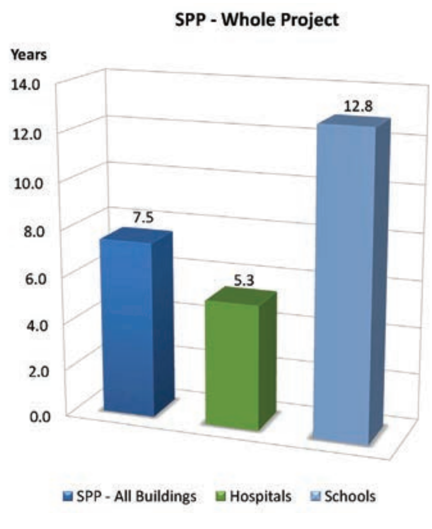

Figure 16: Simple payback period breakdown

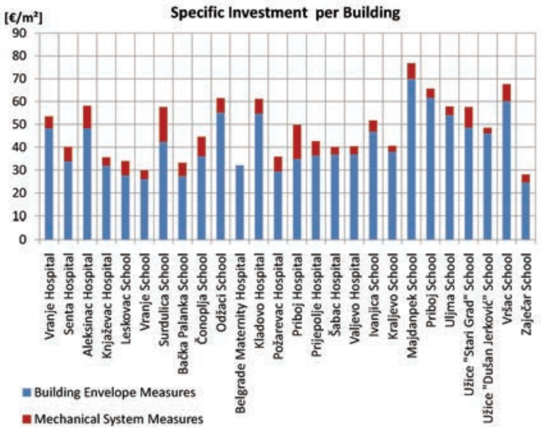

Figure 17: Unit investment of energy efficiency measures breakdown

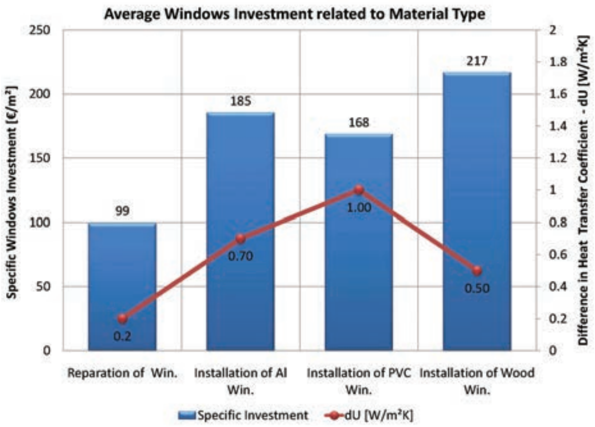

Figure 18: Average unit window investment and U value breakdown

APPENDIX A

Table A: Summary of applied energy efficiency measures and energy consumption

No.	Building Name	Town	Before [MWh]	Before [kWh/m^2]	Implemented Measures	After [MWh]	After [kWh/m^2]
1	Vranje Hospital	Vranje	504	243	Thermal insulation of outside walls, windows and doors replacement on the south and west wing with stairs glazing replacement, variable flow pump installation, old radiator valves replacement with thermostatic ones and pipe insulation	323	156
2	Senta Hospital	Senta	1,155	316	Windows replacement, installation of heat exchanger and 3-port valve, installation of thermostatic valves on radiators, variable flow pumps installation and pipe insulation	714	195
3	Aleksinac Hospital	Aleksinac	1,292	357	Windows and doors replacement, burners replacement, 3-port valve installation, old radiator valves replacement with thermostatic ones and variable flow pumps installation	598	165
4	Knjaževac Hospital	Knjazevac	1,578	273	Windows and doors replacement, burners reparation, 3-port valve installation, old radiator valves replacement with thermostatic ones and old pumps replacement	780	135
5	Leskovac School	Leskovac	541	445	Windows and doors replacement, 3-port valve installation, old radiator valves replacement with thermostatic ones and variable flow pumps installation	307	252
6	Vranje School	Vranje	317	92	Roof insulation, windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pump installation	166	48
7	Surdulica School	Surdulica	843	207	Windows and doors replacement, boilers and burners replacement, variable flow pump installation, 3-port valve instalaltion, pipe insulation and old radiator valves replacement with thermostatic ones	308	75
8	Bačka Palanka School	Bačka Pal.	1,008	223	Windows and doors replacement, variable flow pump installation, pipe insulation, old radiator valves replacement with thermostatic ones	596	132
9	Čonoplja School	Čonoplja	559	271	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones	291	141
10	Odžaci School	Odžaci	413	196	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones	211	100
11	Belgrade Maternity Hospital	Belgrade	7,125	356	Windows and doors replacement	4,246	212
12	Kladovo Hospital	Kladovo	1,902	395	Windows and doors replacement, pipe insulation and old radiator valves replacement with thermostatic ones	1,225	255
13	Kraljevo Hospital	Kraljevo			Replacement of old radiator valves with the thermostatic valves and variable flow pumps installation		
14	Požarevac Hospital	Požarevac	1,860	390	Roof insulation, outside windows and doors replacement,old radiator valves replacement with thermostatic ones and variable flow pumps installation	1,033	217
15	Priboj Hospital	Priboj	1,949	432	Reparation of existing windows, replacement of single pane glazing, installation of 3-port valve, burners replacement, old radiator valves replacement with thermostatic ones, variable flow pumps and water softener installation	1,525	338
16	Prijepolje Hospital	Prijepolje	2,760	435	Outside windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pumps installation	1,267	200
17	Šabac Hospital	Šabac	880	301	Windows and doors replacement, 3-port valve and variable flow pumps installation, old radiator valves replacement with thermostatic ones	571	195
18	Valjevo Hospital	Valjevo	2,093	227	Windows and doors replacement, replacement of old radiator valves with the thermostatic ones, by-pass valve installation	1,777	192
19	Arilje School	Arilje					
20	Ivanjica School	Ivanjica	1,363	288	Outside windows and doors replacement, old radiator valves replacement with thermostatic ones, pipe insulation and water softener installation	886	187
21	Kraljevo School	Kraljevo	645	161	Windows replacement and old radiator valves replacement with thermostatic ones	377	94
22	Majdanpek School	Majdanpek	946	291	Windows and doors replacement, old radiator valves replacement with thermostatic ones and variable flow pumps installation	631	194
23	Priboj School	Priboj	1,221	295	Replacement of existing windows and doors, heat exchanger and pipe insulation and replacement of old radiator valves with thermostatic ones	639	154
24	Uljma School	Uljma	228	192	Windows and doors replacement, old radiator valves replacement with thermostatic ones	134	113
25	Užice "Stari Grad" School	Užice	1,013	283	Replacement of windows and doors, pipe insulation, replacement of old radiator valves with thermostatic ones and water softener installation	740	207
26	Užice "Dušan Jerković" School	Užice	1,238	318	Windows and doors replacement, old radiator valves replacement with thermostatic ones	848	218
27	Vršac School	Vršac	412	162	Replacement of windows and doors, variable flow pumps installation, pipe insulation and old radiator valves replacement with thermostatic ones	187	74
28	Zaječar School	Zaječar	785	224	Windows and doors replacement, pipe insulation and old radiator valves replacement with thermostatic ones	620	177

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Review paper

POTENTIAL SOLAR ENERGY USE IN A RESIDENTIAL DISTRICT IN NIŠ

Sanja Stevanović[1], University of Novi Pazar, Department of Arts, Niš, Serbia
Mila Pucar, Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia
Vesna Kosorić, SEEEA Ltd, Belgrade, Serbia

Serbia is a suitable place for solar energy exploitation with more than 2000 sunny hours per year over 80% of its territory. In the paper, the existing state is analyzed and the possibilities of solar energy use are examined by employing a combined approach. This relies on the following elements: an attached conservatory with remote heat storage for space heating in the period October-April; a canopy covered by flexible organic photovoltaic modules for electricity production in the period May-September, and a solar water heating system throughout the year. In addition to an analysis of energy performance of the proposed design solution, its economic aspect is also discussed, which suggests that investing in energy efficiency projects should be encouraged provided the state adopts an appropriate system of subsidies for the use of renewable energy sources.

Key words: Solar energy; attached conservatory; photovoltaic canopy; solar water heating system; family houses; case study.

INTRODUCTION

There is a common opinion in Serbia that "energy is not a trade good, but a tool for maintaining the population's economic status" (TE Nikola Tesla, 2009). This has a negative effect on the public's awareness of the need for increased energy efficiency. As a result, the current situation can be summarized as follows (Build Magazine, 2008):

- utilization of resources is extremely uneconomical;
- energy and transport systems are outdated;
- use of renewable energy sources and the application of energy efficiency principles are negligible, as the low price of electricity deters investment in energy efficiency projects.

The image of a typical facade from the 1960's and 1970's (Figure 1) best illustrates the condition of the majority of (multi-storey) buildings today.

The measures that have so far been undertaken by the state in order to enhance energy efficiency have proven to be insufficient and have not led to satisfactory results: there is, still, no adequate legislation, nor are there subsidies or supporting measures for projects in the field of energy efficiency. Consequently, the public is not sufficiently acquainted with all the advantages of energy efficient buildings and renewable energy sources. Over the last decade, a number of homeowners have invested in improved external insulation of their properties. Unfortunately, more frequently than not, these are only naive and partial attempts at solving a much bigger problem. Rare are those homeowners who decide to restore thermal bridges or replace the existing windows, doors and fittings in their homes.

The aim of this paper is to estimate the energy gain and cost-effectiveness that could result from the use of solar energy. To this end, a combined approach is employed, which relies on the following design solutions: an attached conservatory for additional heating of space in

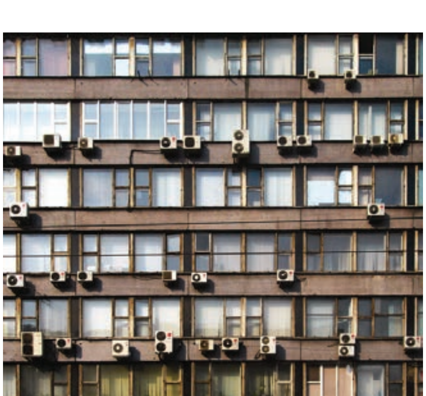

Figure 1. The facade of a multi-storey building from the 1960-80 period

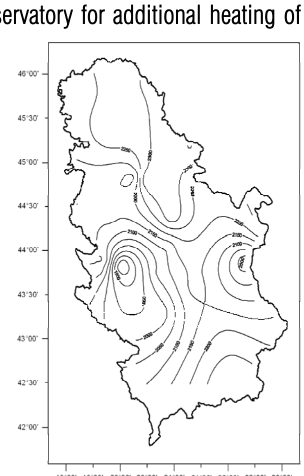

Figure 2. The annual number of sunlight hours in Serbia (Hydro-Meteorological Agency of the Republic of Serbia, 2009)

[1] Bulevar Cara Konstantina 80-86, 18000 Niš, Serbia
sanja_stevanovic@yahoo.com

winter, and a photovoltaic canopy on the conservatory roof for generating electricity in summer. The use of a solar water heating system throughout the year is also discussed as a possibility.

In this case study, an existing family house is analyzed, and the possibility of attaching a conservatory with a photovoltaic canopy is considered, along with the integration of solar thermal collectors. After the house structure, the location and functional arrangement of space are examined, and it is proposed to rearrange the rooms in the house, attaching a conservatory with a photovoltaic canopy, and integration of a solar water heating system. Energy gain is calculated for each component of the proposal; the conservatory is observed for the period October-April; the photovoltaic canopy for the period May-September, and the solar water heating system for the entire year. The economic aspects are also discussed, such as the cost-effectiveness of the attached conservatory, the photovoltaic canopy, and the installed solar water heating system, while taking into account the current price of electricity.

CLIMATE AND LOCATION

Climate

A clear division between four seasons characterizes the climate in Serbia. The winters are long and cold, and the summers are dry and hot. There are more than 2,000 sunny hours over 80% of the entire territory (Figure 2). For this reason, the majority of energy in residential buildings is consumed for heating in winter, and a somewhat lower amount for cooling in summer. As the number of sunlight hours during winter is not small, Serbia is a convenient environment for the application of techniques of passive solar architecture.

The house and its location

The analyzed house is one in the northern line of houses between Đerdapska and Ktitor streets in Duvanište district in Niš. The houses are mainly residential buildings, with some office space, consisting of ground floor, first floor and attic. They were built in the period 1995-2000, at a 13º angle westwards relative to the south (Figure 3 and 4). Their foundation is laid on flat terrain surrounded mainly by greenery and hedges. The streets are two-way asphalt streets with pavements. Between the northern and the southern line of houses, there is a concrete paved pedestrian zone with lamp posts in the middle. There are no paths for cyclists. During winter, the southern house line is not in the shade, and the wind usually blows from the north-east.

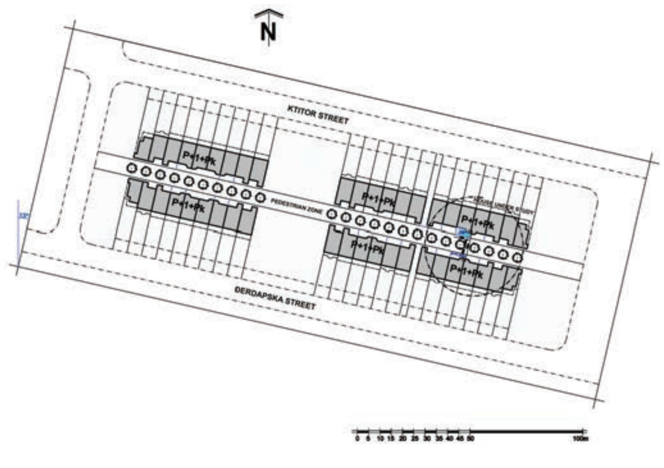

Figure 3. Orientation of the houses in Duvanište district in Niš

Figure 4. The orthophoto image of the houses in Duvanište district in Niš (source http://gis.ni.rs).

FUNCTIONAL ORGANIZATION OF SPACE

The ground floor of the houses is used as an office space; the first floor comprises a living room, a kitchen and a dining room, while the bedrooms are located in the attic. The existing arrangement of space by level is given in figures 5a, 6a, and 7a.

The first floor of the houses in the southern line has its living room orientated to the south-west, and the staircase and the kitchen facing the north-east. The southern line is the mirror image of the northern house line, where the living room is in the north-east and the staircase and the kitchen in the south-west. As a first measure of passive solar architecture, a change in space function is proposed for houses in the northern line that involves switching the locations of the rooms on the first floor: the living room takes the place of the kitchen and the staircase, thus referencing its position to the south to provide more sunlight. Provided a conservatory is attached, and the balcony doors on the first floor are open towards the conservatory, the sun-lit living room will also seem lighter and its overall aesthetics improve. In addition, the living room is now acoustically more comfortable. On one side, it faces the more quiet pedestrian area and, on the other, the conservatory functions as an acoustic barrier. The proposed rearrangement of space, together with the attached conservatory is presented in Figure 6b. As can be seen, particular care was taken to avoid unnecessary dismantling and to preserve as many walls as possible.

The proposed reconstruction is based on two possibilities, each of which supports a different functional scheme: change inside the existing space and change by attaching a new volume, i.e. a conservatory (Krstić-Furundžić, 1997).

Aspects of form

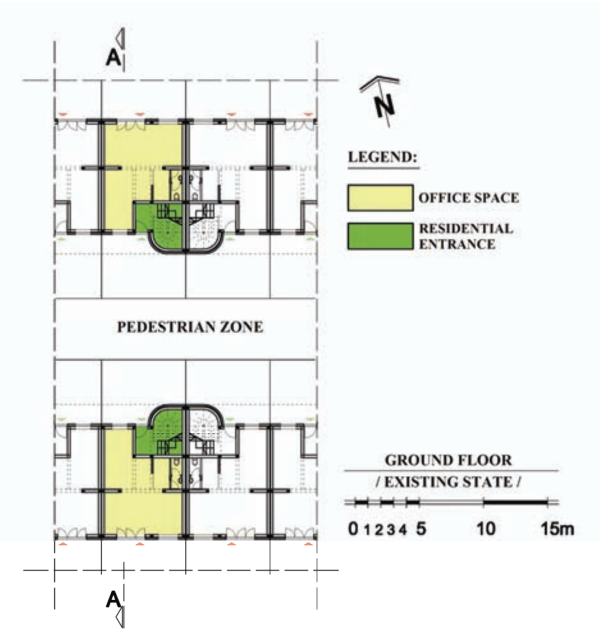

Figure 5a. The existing ground floor

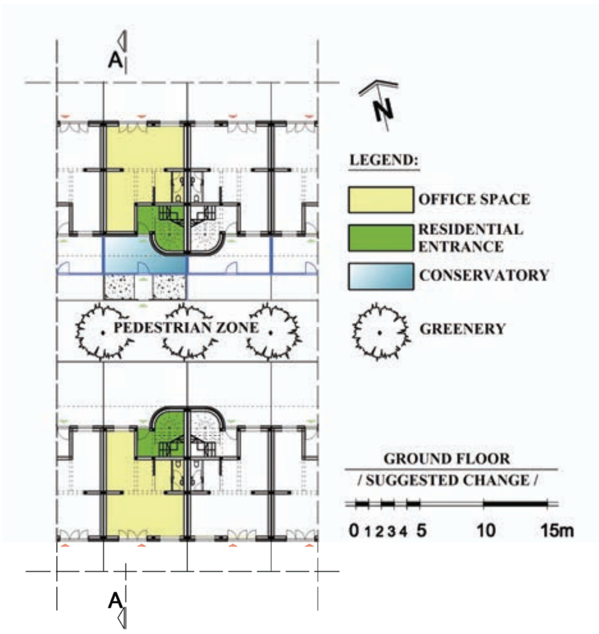

Figure 5b. The reconstructed ground floor, with the attached conservatory

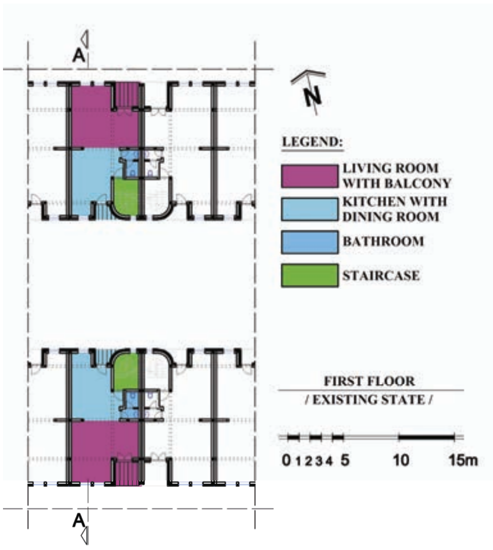

Figure 6a. The existing first floor

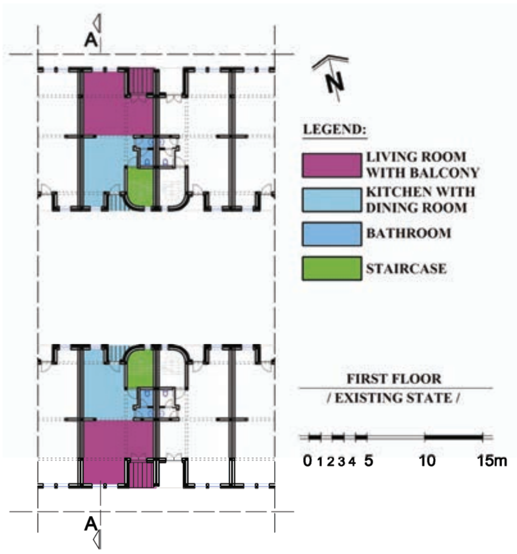

Figure 6b. The first floor with the attached conservatory

Figure 7a. The existing attic

Figure 7b. The attic with the attached conservatory

PROPOSED SOLAR ARCHITECTURE MEASURES: THE PASSIVE AND ACTIVE APPROACH

One of the basic principles of designing energy efficient facilities is the passive use of solar energy (Pucar, 2006). To apply this principle to the houses discussed herein, the balcony of the southern line house can be glass-paned, and a conservatory can be attached to the house in the northern line. Irrespective of the house location, solar thermal collectors can be installed in the south-west pitch of the roof. The proposed solutions are given in Figure 8.

The glass-paned balcony in the southern house line

A conservatory attached to the house in the southern line is not a practical solution, as the entry to the office space is south-oriented. The glass-paned balcony on the first floor captures solar energy, which is used for heating the living area (living room, kitchen, dining room). It turns into a useful space throughout the year, even in late autumn and early spring when outside temperatures are still low. It also functions as an extension of the living room and, due to the glass panes, improves the aesthetics of both the exterior and the interior.

Glass panes should be as neutral as possible, so as not to significantly affect the appearance of the facade. In this respect, wide glass doors are the preferred choice. When wide open, they allow the balcony to regain its primary function and prevent the overheating of space. In addition, the glass-paned balcony reduces the area of the house envelope, as well as transmission and ventilation loss, thereby improving the house's efficacy and resolving the problem of cold bridges. The acoustic comfort of the house is also enhanced, as the balcony functions as a sound insulation space.

A further proposed measure implies planting short deciduous trees in the grounds to the south of the house. Leaves reduce heat in summer and their absence on branches in winter allows sunlight to enter the space, contributing to the solar gain. It has been estimated that deciduous trees planted in the southern and western grounds can lower electricity consumption in summer by up to 5% (Donovan, Butry, 2009). While deciding on tree sorts, it is necessary to select those that can be grown in urban areas and are at most 7m high.

The tree height is relevant, if the shading of the photovoltaic canopy, and solar energy collectors installed in the upper roof part is to be avoided and their malfunctioning prevented. The appropriate tree types include the apricot tree (Prunus armeniaca), cornel (Cornus mas), hazel tree (Corylus avellana), Japanese maple (Acer palmatum), whitebeam (Sorbus aria), etc.

The attached conservatory in the northern house line

The conservatory attached to the house in the northern line contributes to reduced heat loss, better energy performance and higher energy efficiency, as collected solar energy is directly transmitted into the space. The conservatory is so designed as to represent a link between the living area and the natural ambiance. It is attached to the southern facade and is erected to the level of the roof crown, so the impression created is of the conservatory roof as an extension of the house roof. The distance from the southern facade is large enough to

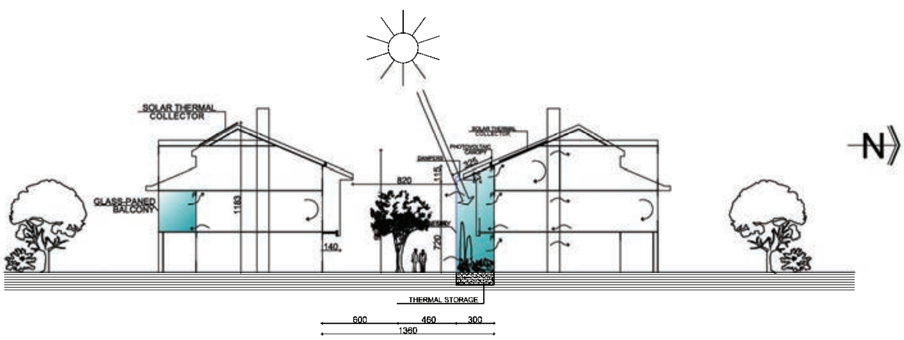

Figure 8. The cross-section of houses with glass-paned balconies, attached conservatories and installed solar thermal collectors in the roof

provide sunlight to the conservatory surface area and the windows in winter months. Functionally, the space of the conservatory directly attached to the living area is the space of the balcony on the first floor, which makes it convenient for use in late autumn and early spring, as well as on sunny winter days. The useful space of the living area is enlarged in this way. Moreover, the exterior structure of the conservatory is significantly distant from the balcony that when one is on the balcony, one gets the impression of a larger open space, than when one is on a glass-paned balcony alone, with no surrounding conservatory. The garden inside the conservatory can also be used during the low-temperature period, but as it is functionally detached from the living room by the staircase and the entry hall, it is reasonable to expect that more time will be spent on the balcony inside the conservatory.

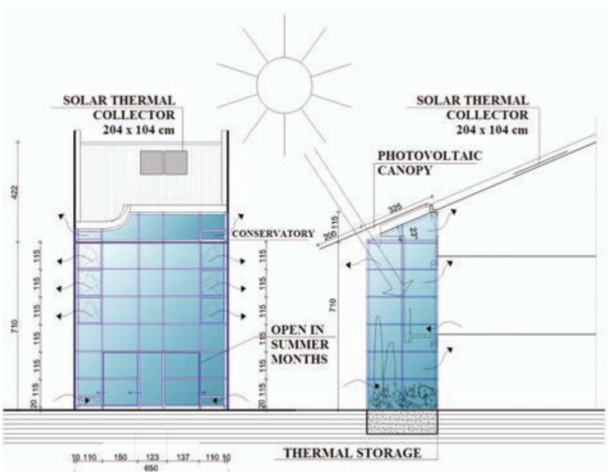

Figure 9. The conservatory

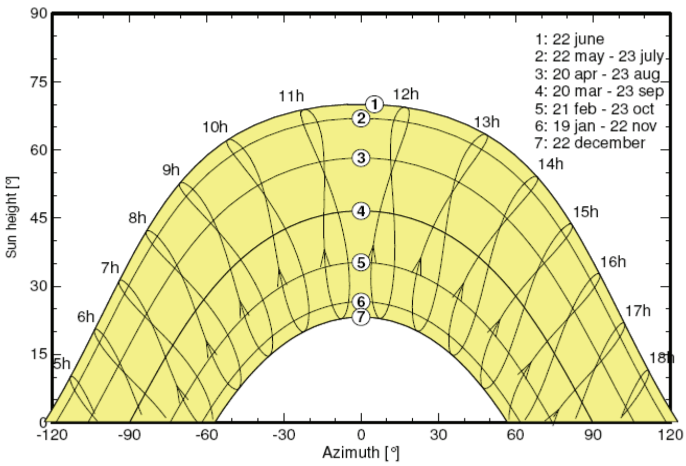

Figure 10. The Sun path in Niš (source: PVSYST v. 4.37 softwar

Table 1: Thermal mass- dimensions and characteristics

Accumulation element	House Walls	Balcony	Total
Material	brick	concrete	
Density (kg/m^3)	1700	2300	
Thickness (m)	0.08	0.12	
Exposed area (m^2)	47.56	4.30	51.86
Exposed mass (kg)	6468.16	1186.8	7654.96
Specific heating capacity (J/kgK)	0.20	0.29	
Heating capacity (J/m^{3}K)	1293.63	344.17	1637.80

The attached conservatory, as a transparent addition to the existing house volume, makes the southern facade of the house visually lighter and brighter, whilst at the same time increasing the dynamics of the south-western façade, due to the various hues of shadows cast by trees planted in front of the conservatory, and the reflection of light inside the conservatory in daytime.

As can be seen from the cross-sections of the conservatory (Figures 8 and 9) and the Sun path in Niš (Figure 10), the grounds are not sunlit in the period October 23-February 21. For this reason, the primary thermal mass of the conservatory should consist of the house walls and the balcony on the first floor (Table 1). The house walls are composed of a mortar layer, a 12 cm thick brick layer, a 6 cm thick mineral wool layer, a 20 cm thick gitter panel, and an additional layer of mortar. The balcony is made of 12 cm thick fortified concrete panels and is paved with terrazzo. For the estimate of the heating capacity of the primary thermal mass, it is assumed that the effective thickness of the brick is 8 cm and that of concrete and terrazzo 12 cm (Pucar, 2006).

As the area of the southern glass-paned (collector) surface of the conservatory is 67.92m^2, the heating capacity of the available primary thermal mass is sufficient for up to 10% of the heating needs of the house. The low accumulation capacity of the primary thermal mass, as well as the fact that a thermal insulation layer behind the bricks is an additional obstacle to convection of heat into the secondary thermal mass, will result in a quick overheating of the conservatory on sunny days and a high fluctuation between day and night temperatures. For this reason, the conservatory should primarily be used as a solar collector, allowing the major part of heat to be transferred into the inside space. In case extra heat is needed inside the house, the balcony doors and bedroom windows in the attic are opened. If the conservatory should be isolated from the house, the balcony doors and bedroom windows can be shut. As the glass in the balcony doors and windows is heat-insulated, it acts as a thermal barrier between the conservatory and the rest of the house.

In order to increase the conservatory efficiency and to lower indoor temperature fluctuations, a heat storage should be constructed and placed in the conservatory under the garden. This allows an extra amount of heat, generated in daytime, to be stored and used during the night or on days with insufficient sunlight. Warm air circulating in the conservatory is collected in the channels, and by means of a fan, is conducted into the stone-layered thermal storage. The storage is designed as a structured pile made of graded stone, primarily shingle, 3-10 cm in size. The storage is heat- and hydro-insulated on all its sides, except for the bottom which is covered with a concrete panel. In order to raise the level of heat accumulation in the storage, warm air from the conservatory should be led through the system of drainpipes dug in the shingle layer and evenly spread throughout the storage.

Warm air is transferred from the conservatory to the shingled storage by thermostatically controlled fans and air channels. When night temperature is below the temperature of the shingled storage, recirculation is activated automatically, and the fan is turned off. The heat is released inside the conservatory by passive radiation convection from the concrete panel on the ground. Warm air rising from the storage maintains the conservatory temperature during the night, reducing temperature oscillations. When extra heat is needed, warm air from the shingle pile can circulate upon reactivation of the fan, thereby providing neighboring rooms with a higher percentage of heat from the storage.

The conservatory's energy performance is highly dependent on the properties of glass. These include total transmissivity, which is the percentage of sunlight transmitted into the conservatory, and the U-value, which is heat transmission per area unit that determines the amount of heat passing from the warmer conservatory to the cooler areas through glass walls. Naturally, the best combination is high transmissivity and low heat transmission. One example from Western Europe consists of a 4mm thick external glass pane, a 16mm space 90% filled with argon, and a 6mm K Glass internal pane of a 78% total transmissivity, and 1.5W/m^{2}K U-value (*see Notes 1*). However, this glass type is not available on the Serbian market, and data about available products are difficult to obtain. One Serbian product offers heat insulated low-E glass of 4-15-4 type, with the space filled with dry air (dew point of -30°C), and with the properties comparable to the type mentioned above i.e.: 73% total transmissivity, 1.42W/m^{2}K U-value (*see Notes 2*). The price of this glass (including VAT) is approximately 33**€**/m^2, which means that the cost of the overall glass area of the conservatory of 103.08m^2 would be slightly below 3400**€**, excluding the costs of transportation and installation.

System for prevention of overheating

For the prevention of overheating in the period May-September, a UV protected roll-on canopy is installed that covers the entire roof surface of the conservatory. It has a 2m overhang down the vertical wall, and is positioned as high as the trees. This provides shading to the vertical south-west surface of the conservatory during summer. Between the canopy and the conservatory roof, there is a 30cm empty space to allow free air circulation. Fresh air is supplied to the conservatory through the external door and dampers at the bottom, while warm air is conducted away through the dampers on top of the conservatory.

To maximize the use of solar energy in the period May-September, when sunlight is most intense, the canopy is covered with organic photovoltaic modules of the third generation technology based on photo-reactive polymer. These modules are composed of several layers: flexible plastic substrate, primary electrode, photo-reactive printed material, transparent electrode, and transparent protective packaging (see Notes 3).

Due to the flexibility of this type of material, the conservatory can make use of solar energy at any time. In the period October-April, the canopy can be rolled up to allow generation of thermal energy inside the conservatory. When unrolled, the canopy dims the inside of the conservatory, and electrical energy is produced that is directly distributed to the electric grid.

As these photovoltaic modules are made of conductive organic polymers, they weigh only 0.9kg/m^2. This means that the system installed on the conservatory roof will contribute an additional 31 kg (excluding the canopy weight). The power of the solar cells is 16.7Wp/m^2. The main disadvantage of this photovoltaic technology is its considerably lower efficiency, compared to that of the first and second generation photovoltaic modules based on silicon cells, cadmium-indium-selenium cells or cadmium-tellurium cells. The advantages include the possibility of rolling up/down the flexible photovoltaic canopy and its relatively low end price. It is expected that within a few years photovoltaic modules of the third generation will have a higher efficacy and lower price (Green, 2003).

Installation of a solar water heating system

For the purpose of water heating, a solar water heating system is installed that consists of solar thermal collectors, a tank of 300l volume, an electric water heater, and the attendant devices (Figure 11). Two solar thermal collectors, 2040 mm x 1040 mm in size, are integrated in the south pitch of the roof, at a 23° angle parallel to the roof pitch (Figure 9).

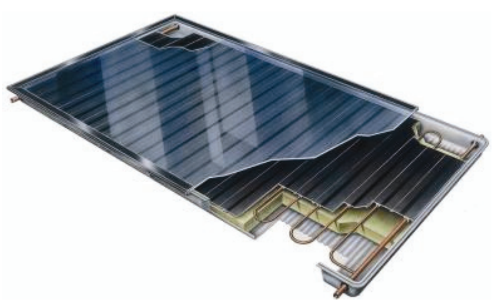

Figure 11. Solar thermal collector (see Notes 4)

ANALYSIS OF SHADOWS

An analysis was carried out regarding the position of shadows that fall onto the northern line of houses, where the conservatories were attached. In this article, a presentation is given for the 22nd December, when the Sun is the lowest on the horizon. At the same time, this is the most unfavorable day in the year, when the level of shadowing of the conservatory is the highest. Almost half of the glass-paned vertical surface of the conservatory is in the shade during most of the day, while the slanting parts of the conservatory onto which the photovoltaic canopy is installed are sunlit during the greater part of the day. Only at 15h, they are in the shade (Figure 12, 13, 14). Part of the roofs in which solar thermal collectors have been placed are sunlit throughout the day. Around 16h the sun already sets, which is evident on the diagrams (Figure 10).

In this work, it is interesting to illustrate the shadow positions on the 21st March and 23rd September at 17h. Based on the analyses illustrated in the figures 15 and 16, it can be concluded that the vertical surfaces of the conservatory are sunlit almost throughout the entire day. Only at 17h, on the 23rd September, the greater part of the vertical surfaces are in shadow, while on the slanting

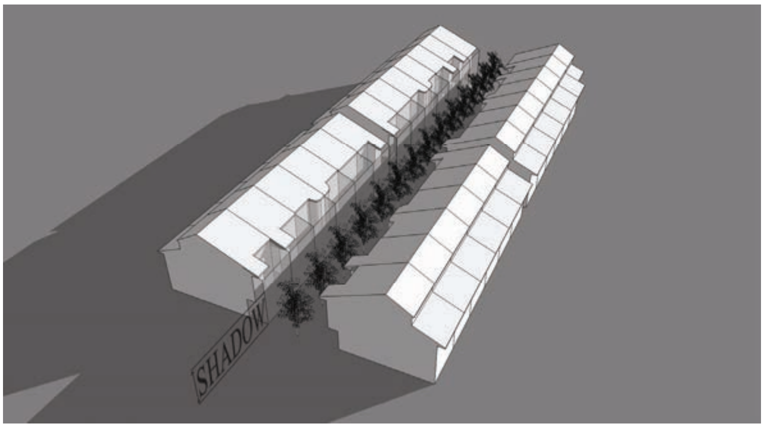

Figure 12. Position of shadow on the 22nd December at 9:00h

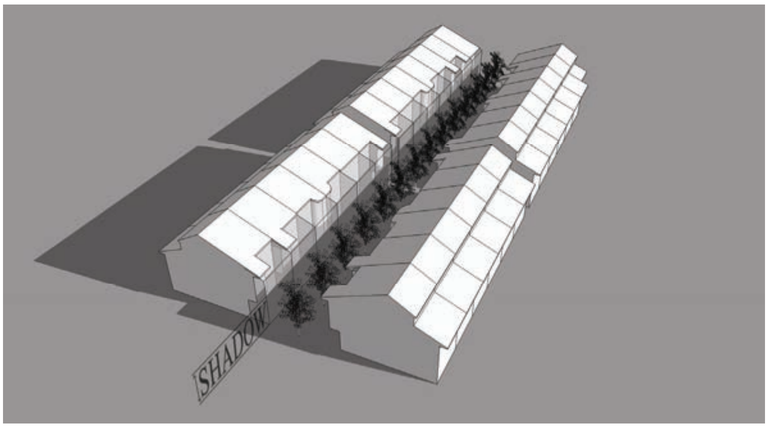

Figure 13. Position of shadow on the 22nd December at 12:00 p.m.

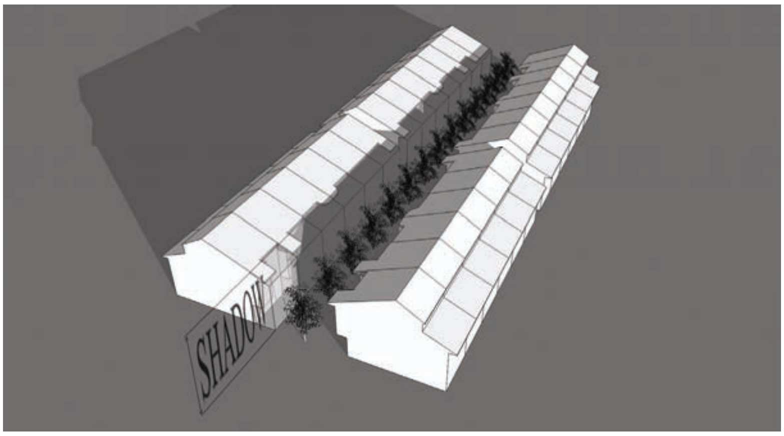

Figure 14. Position of shadow on the 22nd December at 15:00h

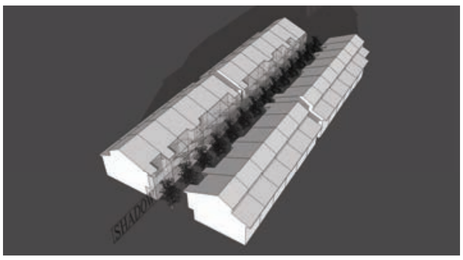

Figure 15.Position of shadow on the 21st March at 17h

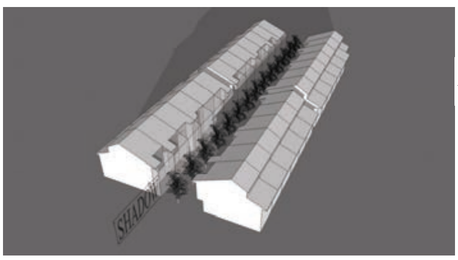

Figure 16. Position of shadow on the 23rd September at 17h

surfaces of the conservatory and on the roof of the house there are no shadows.

In the program PVSYST v.4.37, which has been used in this work, the given values have been calculated for the current situation – orientation and spatial organization.

ENERGY GAIN FOR THE CONSERVATORY IN THE PERIOD OCTOBER-APRIL

The amount of collected solar energy on the various conservatory surface areas by month is shown in Figure 17. The following surface areas are taken into account:

H = solar energy collected on the horizontal surface

K = solar energy collected on the southwest surface (193°) at inclination (23°)

J = solar energy collected on the southwest (193°) vertical surface

I = solar energy collected on the southeast (103°) vertical surface

Z = solar energy collected on the northwest (283°) vertical surface

The energy of solar radiation on the horizontal surface was measured at Davis Automatic Meteorological Unit of the Laboratory for Solar Energy, Faculty of Science, University of Niš, every 10 minutes during the year 2008. As the September of 2008 was exceptionally cloudy for Niš, the amounts for this month were smaller than expected.

The size of the respective surface areas of the conservatory are as follows:

$PK = 21.125\ m^2$, $PJ = 46.80\ m^2$, $PI = 11.70\ m^2$, $PZ = 23.45\ m^2$

Energy gain by month inside the conservatory is the sum of all individual energy gains for each characteristic surface area of the conservatory (K, J, I and Z) represented as the product of their areas (m^2), solar energy collected on them by month, and glass transmissivity, according to the formula:

$$E = (\sum_{\text{on conservatory surface}} \text{P } x \text{ collected energy}) \, x \text{ glass transmissivity} \quad (1)$$

For glass transmissivity, the value of insulated low-E glass used was 73% (0.73). The values of energy gain by month in the conservatory are given in Table 2. Total energy gain in the conservatory for the period October-April is 29.39 MWh.

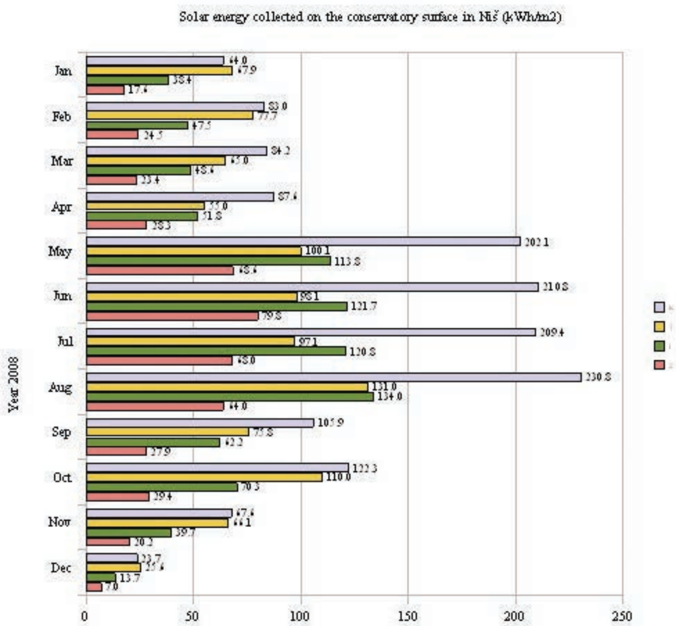

Figure 17. Solar energy collected on the conservatory surface area (K, J, I and Z)

Table 2. Energy gains by month in the conservatory (kWh).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
3 933	4 758	4 335	4 156	8 682	9 006	8 744	10 274	5 230	6 748	3 985	1 478

Table 3. Energy gain for the photovoltaic canopy

	PVWatts (kWh)	Approximate estimate (kWh)
Jan	33.42	36.46
Feb	46.11	47.30
Mar	51.67	47.98
Apr	47.66	49.92
May	108.60	115.19
Jun	113.52	120.13
Jul	112.49	119.36
Aug	119.88	131.54
Sep	54.37	60.33
Oct	70.69	69.71
Nov	41.67	38.54
Dec	10.28	13.53
Annual	810.34	850.00

ENERGY GAIN FOR THE PHOTOVOLTAIC CANOPY FOR THE PERIOD MAY-SEPTEMBER

When unfolded, the canopy has the area of 6.5m x 5.25m = 34.125m^2. Therefore, output power of the photovoltaic canopy is Pmax = 34.125 m^2 x 16.7Wp/ m^2 ≈ 0.57 kWp.

As shown in Table 3, in the column „PVWatts“, the software PVWatts Version 1 (PVWatts, 2009; Mennicucci, 1986) was used for the first calculation of the canopy energy gain. For the approximate calculation of energy gain, a simple formula was applied:

$$E = \frac{\text{collected energy x Pmax}}{1000} \quad (2)$$

where Pmax = 0.57kWp, and collected energy is the monthly collected energy on the surface inside the pitch of the roof for the year 2008 (K in Figure 17).

Both calculations of energy gain give similar results, so it can be expected that the photovoltaic canopy during May-September will generate 500-550 kWh of electrical energy. The average monthly consumption of electrical energy was 390.2 kWh in Serbian households in 2008 (Serbian Electric Power Industry, 2009), so it is anticipated that the energy output by photovoltaic canopy would provide about 25% of the electricity consumed in households over the same period.

ENERGY GAIN OF THE SOLAR WATER HEATING SYSTEM

Computer simulations were done using Polysun 4.3 software under the assumption that a four-member family consumes a daily average of 200l of hot water at 45 C°. Based on the obtained simulations, it can be concluded that the proposed solar water heating system has the potential to meet fully their needs for hot water in the period May-September. Of the average annual needs for hot water 80% are met by using the solar thermal system, and the lowest monthly percentage (approx 30%) is recorded in January and February. A total of 2,317.9 kWh of thermal energy can be generated annually. In Figure 18, the ratio is presented between the monthly generation of thermal energy by the solar system and the energy used for water heating per household.

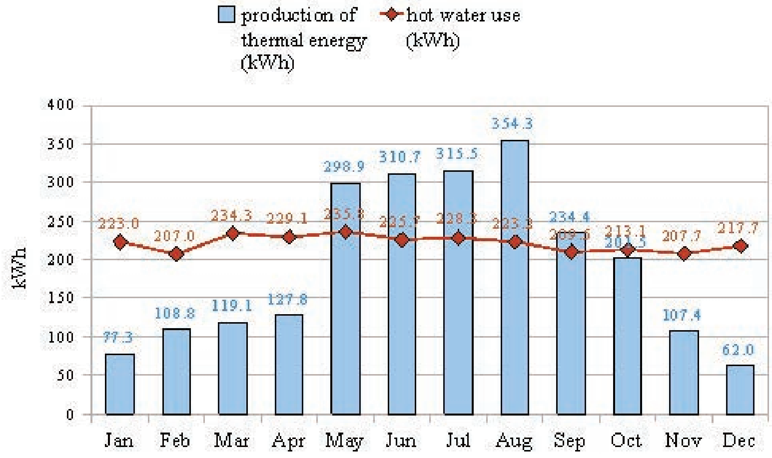

Figure18. Thermal energy produced by the solar system per month and hot water consumption

ECONOMIC ASPECTS OF THE ATTACHED CONSERVATORY, THE PHOTOVOLTAIC CANOPY, AND THE SOLAR WATER HEATING SYSTEM

The price of 3400€ for the proposed low-emission insulated glass (excluding transportation and installation) suggests that the price of the entire conservatory (including the supporting structure), the active heat storage system and the canopy (without the photovoltaic cover) would be approximately 14,000 €. The price of the photovoltaic cover is still unknown, given that its mass production has just begun. It is expected that the price of the system will be 200€/m^2, which gives a final price of about 7,000 € for the photovoltaic cover of the canopy.

The average price of electricity in Serbia in 2008 was 4.322RSD/kWh (Electric Power Industry of Serbia, 2009). If electricity were used for house heating, the annual use of 12.50MWh would cost 54,000RSD, which is slightly below 600€. So, even if the active system of remote storage had the required capacity and efficacy to heat the entire house, it would take as long as 24 years for the investment into the conservatory to pay off. The truth, however, is that this investment can never pay off. If, rather than investing in a conservatory, a household deposits 14,000€ with a bank in Serbia, at the interest rate of 7-8% per annum, their balance at the end of the year will be 815-930€, which is more than sufficient to cover the annual expenses for heating by electrical energy, assuming the current electricity price.

The economic aspects of investing in a photovoltaic canopy seem to be even worse: by generating 550 kWh electrical energy per year, approximately 25€ are saved, which even by a simple division of the amount shows that the installation of the photovoltaic canopy would take as long as 280 years to pay off! It is obvious from this that the low electricity price in Serbia makes any investment in energy efficiency or renewable energy sources a mere enthusiasm.

The estimated payback period for solar water heating system for water heating is 10 years for a single house, assuming the investment price is 1500€, and there is no support by the state. This could be a good economic investment if the entire row of houses obtained a central system for thermal energy storage, because the repayment period would be even shorter (Kosorić, 2009).

It should be stressed that the technologies considered in our analysis have not, as yet, been put into wide use. Photovoltaic systems in the world still have a long payback period, as they are generally characterized by low efficiency and high price. Their cost-effectiveness in Serbia is even lower, given the price of electricity. If a standard conservatory were used, with ordinary glass panes and without special systems, the final price as well as the conservatory's overall operation would be very different. The feasibility of solar water heating system is stronger. Solar water heating system is more available on the market, their technology is known, and the price of the system is decreasing, which in addition to the ecological and energy benefits, increases their economic feasibility.

The price of electricity in Serbia, tailored to the consumers' living standards, should not be used as an excuse by the Energy Efficiency Agency to limit its promotion of energy efficiency to only a few projects. A much better way for the continuous raising of public awareness of energy efficiency and renewable energy sources would be a comprehensive program to subsidize the utilization of energy efficient techniques and technologies in the building sector. With a payback period of 15-20 years, which is the average longevity of the majority of energy efficiency technologies, investment can be made a more realistic option.

CONCLUSION

Although the potential exists for using solar energy in the building sector, its application, in both the design of new buildings and the reconstruction of old ones, is still rare. One of the ways to reduce the amount of energy for heating and cooling residential buildings is to employ bioclimatic principles of architectural design, as well as renewable energy sources, in particular solar energy. The analysis of the residential district in Niš presented in this paper is only a part of a broader research carried out within the doctoral program at the Faculty of Civil Engineering and Architecture, University of Niš, in cooperation with professors and experts in the field. This model can be applied to similar residential districts in other cities and regions in Serbia, taking into account the location-specific parameters (climate, location, building structure, etc.) Passive and active systems were proposed that would reduce energy consumption and improve comfort and functional conditions. An important role in the improvement of functional, energy and formal conditions in the house is given to the conservatory, which protects the house from direct external impacts, whilst connecting it with its surroundings. As an element of passive solar architecture, the conservatory does not use expensive technology, as it is tailored so as to maximize the collected solar energy. The most recent technology of glass manufacture provides various possibilities, as discussed earlier. A relatively new technology was proposed here, which relies on a photovoltaic and solar thermal system for generating electric and thermal energy. In addition to analyzing the performance of passive and active systems of photovoltaic canopies, the economic aspects of the proposed measures were also discussed. As pointed out earlier, some of the proposed measures, especially those relying on new technology, considerably increase the cost of conservatory building, but there are other options of building reconstruction as well.

In conclusion, the application of the principles of bioclimatic architecture and introduction of passive and active solar systems in the building practice require the fulfillment of a series of organizational, educational, economic, and technological prerequisites. The extent to which the needs of house residents can be met depends largely on their economic status. It can be expected, therefore, that projects offering higher energy efficiency will gain more importance with a change in regulations and market criteria, including the price of electricity (Pucar, Nenković-Riznić, 2007).

Notes

During their research the authors used examples and data from the following commercial sources:

1 Pilkington (2006), The Glass Range for Architects and Specifiers, CI/SfB (41) Ro3.

2 Vujić Valjevo (2008), Tipovi termoizolacionih stakala http://www.vujic.rs/_new/content/view/22/70/lang,ser/, pricelist http://www.vujic.rs/_new/_cenovnici/Cenovnik_IZO_stakla.doc, accessed 26.08.2009.

3 Konarka Power Plastic photovoltaic material (source: http://www.konarka.com/index.php/technology/our-technology/)

Konarka Power Plastic, Converting Light to Energy – Anywhere, http://www.konarka.com/media/pdf/konarka_info_sheet_BIPV.pdf, accessed 26.08.2009.

4 Solar thermal collector TS 300 by ThermoSolar AG, Slovakia (source: www.thermosolar.sk)

Acknowledgments

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Pucar, M., Nenković-Riznić M. (2007), Legislative and policy in energy efficient designing and renewable energy sources: Application in Serbia, *Spatium - International Review*, No 15/16, IAUS, Beograd, pp. 66-71.

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Short or preliminary report

IMPROVEMENT OF ENERGY PERFORMANCES OF EXISTING BUILDINGS BY APPLICATION OF SOLAR THERMAL SYSTEMS

Aleksandra Krstić-Furundžić[1], University of Belgrade, Faculty of Architecture, Department of Architectural technologies, Belgrade, Serbia
Vesna Kosorić, SEEEA Ltd., Belgrade, Serbia

Improvement of energy performances of the existing buildings in the suburban settlement Konjarnik in Belgrade, by the application of solar thermal systems is the topic presented in this paper. Hypothetical models of building improvements are created to allow the benefits of applying solar thermal collectors to residential buildings in Belgrade climate conditions to be estimated. This case study presents different design variants of solar thermal collectors integrated into a multifamily building envelope. The following aspects of solar thermal systems integration are analyzed in the paper: energy, architectural, ecological and economic. The results show that in Belgrade climatic conditions significant energy savings and reduction of CO_2 emissions can be obtained with the application of solar thermal collectors.

Keywords: building refurbishment, solar thermal collectors application, architectural integration, improvement of energy performances, reduction of CO_2 emissions.

INTRODUCTION

Building refurbishment aims to improve living conditions, reduce consumption of fossil fuels and environmental pollution. It demands methodological access that includes the application of appropriate phases, procedures and measures, depending on targets. A survey of the elements of methodological access to building refurbishment is given in the scheme in *Figure 1*.

A sustainable approach to building refurbishment represents methodology that includes decision-making based on coordination between demands, targets, building refurbishment technologies and capacity to change indicator (Krstić-Furundžić, 1997).

Different measures aimed to improve the energy performance of the building envelope can be listed. Modern architectural concepts, which are based on the rational energy consumption of buildings and the use of solar energy as a renewable energy source, give the new and significant role to the facades and roofs that become multifunctional structures (Krstić-Furundžić, 2006). The implementation of renewable energy sources and the rational use of energy in building design can reduce the energy use in buildings, the consumption of pollutant energy sources and thereby reduce CO_2 emissions.

The application of mainly neglected, renewable energy sources, for which there is a high potential in Serbia, has been little researched or technologically improved, but is one of the solutions that strives towards the preservation of remaining resources and the environment (Pucar and Nenković-Riznić, 2007). The main target to which this paper is directed is achieving energy savings through building refurbishment, more exactly by the application of solar thermal collectors to achieve solar energy gains and a reduction in the consumption of fossil fuels.

Belgrade's building stock has a significant number of buildings in which energy performances have to be improved. Many suburban settlements were built in Belgrade after World War II. Due to the few prefabricated systems then in use, a significant number of similar buildings in the architectural sense is present. They are also characterized by poor energy performances. The settlement "Konjarnik" is one of the typical representatives of such architecture. The residential building in this settlement has been selected as the model on which the potential for improvements of energy performances by the application of active solar systems are analysed in this paper.

[1] Bulevar kralja Aleksandra 73/II, Belgrade, Serbia
akrstic@arh.bg.ac.rs

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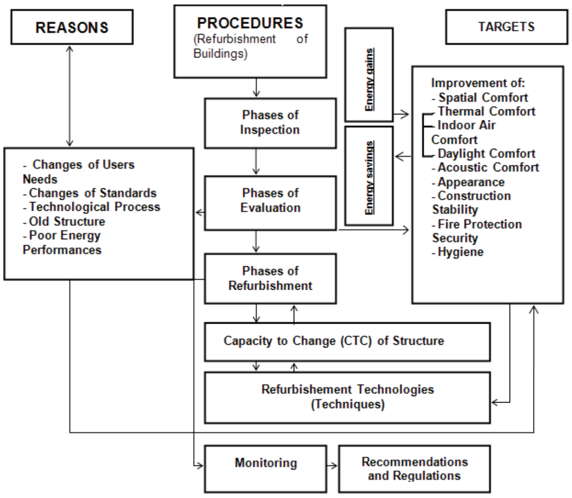


Figure 1: Methodological access to building refurbishment (Krstić-Furundžić, 2005)

Figure 2: Location of „Konjarnik" on the map of city of Belgrade

Figure 3: Building's disposition in the "Konjarnik" settlement

Figure 4: Tipical south-west facade

METHODOLOGY

The analysis in this paper is hypothetical and it aims to show the benefits of applying solar thermal systems to residential buildings in Belgrade climate conditions. Methodological access includes the treatments of:

- existing state,
- consumer,
- solar thermal system,
- architectural integration of solar system,
- reduction of CO_2 emissions,
- simple payback period.

Existing State

Location

Settlement "Konjarnik" is about 4 km far from the city center (*Fig.2*). Due to the city's development, today it is part of the urban city zone. It is a settlement that consists mainly of buildings typical to those built in the 1960s and 1970s.

Belgrade is a city with global irradiance of 1341.8 kWh/m^2 (Polysun 4), and 2123.25 sunny hours per year (Republic Hydrometeorological service of Serbia, 2009).

Building

The settlement is characterized by large rectangular shaped residential buildings. The building that is the subject of this analysis, is situated on the south oriented hillside with a typical south-north orientation; more exactly a deviation of 10˚ to the southwest is present (*Fig. 3*).

Facades oriented south and north consist of rows of windows and parapets, which represent 70% of the surface and verticals of loggias, which represent 30% of facade surfaces (*Fig. 4*).

As the building consists of a number of lamellas, the analyses in the paper were done for one lamella.

The possibilities for the application of solar thermal collectors on the south-west oriented facade and south-west oriented part of roof were analyzed.

Consumer

There are 28 apartments in one lamella and 90 occupants inside them altogether. The initial idea was to explore the potential effects of a solar system based on solar thermal collectors to meet the energy demands for hot water. In these calculations, the real thermal energy consumption was taken into consideration. Thermal energy for hot water: 80 l of hot water per person per day, 80 l x 90 = 720 l (20-50˚C) per day for one lamella which presents 251 kWh per day, i.e. 91618.3 kWh per year for one lamella.

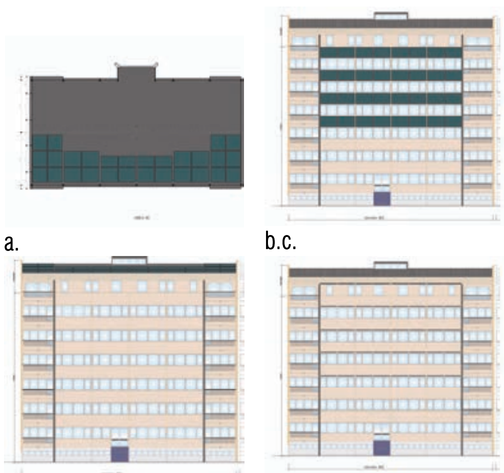
Solar Thermal System

Calculations and simulations of solar thermal systems for all design variants were conducted in Polysun 4 Version 4.3.0.1. In these calculations, the existing water heating system fully based on electricity was substituted with the new system – solar thermal collectors (AKS Doma – manufacturer), with the auxiliary system powered by electricity.

Architectural Integration of Solar System

The design of the integration of the solar systems was defined consequently according to the actual characteristics of:

- The building location – the context (considering urban planning, the social, climatic and geographical aspects),
- The building (considering compatibility in respect to the building construction type, building materials, the shape, the function, the style and design of the building),



a. b.c.

a. d.

Figure 5: Analyzed design variants: a. I Design Variant: roof 40˚ (roof and facade layouts), b. II Design Variant: parapet 90˚, c. III Design Variant: parapet 45˚, d. IV Design Variant: sun shading 0˚

- The facade and roof (considering the physical building characteristics, mounting, physical appearance and characteristics of the solar system).

For analysis, four distinctive variants of the positions of the solar thermal collectors on the building envelope were selected:

- I Design Variant: roof 40˚, area of 100 m^2 (*Fig. 5-a*) - solar panels with slope of 40˚ applied to the roof,
- II Design Variant: parapet 90˚, area of 90 m^2 (*Fig. 5-b*) - vertical position of solar panels,
- III Design Variant: parapet 45˚, area of 120 m^2 (*Fig.5-c*) - solar panels with slope of 45 applied to parapets,
- IV Design Variant: sun shading 0˚, area of 55 m^2 (*Fig. 5-d*) - horizontal position of solar panels.

Reduction of CO_2 Emissions

In calculations of CO_2 emissions of the consumer, for cases in which the solar system substitutes an electricity based system, 0.81 kg CO_2/kWh reduction is used (Krstić-Furundžić and Kosorić, 2008).

Simple Payback Period

For calculations of simple payback period for the analyzed design variants, the following parameters were used: 700 EUR - total system costs per 1 m^2 of solar thermal collectors, 0.45 EUR/kWh – price of energy produced from solar systems (The Croatian Parliament, 2007).

RESULTS

The results of solar thermal integrations were considered and presented through the reduction of energy consumption, reduction of CO_2 emissions, simple payback period and the evaluation of the proposed design variants.

Reduction of Energy Consumption

For comparative analysis of energy performance for the design variants of integrating solar thermal collectors, monthly thermal energy production, hot water demands satisfaction and thermal energy production per m^2 of solar thermal collector were calculated and presented in Figures 6, 7 and 8. It is evident that different positions of solar thermal collectors provide different results regarding these parameters:

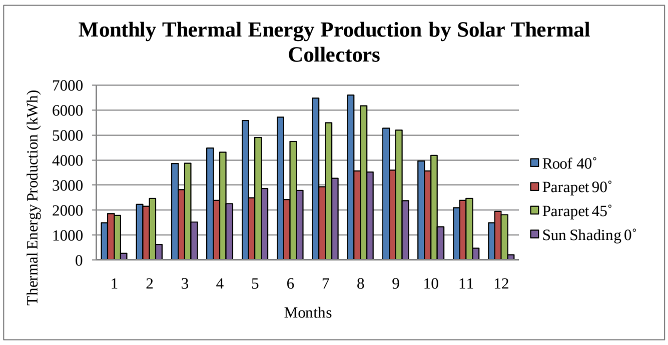


Figure 6: Monthly Thermal Energy Production by Solar Thermal Collectors

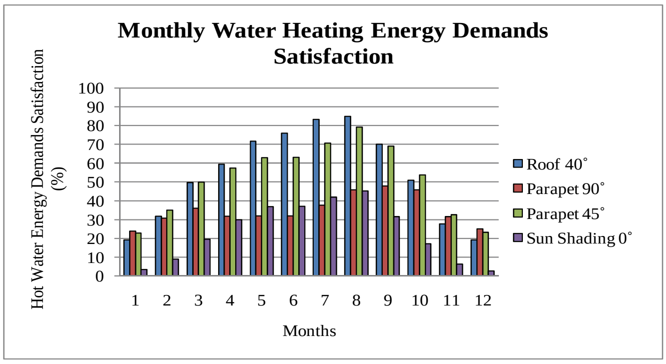


Figure 7: Monthly Water Heating Energy Demands Satisfaction

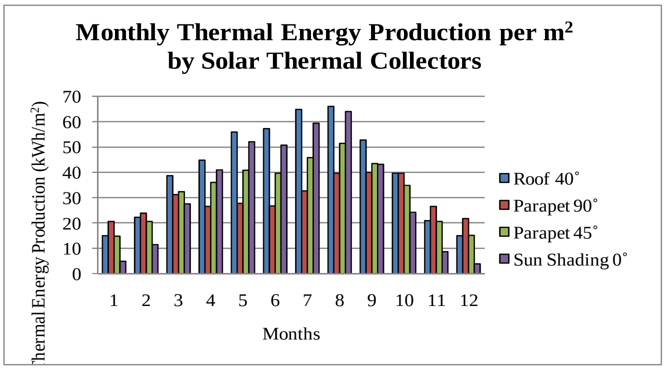


Figure 8: Monthly Thermal Energy Production per m^2 by Solar Thermal Collectors

- Solar thermal collectors integrated onto the roof at 40˚ can produce monthly thermal energy from min 1492 kWh in December to max 6605 kWh in August; they can meet demands for hot water from min 19.6% in December to max 84.9% in August; thermal energy production per m^2 is from min 14.9 kWh/m^2 in December to max 66.1 kWh/m^2 in August;
- Solar thermal collectors integrated into the parapets at 90˚ can produce monthly thermal energy from min 1858 kWh in January to max 3603 kWh in September; they can meet demands for hot water from min 23.9% in January to max 47.8% in September; thermal energy production per m^2 is from min 20.6 kWh/m^2 in January to max 40 kWh/m^2 in September;
- Solar thermal collectors integrated into parapets at 45˚ can produce monthly thermal energy from min 1780 kWh in January to max 6169 kWh in August; they can meet demands for hot water from min 22.9 % in January to max 79.3 % in August; thermal energy production per m^2 is from min 14.8 kWh/m^2 in January to max 51.4 kWh/m^2 in August;
- Solar thermal collectors integrated as sun shadings at 0˚ can produce monthly thermal energy from min 208 kWh in January to max 3524 kWh in August; they can meet demands for hot water from min 2.7 % in January to max 45.3

% in August; thermal energy production per m^2 is from min 3.8 kWh/m^2 in January to max 64.1 kWh/m^2 in August.

Reduction of CO_2 Emissions

In *Table 1*, values for CO_2 emissions reduction are presented for all proposed design variants.

Table 1: CO_2 reduction achieved by solar thermal collectors

	Roof 40°	Parapet 90°	Parapet 45°	Sun Shading 0°
kg/ year	**39908**	**26013**	**38402**	**17395**

Simple Payback Period

Simple payback periods for Design Variants 1, 2, 3 and 4 are sequentially 7, 9, 8 and 8 years.

Evaluation of proposed design variants

In this paper the evaluation of proposed design variants is based on aesthetics, mounting options, energy, economic and ecological criteria. As aesthetical criteria might be characterized by subjectivity, they are adopted according to the solar thermal collector's compatibility to the facade and roof's technical characteristics (dimensions, form, color, material), for which reliable evaluation can be established. Generally, such evaluation is based on the fact that experts make decisions in the design process, and some of them are polled in order for criteria values to be established. The following evaluation criteria have been established:

- c1: Aesthetic characteristics (1 (lowest)-3 (highest)),
- c2: Mounting options (1 (lowest)-3 (highest)),
- c3: Energy Production per year/total system costs (kWh/EUR),
- c4: Energy Production per year/Panel area (kWh/m^2),
- c5: Energy Demands Satisfaction per year (%),
- c6: Reduction of CO_2 emissions (kg/year).

Every criteria (c1-c6) from the design variant with the highest value of that criteria gets 5 points, and other variants get points proportionally. The weights of all adopted criteria were defined and the Evaluation Value (E) is calculated as: E=0.3xc1+0.2xc2+0.2xc3+0.1xc4+0.1xc5 +0.1xc6. The design variant with the highest evaluation value is conceived as the optimal solution.

According to this established evaluation system, Design Variant I has the highest evaluation value (E), as presented in *Table 2*, and therefore it is the optimal solution.

CONCLUSION

The contribution of application variants of solar thermal systems to improve the energy performance of existing buildings is estimated through a comparative analyzes of predictive variants.

For comparative analysis of energy performances of integrating solar thermal design variants, an annual calculation of thermal energy production, along with the setisfaction of hot water energy demands and the average thermal energy production per m^2 per year were carried out and shown in Figures 9, 10 and 11.

On an annual basis, it is evident that design variants with solar thermal collectors can produce thermal energy from min 21475.5 kWh (Sun shading 0°) to max 49269.5 kWh (Roof 40°); these design variants can meet from min 23.4 % (Sun Shading 0°) to max 53.6 % (Roof 40°) hot water demands; thermal energy production per m^2 varies from min 356.8 kWh/m^2 (Parapet 90°) to max 492.7 kWh/m^2 (Roof 40°).

In order to achieve an adequate comprehensive approach for the analysis of proposed design solutions with solar thermal collectors, a multi-criteria decision making method is included in the process of evaluation and selection of design solutions. According to the established evaluation system in this paper, Design Variant I, in which panels are tilted at 40° on the roof of building, was indicated as optimal. This variant was expected to be selected as optimal considering the optimal tilted angle for Belgrade and the lower shading effect present on the roof than on the facade.

Table 2: Evaluation of Design Variants (I-IV) with integrated solar thermal collectors

c	I		II		III		IV	
	p	e	p	e	p	e	p	e
1	3	5	3	5	2	3.3	1	1.7
2	3	5	2	3.3	2	3.3	2	3.3
3	0.7	5	0.5	3.6	0.6	4.3	0.6	4.3
4	492.7	5	356.8	3.6	395.1	4	390.5	3.9
5	53.6	5	35	3.3	51.7	4.8	23.4	2.2
6	39908	5	26013	3.3	38402	4.8	17395	2.2
E	5		3.9		3.87		2.86	

Through the design variants presented and discussed in the paper, it can be concluded that through the application of solar thermal collectors in building refurbishment, numerous benefits can be achieved over a short period of time and which can be identified to decrease conventional energy consumption and environmental pollution to improve comfort inside buildings, and provide opportunities for new aesthetic potentials in the refurbishment of existing buildings. In Belgrade, as well as in Serbia, there are a large number of housing settlements with the same or similar prefabricated buildings, as in the settlement Konjarnik, indicating that significant energy savings and CO_2 emission reductions can be obtained. In addition, the results presented in this paper can popularize the application of solar systems in building refurbishment.

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Scientific analisys or debate

SELECTION OF BUILDING MATERIALS BASED UPON ECOLOGICAL CHARACTERISTICS: PRIORITIES IN FUNCTION OF ENVIRONMENTAL PROTECTION

Milica Jovanović Popović [1], University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Saja Kosanović, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia

Numerous scientific researches show that the activities connected with building materials produce significant negative environmental effects. Observed from the point of architecture, the use of building materials is found to be one of the critical factors of environmental pollution and degradation. The purpose of introducing architectural interventions, including proper selection, is the reduction of the negative environmental impact of building materials. The aim of this paper is to define, from the ecological aspect, basic principles for the selection of building materials. First, principles were defined through the all – inclusive analysis of every phase in the life cycle of building materials. Summing categories: embodied energy and embodied CO_2 are discussed afterwards. In the order to simplify the procedure of arriving at a decision, priorities in selection were emphasized in every separate segment of this paper. The selection of building materials with reduced negative environmental impact (ecologically correct building materials) is one of the key decisions in the process of designing ecologically correct buildings.

Key words: life cycle, environmental impact, criterion

INTRODUCTION

A study of the environmental impact of building materials is based upon the examination of their behaviour from the process of getting raw materials and concluding all operations until the final return to the natural environment in the form of waste. This series of processes represents "the life cycle of building materials". The basic phases in the life cycle of building materials are: 1. obtaining the raw materials; 2. production; 3. transport to the construction site; 4. installation; 5. use and maintenance; 6. decommissioning; 7. transport of the decommissioned materials; 8. disposal / re – use / recycling. Building materials with a single use have a "linear" or "open" life cycle which ends with the disposal of the material in the form of waste. Building materials that are used more than once have a "circled" or "closed" life cycle. (Jovanović-Popović *et al*., 2008)

The environmental impact of building material depends on: the origin of raw materials, the method of production, the distance between the production and construction sites, the method of transport, the content and features and possibility of re – use / recycling. The rule of thumb is that building material has potential negative environmental impacts in every phase of its life cycle.

Adequate selection accounts as one of the basic architectural measures applied in the purpose of reduction of negative environmental impacts of building materials. (Kosanović, 2007) Additionally, proper selection of materials in the design stage will reduce negative environmental impacts in every phase of the life cycle of the whole building, in which the flows of mass and energy exist.

CRITERIA FOR THE SELECTION THROUGH THE PHASES OF LIFE CYCLE OF BUILDING MATERIALS

Proper selection of a certain building material requires the analysis of environmental impacts in every phase of the life cycle. Criteria for the selection of building materials throughout the phases of the life cycle are given in Table 1.

Raw materials

Whenever raw materials are taken from nature, the resources are spent and therefore gradually exhausted. The use of narrow – spread (for example, some kinds of exotic wood), non-renewable or slowly renewable resources is especially critical. Obtaining raw materials from earth (necessary, for example, for the

[1]Bulevar kralja Aleksandra 73/II, 11 000 Belgrade, Serbia
mjovanov@eunet.rs

Table 1 – Criteria for the selection of building materials through the life cycle phases

Phase	Criteria		Priority in selection
RAW MATERIALS	**Origin**	Natural origin	Natural origin / Raw materials with recycled content
		Artificial origin	
		Recycled content	
	Renewable resources	Raw materials from renewable resources	Raw materials from (quickly) renewable resources
		Raw materials from non-renewable resources	
	Content	Presence of harmful substances	Without the presence of harmful substances
	Availability and spread		Available and wide – spread resources
	Environmental impacts	Water, air and soil pollution	Activities on raw materials with minimum negative environmental impacts/ Activities safe for workers' health
		Erosion	
		Changes in soil structure	
		Natural ambient degradation	
		Free land occupation	
		Impacts on living world	
	Energy consumption	Quantity of consumed energy	Minimum in energy consumption /
		Origin of consumed energy	Energy from renewable resources
PRODUCTION	**Energy consumption**	Quantity of consumed energy	Minimum in energy consumption /
		Origin of consumed energy	Energy from renewable resources
	Water consumption	Pollution of consumed water	Minimum in water consumption
	Solid waste production	Utility value	Minimum in solid and liquid waste generation / Waste with utility value / Waste with the possibility of biological decomposition
		Disposal	
	Waste liquids	Possibility of use	
		Disposal	
	Harmful emissions	CO_2 Emission	Minimum of harmful emissions
	Threats to workers' health		Safe production
TRANSPORT	**Distance**		Locally available materials /
	Energy consumption		Efficient methods of transport
INSTALLATION	**Energy consumption**	Quantity of consumed energy	Minimum in energy consumption
		Origin of consumed energy	
	Water consumption	Pollution of consumed water	Minimum in water consumption
	Solid waste production	Possibility of use of generated waste	Minimum in waste production / Waste with utility value
	Noise and dust production		Efficient installation of high – quality materials
	Threats to workers' health		Materials without harmful emissions and radiation
USE AND MAINTAINENCE	**Durability**	Long – lasting	Long – lasting materials easy to maintain
	Maintenance	Energy consumption	
		Water consumption	
	Impacts on users health		Materials without harmful substances, with low emissions, certified to the absence of radon
	Impacts on outdoor environment		Non-reflecting materials / Materials with optimal thermal performance
DECOMMISSIONING	**Energy consumption**	Quantity of consumed energy	Minimum in energy consumption
		Origin of consumed energy	
	Water consumption	Pollution of consumed water	Minimum in water consumption
	Solid waste production	Possibility of the use of generated waste	Minimum in waste production / Waste with utility value
	Noise and dust production		Possibility of silent and simple decommissioning
	Threats to workers' health		Materials without harmful emissions and radiation
RE – USE	**Possibility of re – use**		Materials that may be re – used / Re – used materials
RECYCLING	**Possibility of recycling**		Materials that may be recycled / Recycled materials
DISPOSAL	**Possibility of biological decomposition of disposed material**		Materials with the possibility of biological decomposition

production of ceramic) causes its physical pollution – change of geomorphologic characteristics as well as free land occupation; this further leads to a series of negative ecological consequences in the environment. The process of obtaining raw materials is often followed by air pollution, which causes new negative effects on the living world. The processes of obtaining raw materials demand the use of energy and therefore cause energy resources consummation and harmful gases generation. If a building material is produced from artificially derived raw materials (as is the case with, for example, PVC and other kinds of plastic, synthetic colours and some types of thermo isolative materials), then the negative environmental impact will be additionally increased, since obtaining these raw materials demands an industrial process which carries numerous negative environmental effects.

When analyzing the phase of raw materials, priority in selection should be given to the materials obtained from natural, quickly renewable, available and wide – spread resources, materials with recycled and without harmful content, materials which originate from raw materials obtained in ecologically safe processes, with the minimal use of energy, water and free natural land.

Production

In the process of production, which spends raw materials, the health of workers is especially put at risk. Production of building materials often comprises of an energy-intense series of actions (as, for example, is the production of metals or cement) which carries numerous significant environmental consequences. 5 % of the totally consumed energy in all human activities goes to the production of building materials. Generation of harmful by – products without usable value: solid waste, wasted liquids and gases in the production-phase contributes to the pollution of air, soil and water. This is obvious in examples of steel and PVC production. Certain production processes cause the occurrence of smog and acid rains. During the production of some building materials (for example, of steel), a large quantity of water is used, and after being used, the water becomes polluted. The pollution of air, water and soil caused by the production of building materials has significant negative effect on the living world.

Priority in selection will belong to materials produced by minimum possible quantities of energy and water, the materials at which the production process requires a minimal generation of harmful solid waste, liquids and gases and the materials which during production carry no risks to the workers' health.

Transport

During the transport of building materials from the production to the construction site or from the decommissioning to the site of disposal / re – use / recycling, the use of energy is essential; this causes oxygen consummation, air pollution and resources exhaustion. Air pollution then consequently contributes to global warming, the occurrence of smog and acid rain and to the reduction of natural light in the environment.

Priority in selection is given to locally available (produced) building materials transported in an energy efficient way.

Installation

The installation of building materials is followed by the generation of dust and other harmful particles which pollute air, soil (when get to the surface) and water (by rainfall draining). Workers' health, especially in cases of the installation of building materials with harmful content (as synthetic colours are), is exposed to risk. The process of installation is often responsible for the generation of noise. The installation of some building materials is followed by the use of water. Consumed water is transformed into waste; it goes into the soil or into water currents and pollutes them. Installation normally requires the use of energy, necessary for the work of machines and equipment, for lighting, heating or cooling the working environment etc. Large quantities of waste are generated during the installation of building materials due to the use of packed building materials, damaged materials, the production of materials on the site, the adoption of dimensions of materials etc. The highest percent of waste generated during the installation is disposed; only a small part of it is re – used or recycled for new building material.

Observed from the aspect of environmental impacts occurring during the phase of installation, priority in selection is given to materials which are installed with a minimal use of energy and water, materials that have no risks to the workers' health and the materials which can be installed with a minimal occurrence of noise, dust and waste. For the purpose of reducing the quantity of waste generated during installation, priority should be given to prefabricated materials (components), materials in which what is left over from installation may also be used or may be recycled, materials resistant to damage, materials of standard dimensions, as well as materials in which the wrapping material also has a usable value or the potential to be biologically recomposed, re-used or recycled.

Use and maintenance

Certain building materials during the phase of use and maintenance emit harmful radiation or substances which are toxic or even carcinogenic. Emitted chemicals, which may be detected in the air of interior space for a long period of time following the installation of a material, worsen the air quality and contribute to the "sick building syndrome". Potential negative effects during the phase of use frequently have artificial building materials. Many of the hazards of these materials still haven't been sufficiently investigated or haven't been investigated at all. Some of the materials have such lasting harmful impacts that continued hazard doesn't stop even after disposal. Building materials which originate from earth (for example, ceramics, aggregates, stone, gypsum etc.) potentially contain radon, radioactive and carcinogenic gas without odour and colour, generated by uranium and radium decay in the earth. Building materials produced from industrial waste (concrete or artificial stone, for example), slag from the blast furnace and fly ash also may be radioactive. Mineral fibres, present in some building materials (in mineral and rock wool, for example), after inhalation potentially cause allergic reactions and may even have carcinogenic effect. Synthetic materials (plastic masses, for example) contain harmful organic compounds; after the release from the material into the air, these substances get into the organism of the users and potentially cause a variety of diseases. Synthetic materials derived from wood, colours and some kinds of thermo isolative materials may contain formaldehyde, colourless gas of an unpleasant odour with proved harmful effect on human health. Depending on the place of installation in the building and on the kind of installation, such installed building materials during the phase of use and maintenance potentially cause significant negative effects in the outdoor environment: a reduction of relative humidity in the building's surroundings, rapid rainfall draining, an increase of the temperature in the building's surroundings, and a creation of glare.

Priority in selection should be given to building materials without harmful content, materials which aren't radioactive, which do not produce glare and which are easy to maintain. Thermal performance is also an important selection criterion; selected materials should contribute to the energy efficiency of a building. (Jovanović-Popović *et al*., 2006)

Decommissioning

Decommissioning of building materials includes a series of activities conducted in order to eliminate a building in its existing form. Decommissioned building materials are either treated as waste or will be re – used / recycled. The intensity of negative environmental impacts generated during this phase is higher in the case of demolition than in the case of the building' renewal, since it concerns the total decommissioning of all previously installed building materials. Decommissioning consumes energy (electrical or in the form of liquid fuel) and water. It generates noise, solid waste, dust and other polluting particles that pollute air, water and soil.

Priority in selection is given to building materials that can be decommissioned in a simple way, using minimal quantities of energy and water, generate minimal quantities of waste, noise, dust and other particles and are without risks to the health of workers employed in decommissioning.

Disposal / re – use / recycling

Disposing of solid waste leads to free land occupation, soil pollution and to the degradation of the environment. Water and air are then polluted over the soil; finally, polluted elements of natural environment have negative impacts on plants, animals and on human health. If the life cycle of a certain building material ends by the material's re – use, then the negative impacts in the earlier phases: raw materials, production and disposal are totally cancelled. Additionally, if the source of re – used material is local, then the negative environmental impact that would occur in the phase of transport is reduced to a minimum; if the source of re – used material is the construction site itself, then the potential negative impacts of transport are totally cancelled. Recycling cancels negative environmental impacts that would occur during the phases of raw materials obtaining and disposal and reduces partially negative environmental impacts that would occur in the phase of production of new building material.

Priority in selection is given to building materials that can be or are already re – used, to the materials that have the potential to be recycled or already are carrying recycled content, and finally to materials with the potential of biological degradation.

SELECTION BASED UPON THE VALUES OF EMBODIED ENERGY AND EMBODIED CO_2 OF BUILDING MATERIALS

After the determination of environmental impacts of building materials in each separate phase of the life cycle is completed, and from the reason of simplifying the procedures of comparison and selection, the next step of analysis is the determination of the total environmental impacts in the following categories: embodied energy and embodied CO_2. The total environmental impact of a material in these categories represents the sum of impacts in these separate phases of the life cycle.

Embodied energy

The embodied energy of building material is defined as the sum of quantities of energy consumed in certain phases of its life cycle. It is the energy necessary for the obtainment,, production, transport, installation, maintenance, decommissioning and waste disposal of raw materials. In the value of embodied energy of building material, however, the quantity of energy requested for operation and maintenance of capital equipment and services in production may also be included. The calculated value of embodied energy is expressed in *MJ* or *GJ* through the mass unit (*kg*) or through surface (m^2) or volume unit (m^3) of the installed material.

The energy intensity of building materials may also be shown by the value of *primary embodied energy.* There are two variables whose sum gives the value of primary embodied energy. The first of the two represents the total quantity of energy necessary for the obtainment, production and installation of raw materials; it represents the stable value that is specific for each building material. The second variable is the energy required to transport a material from production to the installation site; the value of this variable is changeable – the value of spent energy increases with the growth of distance between the production and installation sites, which consequently leads to the increase of total value of primary embodied energy. Altogether, these factors lead to the conclusion that the value of the primary embodied energy of locally available building material will be lower than the value of embodied energy of the same material transported from a larger distance. Therefore, the priority in selection should be given to locally-produced building materials.

The value of primary embodied energy is higher with building materials whose production process is very intense, as well as with building materials derived from artificial raw materials. Priority in selection should be given to those building materials in which the consummation of energy in the phases of obtaining raw materials and especially in their production is brought down to minimum. The best choice, considered from these factors, are re-used building materials, since the first two phases of their life cycle are completely cancelled. Good choices are also recycled building materials – materials with recycled content so that the production process is reduced. A low value of energy required for production is characteristic of some natural building materials: wood, stone, aggregates and gypsum, for instance. On the other hand, the production process of some building materials, like cement, aluminium and steel, glass, ceramics etc. is very intense and demands high temperatures, which contributes to a negative increase of value of primary embodied energy.

When choosing building materials based on the criterion of embodied energy, attention should also be given to the thermal performance of a building in which selected materials are to be installed. It may occur, however, that increased use of materials (leading to an increase in total embodied energy), brings positive results in the reduction of the operative energy of the building. (Jovanović-Popović *et al*., 2007)

Embodied CO_2

Embodied CO_2 represents the total sum of quantities of this gas (presented usually in tonnes), delivered into the atmosphere in the following phases: obtaining raw materials, production, transport and installation of building material. As a result, in these phases there exists a significant use of energy obtained from the combustion of fossil fuels.

Embodied CO_2 isn't directly proportional to the value of embodied energy of the same material: its value depends on the resource of the energy spent in processes, on the type of usable energy and on the energy's origin. (Jovanović-Popović *et al*., 2008) Processes which demand electrical energy give-off a higher emission of CO_2, compared to processes supported by healthy energy. Processes in which energy is obtained from renewable energy and then used (in hydro plants, for example), give low emissions of such gasses. In Scandinavia, for instance, the highest percent of energy used for the production of aluminium comes from hydro plants; therefore, the value of embodied CO_2 of this material in the production phase is close to zero.

The importance of taking into account the value of embodied CO_2 in the selection of building materials is visible in the fact that this gas composes 80 – 85 % of the total volume of gasses creating the greenhouse effect on Earth and that about 12 % of total CO_2 emission comes from various phases in the life cycle of building materials.

CONCLUSION

The negative environmental impact of building materials cannot be completely eliminated, but can be reduced in large scale by applying certain effective interventions. Effective selection accounts as one of the architectural measures applied in order to reduce the negative environmental impacts of building materials. These measures consists of a series of steps; each of them represent a particular aspect of selection and therefore should be considered separately, before determining the final complex decision about which building materials are to be used.

Priority in selection is given to: the building materials that do not damage human health (that do not have harmful content, do not produce harmful emissions and are not radioactive), the materials with a minimum quantity of generated waste within the phases of the life cycle, re-used and materials with the potential for re-use, recycled and new materials that may be recycled, natural materials obtained from (quickly) renewable, available and wide spread resources, materials with low values of embodied energy and embodied CO_2, materials with the potential for biological decomposition, long – lasting materials. As the number of building materials distinguished by all these characteristics is very limited, priorities in selection need to be established, depending on each separate case and on other required characteristics of materials.

The absence of national legal regulation in the field of reduction of negative environmental impacts of building materials has as a consequence relied on the exclusively volunteer devotion and efforts of architects and other participants involved in the processes of the design and construction of buildings. It is the architect who has an assignment to point out to Investors all the advantages of the selection of ecologically correct options of, not only basic, but also of alternative building materials.

The introduction of legal regulation in the terms of: defining and application of relevant methods for the assessment of ecological quality of building materials, manufacturers' obligations about the availability of data on the methods and environmental effects of production and about issuing the certificates that would testify ecological accuracy, compulsory testing of building materials for the presence of radon, setting permitted values of embodied energy and embodied CO_2 in building materials, etc. is urgent. After the regulation of these areas is introduced and its implementation has begun, the process of reaching responible decisions about the selection of building materials will be simplified considerably.

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Review paper

SELF-COMPACTING CONCRETE AND ITS APPLICATION IN CONTEMPORARY ARCHITECTURAL PRACTISE

Ruža Okrajnov-Bajić[1], University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Dejan Vasović, University of Belgrade, Faculty of Architecture, Belgrade, Serbia

In majority of the most modern architectural designs realised in the past 10-20 years, concrete having features in fresh and hardened state as well as making, placing and curing techniques that are defined in detail was used. Quite frequently concrete which was self-compacting in fresh state was used. In order to get acquainted with this material and with possibilities of its application this paper presents various buildings in which it was used. The definition of self-compacting concrete is given and advantages of its application are underlined. Next, features of fresh SCC, test methods are described in detail and classifications especially defined for this material are proposed.

Key words: architectural concrete, self–compacting concrete, flowability, viscosity, passing ability.

INTRODUCTION

Building conditions for contemporary architectural buildings set new, various requirements regarding construction methods of reinforced concrete buildings. Meeting those criteria led to development of concrete with specifically defined properties in fresh state. An idea of **self-compacting concrete** (SCC), a material that flows, that is placed into formwork and that is compacted under the influence of self-weight only, without vibration and additional processing emerged. Realisation of self-compacting as the key feature of fresh concrete enabled at the same time application of technologically higher-quality material with improvement of economic building conditions.

The main advantages of application of self-compacting concrete on site are as follows:

- No vibration of fresh concrete is necessary during placement into forms.
- Placement of concrete is easier.
- Faster and more efficient placement of fresh concrete is achieved. Total concreting time is reduced.
- Noise level on construction site is reduced. Thus the number of working hours on the construction site can be increased and the night shift in urban zones is enabled.
- Energy consumption is reduced.
- Required number of workers on construction site is reduced.
- Safer and healthier working environment is obtained.

Upon self-compacting concrete hardening in structures:

- High quality of placed concrete is achieved, regardless the skill of the workers.
- Good bond between concrete and reinforcement is obtained, even in congested reinforcement.
- High quality of concrete surface finish is obtained with no need for subsequent repair.
- With a better final appearance of concrete surface, smooth wall surfaces and flat floor surfaces that need no further finishing are obtained.
- Improved durability of structures is achieved.
- Maintenance costs are reduced.

EXAMPLES OF STRUCTURES BUILT OF SELF-COMPACTING CONCRETE

Earliest research in design of self-compacting concrete mixes began in the mid-eighties in the twentieth century in Japan. The main drive for this research were the endangered durability of reinforced concrete structures, need for easier and high-quality fresh concrete placement and lack of skilled labour force. In 1986, Okamura, Kochi University, Japan, was the first to propose concrete that would be placed under the influence of self-weight only. The new technology was possible owing to the development of concrete superplasticisers which had been developed during the previous decades.

After an extremely successful initial application in actual structures in Japan, the application of self-compacting concrete began in the entire world. Presently it is a very eagerly used material both in construction sites and in

[1]Bulevar kralja Aleksandra 73/II,11000 Belgrade, Serbia
bajic@imk.grf.bg.ac.rs

production of precast members. Extensive testing of physical and mechanical properties of SCC was carried out during the past decade. This was followed by economic analyses which confirmed the rationality of SCC application. Practical application was extended from large infrastructure buildings (bridges, tanks, retaining walls, tunnels, etc.) onto architectural buildings also. SCC appears here as a structural material in load-bearing members but at the same time it also appears frequently as architectural concrete. Architectural concrete was defined by the American Concrete Institute as "concrete which will be permanently exposed to view and which therefore requires special care in selection of the concrete materials, forming, placing and finishing to obtain the desired architectural appearance". Several characteristic examples are shown below.

Burj Dubai

The Burj Dubai structure represents the state-of-the-art in super high-rise buildings. During its construction the most recent accomplishments in all fields have been united, including concrete production technology. Several different concrete mixes were used in this project. It was necessary to place 230000m^3 of fresh concrete. That is the quantity that was built-in into tower, podium and office annex excluding foundations. The designed concretes were obtained using Portland cement combined with silica fume, fly ash or ground slag. As a result, different materials having high density and high final strength were obtained (concrete C50 was built-in into floor structures and C60 and C80 into vertical load-bearing members).

The structure has sufficient rigidity, toughness and high load-bearing capacity. In course of construction of the building the concrete was pumped to higher and higher heights so it was necessary to provide extraordinary flowing ability of concrete through pipes. A world record was achieved: on November 8, 2007 highest vertical concrete pumping for buildings, 601m, was performed. Everything in this fantastic project was carefully planned. Thus concrete was poured usually at night to enable work at lower temperatures and higher humidity. Concrete was additionally cooled by adding a part of water in the form of ice. Total height, 818 m, was reached on January 17, 2009 (http://www.burjdubai.com/)

Arlanda Airport Control Tower, Stockholm, Sweden

This tower was designed by Wingårdh Arkitektkontor AB. The total height of the tower is 83 m. The structure of the pillar consists of two shafts having different dimensions which is emphasised by two-colour design. There are several eccentrically placed circular floor structures at the top. Facade walls are parts of a cone. The tower was completed and opened in 2001. Today it represents a symbol of Stockholm.

During the construction stage, the inner formwork was being climbed by a crane while the outer scaffolding and formwork were self-climbing. SCC was used in order to achieve the concreting speed of a standard floor height h=3.27m in a 4 day climbing cycle of formwork and to ensue high-quality concrete placing without vibration. The decreased noise level during concrete placing enabled concreting during the night shift.

National Museum of 21st Century Arts (MAXXI) in Rome, Italy

MAXXI was designed by Zaha Hadid. In 1998 she won the international competition out of 273 candidates. The museum building covers a surface of 30,000 m^2 in Flaminio District on a site originally occupied by a car factory and army barracks built in the 19th century. The building is characteristic for its winding exhibition space formed of reinforced concrete walls with glass roof. These structures look more like bridges since they only have walls at the sides and a floor structure while the roof is of glass on steel girders. On its winding path the structure comes across large spans, irregular supports and long overhangs. In some places the walls are 14m high. Reinforced concrete wall surfaces are visible and they require a perfect surface finish. In order to

Figure 1: Burj Dubai, May 2009.

Figure 2: Arlanda Airport Control Tower, view,

(http://en.wikipedia.org/wiki/File:Arlanda_Flightower.jpg)

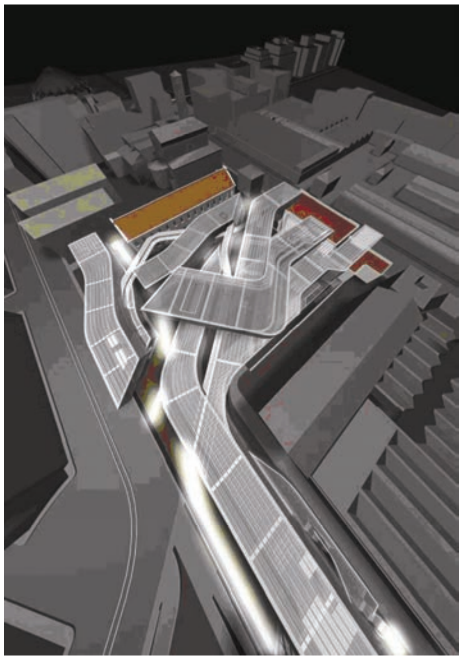

Figure 3: National Museum of 21st Century Arts in Rome, Italy, model

(http://www.maxxi.parc.beniculturali.it/english/museo.htm)

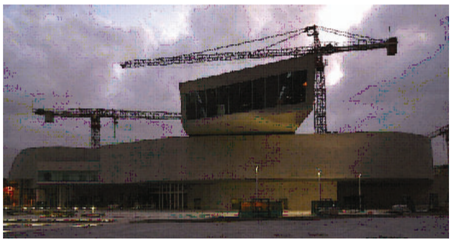

Figure 4: Entrance of the MAXXI under construction (http://www.maxxi.parc.beniculturali.it/english/museo.htm)

meet all these high requirements the contractor for the concrete structure decided to use self-compacting concrete. The concrete was cast along the entire lengths of the walls to avoid construction joints. This amounted up to 70 meters in length and 9 m in height in some members. The concrete was mixed and made on the construction site. Concreting lasted even up to 18 hours. To avoid segregation, the height from which the fresh concrete was poured was limited to maximum 15cm. Application of powdered limestone and epoxy-resin additives provided perfectly smooth surface finish of concrete walls. To prevent development of excessive heat in fresh concrete, concreting was performed only when the temperature was below 25º, i.e. practically from November to April.

Ušće Shopping Center

The Ušće Shopping Center was designed by a company from Belgrade, "ARCVS", while Italian company "Chapman Taylor", whose architect Gerardo Sanella designed the interior decoration and facade views, joined in 2008. The building was built since mid-2007. As many as 5000 people worked on the construction of the building at a particular same moment. Upon opening on March 31, 2009, Belgrade gained the largest Shopping centre in the region with 130,000 m^2 in area.

Figure 5: Ušće Shopping Center

Within the structural design, concrete MB40. was specified for foundations, floor structures, columns, etc.. To shorten the construction periods and to obtain high-quality visible part of the structure, the decision was made immediately before the beginning of the construction works that the fresh concrete to be used will be self-compacting in some parts of the construction..

Peripheral walls of underground structures were built with SCC. Used fresh concrete reached flowability class SF3 (SF = 850mm, see Table 1) Hardened concrete was MB 40 . Columns of underground floors were also made with SCC. Flowability of fresh concrete was SF = 900mm, and class of hardened concrete was MB60. Concrete in foudation slabs was SCC, with flowability of fresh concrete SF = 900mm. Hardened concrete was MB40. Foundation slab thickness of 30cm provided complete watertight concrete.

These are only some of the most recent and most modern architectural buildings in which SCC was used. It is expected that the implementation of SCC in the future be more frequent and wider.

Basics in technology of self-compacting concretes are described in the following sections.

DEFINING THE PROPERTIES OF FRESH SELF-COMPACTING CONCRETE

Behaviour and usability of fresh self-compacting concrete can be defined with four key properties of fresh concrete mix:

- Slump-flow - flowability is a property of fresh concrete mix to flow and fully fill complex formwork under action of self-weight only. This is the first, essential property, and therefore it is always (e.g. with every new batch on construction site) necessary to perform the slump flow test.

- Viscosity is the resistance of the fresh concrete to flow once it has already started to flow. We can also speak of density of concrete as a fluid. Through terms of time we can gain an insight into rate of movement of fresh concrete mass. Low-viscosity concrete will have large initial flow and then it will stop. High-viscosity concrete will flow slowly but it will continue to move in a longer period of time. The reciprocal of viscosity is called fluidity. Fluidity can be defined as flowability in a certain period of time.

- Passing ability is a property of fresh concrete mix to find its way through congested reinforcement assemblies or small openings between reinforcing bars. When defining the necessary SCC passing ability, geometry, reinforcement quantity and arrangement, maximum aggregate grain size and previously adopted slump-flow and viscosity are taken into account.

- The dimension of the smallest opening (limit opening) through which the SCC must continually pass is defined. Testing of this property must be especially emphasised since in a large number of structures the reinforcing bars are spaced at a sufficient distance thus enabling SCC to bypass them without any problem and to fill the space between them.

- Segregation resistance – stability is a feature of maintaining constant content of all components in the mix during transport and placing, without segregation of coarser aggregate grains or water bleeding. If the stability of the mix is not sufficient, two types of segregation occur, in respect of time and place of occurrence:

1) *External segregation* occurs during transport or placing concrete into formwork. It is manifested by visible cement slurry bleeding in the first wave of concrete and by piling of coarser aggregate grains in front of obstacles or near the location where the concrete is placed into the structure.

2) *Internal segregation* occurs after the concrete has been placed into forms, before cement starts setting. Coarser aggregate grains settle in the lower layers of concrete section and cement slurry bleeds on the surface. Internal segregation has the worst influence in high elements (columns, walls). In thin plates this phenomenon gives weak surface finish and causes cracks.

Segregation resistance becomes a very significant parameter in self-compacting concretes with higher slump–flow classes or in placing which can be favourable for segregation (when placing concrete from a larger height or along longer flow path). Only in these cases it is necessary to define the segregation resistance class.

CHOICE OF MATERIALS

The following are the key steps in choosing materials for self-compacting concrete mixes:

Defining the type of aggregate, maximum grain size and grading curve. Maximum aggregate grain size is limited to 8 – 20 mm. Decreasing maximum grain size results in lower local stresses in cement paste, influences improvement of concrete workability without vibration and prevents segregation of coarse grains. In normal strengths, natural, river aggregate is used. With its smooth surfaces it contributes to better flowability and workability. Only in cases where high classes of hardened concrete are required, crushed aggregate can also be applied. Aggregate grading curve is usually continuous, with maximum quantity of fine aggregate.

<u>Adopting mineral additions:</u> Mineral additions are inorganic materials that are added to concrete. They are classified into two groups:

- Inert: Fillers which include powdered limestone, and pigments
- Pozzolanic or latent hydraulic additions: those are ground granulated blast furnace slag (GGBFS), fly ash (FA), silica fume (SF), synthetic silica and natural pozzolana.

The following are the most important properties of mineral additions: High level of fineness, high pozzolanic activity and compatibility with other ingredients of the mix. Moistened fine particles of mineral additions "lubricate" like spheres the cement grains thus reducing friction in fresh concrete mix. They give the concrete better workability and higher cohesion and impermeability. Water bleeding from fresh concrete mix is significantly reduced.

<u>Adopting the type and quantity of hydraulic binder:</u> As a rule, the mixture for SCC is designed with a large quantity of cement. Expected cement quantities are 350–500 kg/m^3. If reduction of hydration heat is desired when designing the mixture, cements with low hydration heat should be applied, a part of the cement mass should be replaced by puzzolana or special measures for reducing temperature of the fresh concrete mix should be provided. If high final strengths are desired, it is considered that it is absolutely necessary to use silica fume in addition to cement. Application of silica fume should be limited to 20–25% of cement mass. If additional quantities of filler are required, powdered limestone can be used. Thus 2 types of fine particles are added and a best package is achieved. Powdered limestone is an inert filler and silica fume can be considered to be both a filler and a latent hydraulic binder at the same time.

During the recent years microfine cements (for example, Mikrodur®, Nanodur®, Dyckerhoff products, Germany) have appeared on the market (Strunge J.and Deuse T., 2008). These are new types of cement having finer grain size and different order of magnitude of size of individual particles. Dense packing in cement rock is enabled by combining cement, microfine cement, finely ground blast furnace slag and synthetic silica. In a carefully developed production process, Portland cement clinker and blast furnace slag are separately ground to a desired fineness. Next, the components are joined in accordance with individual requirements in a special process. The final product has a guaranteed constant "granulometric composition" of fine, reactive particles instead of uniform "coarse" ordinary cement grains.

<u>Adopting the water/powder ratio, with simultaneous application of chemical admixtures.</u> Self-compacting concrete is much more sensitive to water content than ordinary concretes. The specified water quantity must be sufficient for chemical reaction with all hydraulic binders. Larger quantity of cement requires a larger quantity of water in a fresh mix. Further increasement of water quantity is necessary to increase the workability of fresh concrete but we usually remain at water quantity 150 – 210 l/m^3. The final water/powder ratio (by volume) is 0.85 – 1.10. The required flowability and other properties of fresh concrete are achieved by wide application of chemical admixtures.

Admixtures are materials which are added to concrete in very small quantities (compared to the cement mass) before or during mixing in order to achieve certain properties of fresh or hardened concrete. Specific admixtures have been developed for self-compacting concrete:

- <u>**high range water reducing admixtures - HRWRA**</u> Application of HRWRA provides fluidity of fresh concrete and reduces the required water quantity.
- <u>**Viscosity modifying admixtures-VMA**</u> increase the cohesion of fresh concrete and can replace a part of mineral additions. They have the effect of cement paste densifying and keeping fine particles within the matrix.
- <u>**Special admixtures for SCC – combined HRWRA + VMA**</u>: The majority of admixture manufacturers produce special admixtures for SCC which include both HRWRA and VMA within them. By application of these special admixtures, possible incompatibility in application of separate admixtures is avoided and desired viscosity of fluid mix is obtained.

CONCRETE MIX DESIGN

In SCC mix design, required quantity of individual concrete components is defined. In addition, it is necessary to achieve the following:

- The paste carries the aggregate grains. Therefore the paste volume has to be greater than the volume of voids between the aggregate grains. Each individual aggregate grain has to be fully coated and lubricated by a layer of paste. Thus the fluidity is increased and the friction between aggregate grains is reduced.
- Fluidity and viscosity of the paste have to be controlled and balanced by the choice and ratio of cement and admixtures. Limitation of water/powder ratio and application of chemical admixtures gives best results in obtaining required properties of concrete in fresh state.
- In order to control concrete shrinkage and temperature during the hydration process significant quantities of mineral additions and fillers are applied. At the same time, mineral additions increase the final strength of concrete.
- The coarse aggregate grains must be fully surrounded by mortar. This reduces coarse aggregate interlock when the concrete passes through narrow openings in forms or gaps between reinforcement. The quantity of coarse aggregate in SCC is always reduced.

As a result, concretes having the following in comparison to vibrated concretes are obtained:

- Lower coarse aggregate content with limited nominal maximum grain up to 20 mm,
- Greater total quantity of fines, lower than 0.125 mm (cement, active and inert mineral additions and finest aggregate particles),
- Increased paste content,
- Lower water/powder ratio,
- Increased quantity of superplasticisers or hiperplasticisers (HRWRA),
- Included application of viscosity modifying admixture (VMA).

In order to obtain the required properties of concrete in fresh and hardened state it is necessary to define the mix design method (procedure). The best known is the Method of mix design by Okamura, in 6 steps. The properties of concrete mix thus specified must be confirmed by laboratory testing in each step and corrected if necessary.

TEST METHODS

Behaviour of fresh, self-compacting concrete is not included in current codes for concrete structures. The existing methods used for testing ordinary (vibrated) concretes in fresh state are not suitable for SCC testing either. Therefore it is necessary to define the methods for fresh concrete properties testing and to give a relation between the set conditions at the moment of concrete placing and specified material properties.

Test methods are in the development and standardisation stage. Some of the most frequently used methods, (Specifications and Guidelines for Self-Compacting Concrete, 2002), properties that can be checked by a specific method, as well as recommended concrete classification, if it exists (The European Guidelines for Self-Compacting Concrete, 2005) are presented here.

Slump flow test and T_{500} time test

Slump flow gives an assessment of horizontal free spread (flow) of self-compacting concrete without obstacles. The method was developed in Japan from the well-known Abram's cone slump method.

Equipment: Metal cone 300 mm high, base 200 mm in diameter, top opening 100 mm in diameter. A rigid square plate measuring 700 - 1000 mm, with a marked centre of the cone and a circle 500 mm in diameter.

Procedure and basic measuring values: The cone is placed on the board, filled with concrete and then raised. Instead of measuring the settlement of concrete in the cone, the diameter of concrete circle SF = d is measured when the fresh concrete mass stops flowing. Slump flow is calculated as the average value of two measured diameters perpendicular to each other:

$SF = (d_m + d_r)/2$

This is a fast, simple method which is most frequently used both in laboratories and in construction sites. It gives a good assessment of deformability (flowability of fresh concrete) and can give visual information on stability. It does not give any information on passing ability of fresh concrete.

It is necessary and obligatory to define the slump flow class, SF, as the basic

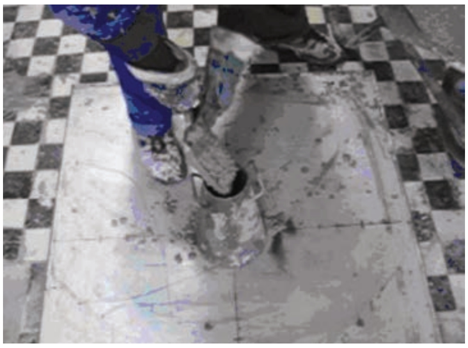

Figure 6: Filling the Abram's cone

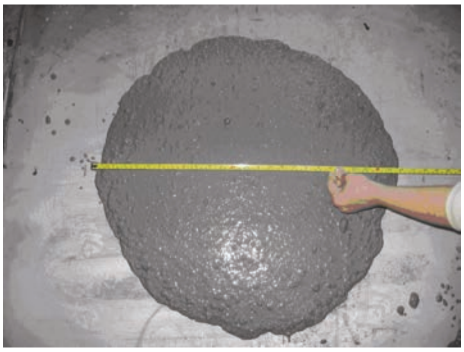

Figure 7: Resulting concrete spread 670 mm (class SF2)

Table 1: Proposed classification and criteria for SCC slump flow testing

Concrete class	Slump flow (mm) specified	Confirmation of required spread criterion
SF1	550 – 650	520mm $\leq d_m \leq$ 700mm
SF2	660 – 750	640mm $\leq d_m \leq$ 800mm
SF3	760 – 850	740mm $\leq d_m \leq$ 900mm
Stated value of spread concrete diameter	d_m	$d_m \pm$ 80 mm

characteristic of fresh concrete mix, in the concrete design. Three classes are proposed and the mark is derived as an acronym from the name of the test in the English language:

Application of concrete according to the introduced classes:

SF1 can be applied in:

- Slightly or non-reinforced concrete structures that are cast from the top with free spread from the delivery point (for example, floor structure slabs),
- Pumped concretes,
- Sections of structures that are sufficiently small to prevent larger horizontal flow (piles and some sections of foundations).

SF2 can be applied in majority of normal structures (walls and columns).

SF3 is usually applied in concrete with maximal aggregate grain size less than 16 mm, in elements with congested reinforcement, in structures with complex shapes of forms, if the forms are filled from below. SF3 class gives better surface finish than SF2 when the fresh concrete is placed normally vertically but the risks of segregation are higher.

In special cases self-compacting concretes with flow diameter greater than 850 mm can be required but then special care should be taken of control of all forms of segregation. In that case maximum grain of coarse aggregate should be less than 12 mm.

In case time required to reach the spread concrete diameter of 500 mm is measured, viscosity of the fresh mix can also be controlled. The planned classification is given in table 2.

V-funnel test and V-funnel test at $T_{5minutes}$

This method was developed by a Japanese team of researchers: (Haykawa M., 1993) and (Okamura H. and Ouchi M., 2003). The method is simple so it can be applied both in a construction site and in a laboratory.

Testing imitates flow of concrete during placing thus giving a good insight into viscosity and deformability of fresh concrete. Information on stability of the mix (segregation resistance) can also be obtained. The test is related to concrete with maximum aggregate size 20 mm. The basic value measured is time required for the concrete to flow through the funnel.

Equipment: Metal funnel, shown in the figure. The funnel width is constant and is always 75 mm. The top section is 450 mm high, the top opening is 515 mm long (the inclination of the funnel top part sides must be 2:1). The bottom, narrow part of the funnel is always 150 mm high and the size of the bottom opening with a movable bottom is 65/75mm. The funnel holder must provide stability and vertical position of the funnel during filling and emptying.

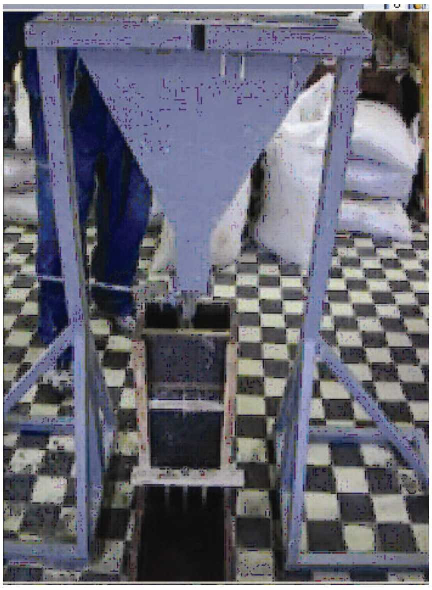

Figure 8: V–funnel test (Okrajnov–Bajić R., 2009)

complicated forms. It gives best surface finish. Coarse grain segregation and cement mortar bleeding must be specially controlled in these mixes.

VS2 / VF2 is a class with no upper limit. It is logical that the density of fresh concrete increases and that the formwork pressure decreases with increase with time. (appearance of tixotropic effects). Segregation resistance is improved. Possible negative effect is lower quality of surface finish (appearance of blow holes). More sensitive to stoppages in delivery of fresh concrete.

Viscosity testing is required in special cases. It is very useful information in concrete mix design. As additional information $\mathbf{T_{500}}$ can confirm constant concrete quality from one to the next batch during slump testing.

Table 2: Proposed SCC classes with parallel criteria for respecting methods

Concrete class	**T_{500} (s) , specified time of concrete flow to d_m= 500 mm,**	**Corresponding time of V-funnel emptying t_v (s)**	**Confirmation of required criterion (for emptying time of V-funnel (s))**
VS1 / VF1	$t \leq 2$	$t \leq 8$	$t \leq 10$
VS2 / VF2	$2 < t$	$8 < t \leq 25$	$7 < t \leq 27$
Target time for V-funnel emptying			$t - 3 \leq t \leq t + 3$

Measuring Procedure: The funnel is moistened and placed on a flat, stable base; a container is placed under the funnel. The funnel is filled with concrete using a scoop, without compaction. The movable bottom of the funnel is opened after 10 s and free flow of fresh concrete under gravity action is enabled.

Basic measure: The time from the moment of opening the movable bottom to the moment when light at the bottom appears is measured.

If viscosity is described as time required for the V-funnel to be emptied (time needed for fresh concrete to flow out so that light can be seen at the bottom), two classes are used: VS1/VF1 and VS2/VF2. The proposed classification of self-compacting concretes by viscosity was introduced in 2005 in European Guidelines for Self-compacting Concrete. It is described in the following table and it gives parallel criteria for the time for the concrete to flow out of the V-funnel and concrete flow time to diameter 500 mm, $\mathbf{T_{500}}$ (method described in previous chapter).

VS1 / VF1 has excellent filling ability even with congested reinforcement and in

L-box test method

This method, based on Japanese designs for underwater reinforced concrete structures, was described later (Petersson Ö. Et al. (1996). It is used as a primary method in testing passing ability of concrete through congested reinforcement (The European Guidelines for SCC, 2005).

Equipment: "L" shaped box made of rigid non-absorbing material is used. The longer side is placed horizontally on a rigid base. There is a moveable vertical gate at the connection between the two sections; immediately behind it there are vertical obstacles (usually one row of vertical rebars 3 Ø12 with a gap of 41 mm or 2 Ø12 with a gap of 59 mm). The dimensions of the box are defined [6] with tolerance ±1mm.

The basic dimensions which are measured are: $\mathbf{H_1}$ – height of concrete in the vertical section (immediately behind the moveable gate) and $\mathbf{H_2}$ – height of concrete at the end of the horizontal section of the L-box.

Procedure and basic measurement: The inside surfaces of the L-box are moistened and surplus water is removed. The gate is closed. The vertical section of the box is filled with concrete without compacting. The filled box is left to stand for 1 minute. The concrete is observed for appearance of segregation. The moveable gate is lifted and the concrete is allowed to flow freely through the vertical grid and to fill the horizontal section of the box. When the fresh concrete stops flowing, measure $\mathbf{H_1}$, the height of concrete in the vertical part (immediately behind the moveable gate), and $\mathbf{H_2}$, the height of concrete at the end of the horizontal part of the L-box. Both heights are calculated in three points, by subtracting the height between the edge of the concrete and the top of the box from the maximal height of the box. The passing ability (the ratio of concrete heights at the end and at the beginning of the L-box) is calculated and it gives an estimate of the passing ability of fresh concrete.

PA = H2 / H1.

The passing ability should be within the limits $0,8 \leq H_2 / H_1 \leq 1,0$, regardless whether L-box with 2 or 3 vertical rebars is used. If the blocking ratio is closer to 1.0, the passing ability of fresh concrete mix through the reinforcement cage and formwork filling are better.

The proposed classes for passing ability PA (The European Guidelines for SCC, 2005) occur depending on the size of the gaps between the rebars. Thus the following criteria are adopted:

- In case of thin slabs with clear distance

Table 3: Introduced classes and criteria for use in L-box testing

Concrete class	**Passing ability**	**Confirmation of the required criterion (for passing ability PA)**
PA1	$0.8 \leq PA$ with obstacle with 2 rebars	$0.75 \leq PA$
PA2	$0.8 \leq PA$ with obstacle with 3 rebars	$0.75 \leq PA$
specially defined passing ability of L-box		not less than 0.05 below specified value of PA

between rebars greater than 80 mm and for other structures with clear distance between 2 rebars greater than 100 mm, it is not necessary to test the passing ability;

- **PA 1**: in architectural buildings and vertical structural members having clear distance 80-100 mm between 2 reinforcing bars, L-box with 2 vertical rebars is used;
- **PA 2**: In heavily reinforced members of engineering structures having clear distance 60-80 mm between 2 rebars, passing ability is tested in an L-box with 3 vertical rebars.
- In complex structures having clear distance between 2 reinforcing bars less than 60 mm, the passing ability of the concrete shall be tested separately for the specific maximal aggregate grain and the specified arrangement and distance between the reinforcing bars.

In case of segregation, obvious blocking of coarse aggregate behind the vertical rebars can be detected visually. At the same time, the flow of the concrete in the horizontal section of the L-box is seriously slowed down.

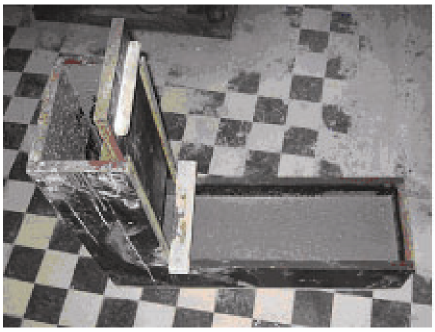

Figure 9: L-box

Figure 10: L-box

Testing using this method is shown in *Figures 9 and 10* (Okrajnov–Bajić R., 2009)

Summary of test methods: The number of methods proposed for standard SCC testing is large. It was expected that 1 test which would comprise testing of all properties of fresh concrete will be defined, but that proved to be an impossible requirement. Work conditions on construction sites require more simple and robust equipment (slump flow and T_{500}), while some of the proposed test methods have been used since the beginning of SCC making and thus there is abundance of data. However they are used in laboratory conditions (L-box, V-funnel, U-box). Segregation testing is performed by relatively new and unknown methods.

The following are shown as basic methods (The European Guidelines for SCC, 2005):

- Slump flow + T_{500},
- V-funnel – alternatively T_{500}
- L-box
- Sieve segregation resistance test. It is not presented here since it is relatively rarely specified.

CONCLUSION

Contemporary architectural buildings set new, high technological requirements. Concrete which appears in all contemporary architectural buildings adapts to these new building conditions. Thus, today we can speak of self-compacting concrete which is transported by pumps to heights even up to 600 m, about concrete which can be continually placed into congested reinforcement and which can be allowed to flow and can be placed into forms under the action of self-weight only, without vibration. Self-compacting concrete appeared as a response to increased conditions of reinforced concrete buildings durability and high-quality smooth surface of architectural concrete. As a material, it seeks new standards in production and control. These standards connect fresh concrete properties and possible application fields.

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Review paper

A NEW APPROACH TO RENEWAL AND PRESENTATION OF AN ARCHAEOLOGICAL SITE AS UNIQUE CULTURAL LANDSCAPE

Mirjana Roter-Blagojević[1], University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Gordana Milošević, University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Ana Radivojević, University of Belgrade, Faculty of Architecture, Belgrade, Serbia

In recent years, a series of students' projects have been carried out at the Faculty of Architecture of Belgrade with aims at protection and investigation of possibilities or presentation of archaeological sites dating from the Roman period, in which Serbia is very rich, and their active inclusion in modern way of life and tourist programmes.

The project for the revitalisation of the Roman military camp Timacum Minus was one of them. It showed that the students' involvement in resolving complex issues of the presentation and revitalisation of archaeological remains was fruitful because numerous fresh ideas were obtained in numerous subjects. The focus was on a concept that significant cultural and historic areas with ancient remains were to be presented to both the domestic and foreign public in a modern manner and in interaction with the environment, the natural beauties of the landscape. The projects enable to promote an interactive relation with the historic area as a place where visitors, at various activities, meet with history, but also with a reflection of a modern era.

Keywords: environment, landscape, revitalisation, identity, authenticity

INTRODUCTION

Taking care of the landscape values, which is often a specific synthesis of natural and constructed elements, started in 18th century in travel accounts of European educated elite. However, only in the 1920s a term cultural landscape was introduced for the first time, which lead to differentiating areas in our natural environment, that have gained value through human action (Stovel, 2003). At the beginning of the third millennium, the European Landscape Convention (Florence, 2000) linked the cultural landscape with a need to establish a sustainable development based upon balanced and harmonized relations between social needs, industrial activities and the natural environment. On that occasion, particularly emphasised was the significant role the natural environment had not only in ecological and living environment terms, but also in terms of cultural and social aspects. The landscape is a basic element of the living environment of the population, an expression of their common cultural and natural heritage and the foundation of their identity. (*European Conventions and Recommendations of Cultural Heritage, 2005*).

Considering that archaeological sites are a form of architectural heritage which is directly connected to its location and the natural surroundings, the primary goal of this research and the students' project presented in this paper is to examine the possibilities of reconstruction and revitalisation of the archeological site Timacum Minus, located in the village of Ravna near Kneževac. This is to be achieved by including this site in modern development of the whole area as a specific cultural landscape. Students' project was inspired by the need to change our understanding of preservation and revitalisation of archeological sites in our country, which is mostly based on presentation of the conserved remains of structures as an individual historical and cultural object, without any interaction with its immediate and wider surroundings.

This students' project is directing the publics attention to a neglected archeological site that has not only considerate natural, cultural and historical value as a unique cultural landscape, but also has great potential for cultural tourism and development of traditional forms of work, like growing grapevine and making wine, which have been present there since the ancient times. It also stresses the need for greater inclusion of international cultural heritage charters and recommendations in the planning process for maintaining authenticity and traditional values of historical sites, their architectural and intangible heritage, as well as a modern understanding of the role and usage

[1]Bulevar kralja Aleksandra 73/II,11000 Belgrade, Serbia
roterm@arh.bg.ac.yu

Figure 1: Badenweiler, Germany, Roman bath, shelter 2001

(photo U. Wulf-Rheidt)

of protected historical sites as a basic part of integral sustainable development of the region.

CONTEMPORARY APPROACH TO PRESERVATION AND PRESENTATION OF ARCHAEOLOGICAL SITES

Introduction of the term cultural landscape had its influence in changing the views on protection of archaeological sites and the presentation of the remains of structures within the sites. Erection of various protective structures – from provisional or permanent ones over the conserved remains of structures (Schmidt, 1988) – today is an obsolete form of protection and presentation because it interrupts integrity of the site and gets in the way of viewing its authenticity and entirety. Furthermore, it is considered that archaeological parks arrangement solely as tourist and recreational zones, where the conserved remains of structures are presented, or the remains of structure parts of particular style are exhibited in specially and newly erected buildings exhibiting stone fragments, sculptures and other items, does not help in having an insight into the real values and meanings of the site, its erstwhile appearance and understanding of the functions and meanings of the preserved structures.

Observing historic sites in their interaction with the environment has its influence on a change of the way we relate to areas with archaeological remains of structures, particularly those outside the modern settlements. Those are the sites that can be characterised as cultural landscape, since there are manifested interaction and solid linkage between the traces of human activities and natural environment, of their natural features and traits which had an impact on people in a distant past to remain on one place, to settle there and build all sorts of structures. Archaeological sites can be classified as organically generated landscapes, as they came about out of social, economic, administrative or religious needs, and in their present form they exist as an expression of assimilation with the natural environment or as a response to it.

In types of cultural heritage, thus in archaeological sites, there are numerous problems initiated in the protection activities and through attempts to include them in modern way of life. One of the most important problems is the site authenticity preservation while undergoing protection and renewal interventions. According to the *Nara Document on Authenticity* (UNESCO, ICOMOS, ICCROM, 1994), a historic site should be a true testimony of the culture and tradition it represents, and its authenticity is an expression of tangible and intangible aspects of a structure (Jukilehto, 2003). In the issue of archaeological sites, it was the insistence on the significance of the authenticity preservation of structure remains that had its influence in the past to make a presentation of the preserved building remains a primary goal, and restoration and ideal reconstruction to be just a secondary activity. But the modern times and a need for site revitalization and utilisation ask for a more active approach, meaning restoration or ideal reconstruction of structures, as well as building new structures on archaeological sites so that they could be utilised in a more active fashion. In partial or total restoration or reconstruction of structures, a new quality of the site „authenticity" is achieved, or better still, the presentation of its erstwhile appearance. The intangible aspect of authenticity linked to the substance of the site and the place and structure purpose is regenerated through modern presentation, thus trying to recall to life the lives of people, traditions, rituals, etc.

The issue of the site integrity preservation, the state a site has acquired up to the present day, is also manifested in archaeological sites in particular. Modern protection concept tries to preserve the visual, structural and functional integrity of a site. Any activity in the historic area, even the smallest intervention for purposes of its presentation as a monument of culture, represents a new purpose and imposes numerous alterations in the spirit of modern times. Recommendation concerning *Safeguarding and Contemporary Role of Historic Areas* (UNESCO, 1976) advises us that every historic area and its surroundings should be considered in their totality as a coherent whole whose balance and specific nature depend on the fusion of the parts of which it is composed and which include human activities as much as the buildings, the spatial organization and the surroundings (Jukilehto, 2003). This is particularly important for archaeological sites, in which certain balance should be established between the condition they were found in and new up-to-date interventions in regard to their protection, presentation and utilisation in the modern times.

Figure 2: Pergamon, Turkey, Hellenistic-Roman peristiyle building, shelter 2004

(photo: U. Wulf-Rheidt)

Modern approach to archaeological heritage, especially when regarded as integrated with its natural environment, should place human development as an aim of its protection and presentation, within the spirit of recommendation concerning *Safeguarding Cultural and Natural Heritage* (UNESCO, 1976), thus regarding it as one of the basic components of regional development plans and planning in general (Jukilehto, 2003). If the role which archaeological sites as elements of cultural landscape have in the frame of sustainable development of a region, where this development is based upon balanced and harmonised relations between the needs of minor and major social community, industrial activities and living environment, inclusion of the sites in modern life activities of communities could be made possible. In revitalising archaeological sites and in their inclusion in modern-age activities, an interconnection of cultural and natural heritage could be made manifest, as the foundation of an identity of a place. In this way, via preservation and presentation of an interaction between a man and the nature in an area through centuries, an essential quality of an area is singled out, which defines the character and the meaning of a place. (Đokić et al., 2008, pp. 86-87.)

INVESTIGATING POSSIBILITIES OF PROTECTION AND PRESENTATION OF ARCHAEOLOGICAL SITES THROUGH EDUCATION AND STUDENTS' PROJECTS

Involving education in the process of protection of cultural and natural heritage is one of the prerequisites of its successful outcome. For that reason it is very important to actively involve the immediate social community, the members of the population of a particular area and their local authorities and get them acquainted with the values and potentials of historic areas and archaeological sites. As particularly important form of education is involvement of students of archaeology and architecture in workshops, who in the process of site investigations are to design various ways of presentation of the remains of structures on the site and their utilisation as an aspect of the area revitalisation (Felix Romuliana, 2007).

It was the need for education of the future builders, who will be, in their practice among other tasks, dealing with issues of archaeological site presentation, that became the basic reason for initiating work with students on complex projects at the School of Architecture of Belgrade (Kurtović-Folić, N., Roter-Blagojević, M., Jadrešin-Milić, R., 2006). In order to carry out projects of different character and needs, three ancient sites in southeast Serbia were picked out, all with specific problems of protection and presentation: a section of the necropolis of the ancient Naissus (Niš), a section of an ancient settlement with villas in Mediana nearby Naisus and the immediate area around an ancient fortification and settlement of Timacum Minus nearby Knjaževac.[2]

The aim was getting the students acquainted with modern principles of and approaches to preservation, protection and revitalisation of cultural heritage and the need for associating education from the field of protection with a cultural dimension of safeguarding intangible heritage of a site along with its identity as an expression of both global and local influences. (Neuckermans, 2004)

Natural and cultural values of the Roman military camp Timacum Minus near Knjaževac and the state of their protection and presentation

One of the most significant ancient cities in the central Balkan region is Naissus. The settlement was formed in the middle of a glen which was a crossroads of several important roads and was also quite suitable for agriculture and livestock farming. The position of the city at a crossroads, fertile land and favourable locations of mines along the slopes of the surrounding mountains offered good conditions for an economic development of the town and its important place in commercial activities. These natural advantages enabled a steady development of an ancient town, but also of other settlements in the Niš valley.

The town is believed to be the birthplace of the emperor Constantine the Great. Since the emperor and his successors often visited the town, it grew into an important Roman settlement with the imperial residency. *Naissus* was a significant stop on the old military road which connected the present day Arčar in Bulgaria (*Ratiaria*) and Lješ (*Lissus*) in Albania. To the north the road led to Belgrade (*Singidunum*) and to the east to Constantinople.

In the area of greater Niš many local roads were built (*viae vicinales*), whose directions have been confirmed by the arrangement of stops along the roads, remains of settlements and necropoleis. *Timacum Minus* was located in the Timok region, in the village of Ravna, where the remains of a military camp, civilian settlement and necropoleis have been discovered. It is thought to be the oldest Roman fortification in the Timok region, on the area of about 2 ha. The oldest remains of an earthen fortification with palisades and wooden square towers and a defence moat, date back to the mid 1st century A.D. In the mid 2nd century. a new stone fortification was built, and in the late 3rd century, the renovation of the existing ramparts was done and the square towers were built. The parts of the ramparts and of one tower were reinforced anew in the mid 4th century and again in the second half of 4th century, when towers of rectangular plan were built, using the technique opus mixtum. The fortification was destroyed in a fire in 5th century (Petrović, 1986; Petrović, 1995).

Figure 3: Roman military camp Timacum Minus near Knjaževac

Inside the fortification, along the via principalis, a part of a building was discovered, a granary (*horreum*), dating from 4th century. In the fortification corner there are traces of a rotund structure which was probably a cistern or some other building serving for ore processing. The traces of a civilian settlement have been found on the south side of the fortification and most probably date from 2nd – 3rd century. There are baths (*thermae*) at the bank of the river Timok, built and utilised from 2nd to the late 4th century. The findings of architectural elements and a sacrificial altar suggest that there were temples within a settlement. At the outskirts of the settlement a necropolis has been discovered, dating from the second half of 4th century and first half of 5th century. Also, tombstones have been preserved, originating from another early Roman necropolis in the vicinity, where they were taken from and built into the fortification towers and ramparts.

The area of the Roman camp *Timacum Minus* today is under protection and archaeological investigations are being conducted on the remains of the fortification walls, the towers and the camp gates. Conservation works have been performed in accordance with the modern approaches, based upon a concept of protection and presentation of the remains in the state they have been discovered. With time, the remains that were presented on lower levels were being gradually covered with a debris. There are no information billboards on the site, which makes it unappealing and unintelligible for visitors.

[2] For the revitalisation projects for the archaeological site of Mediana near Niš (2004-05) and the revitalisation projects for a Martyrium and a Basilica in Jagodin mala of Nis (2005-06) mentor was N. Kurtović-Folić. For the revitalisation projects for the archaeological site Timacum Minus nearby Knjaževac (2007-08) mentor was M. Roter-Blagojević.

Figure 4: Village of Ravna, archaeological and ethno complex

In the immediate vicinity of the ancient remains there is a village of Ravna where an archaeological and ethno complex has been established. It is situated in a courtyard of a village school dating from 1906, which represents a rare preserved example of a school building from the early 20th century in this region. Today, the school building is used to house the researchers, archaeologists and ethnologists, but also as a workshop and a storage for keeping archaeological findings. Besides the school, there are two village cottages presented, which were brought from the area along the river Beli Timok, representing typical folk architecture from the late 19th and early 20th century. There are also presented some structures of industrial interest, a barn and a pot still for making brandy. In the 1920s, these old buildings were displaced and are made a museum area. A larger building houses the museum of wines that are traditionally made in this region. In the schoolyard, around an old well, a small area with early Roman tombstones and stone fragments was created.

Although this archaeological and ethno park of the village of Ravna has been included in a programme for tourists visiting the region of Stara Planina, there are few visitors and the area of the military camp is rather unappealing to tourists because of its appearance of a neglected site.

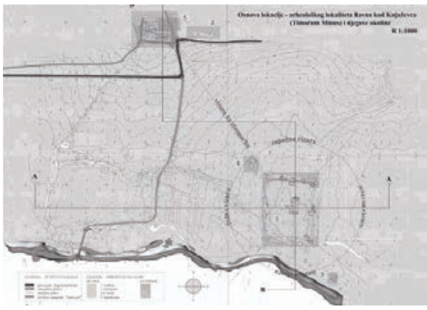


Figure 5: Village of Ravna, position of archaeological and ethno complex

Methodology and the content of the work with students

Investigating the possibilities of revitalising and reviving protected historic places of a very rich past and significant cultural values, the student were confronted with important professional issues of integrating modern functions and typologies of structures into areas containing preserved remains of old structures, and with issues of finding a concept of their active utilisation under modern conditions. The aim was for the students to master the methodology necessary for proper understanding of the problems with regard to integrative protection of the architectural heritage and for providing sustainable solutions which are to enable safeguarding and revitalisation of the cultural and historic heritage not only as a bearer of a cultural identity, but as an important source of economic and social development of a country, as well (Prodanović, 1997)

Involvement of the students and professors of the School of Architecture of Belgrade, with the assistance of the architect of the Institute of Archaeology of Belgrade, in carrying out these projects, was also supported and made possible in collaboration with archaeologists from Knjaževac, which has created a valuable co-operation of education and scientific institutes with the local authorities for purposes of finding creative ideas and most suitable solutions for improvement of archaeological sites. The aim was to view the site area through the students' eyes and to investigate as many as possible different ideas of its future life, but without imposing too rigid institutional framing and restrictions.

For students it was opportunity to check up their creative abilities and a capability of respecting numerous mandatory restrictions imposed through principles of protection and the very character of the place, in order to produce modern, resourceful and innovative solutions. In the work on these projects, the students improved their education substantially, because, while working on the project and through contacts with their professors and other professionals, they mastered some specialised skills and knowledge, which is to be of great help to them in dealing with similar issues in their further practice.

In the first stage of project, the focus was on a through understanding of the place itself, its cultural and historic meaning and natural values. A very detailed investigation was conducted of the existing documentation on the researched structures and the relevant literature on the culture, customs, ways of life and architecture of the investigated period. In addition, historic conditions were investigated, those when the historic places in question had originated, the presumed course of their development, architectural and construction characteristics of structures, building techniques, types of materials and ways of their utilisation, etc. The aims was to set a correlation of the architecture of structures discovered on the investigated sites and of those of the same purpose and significance discovered on other sites elsewhere in Europe. Such a method is important for creating a picture of universal values of the sites and structures, but also of particular values that the local characteristics yield (Pucar *et al*., 1998)

At this stage of work, the students got acquainted with various methods and approaches in presentation of archaeological remains, which were being implemented on numerous other archaeological parks both in the world and in the immediate surroundings. The aim was for students to comprehend advantages and disadvantages of various methods – from the most minimal interventions, entailing only presentation of the conserved remains and anastylosis, up to the extensive works on partial or complete reconstructions of the assumed authentic architecture.

The work on comprehending the meaning, character and values of a site, as well as development, and revitalisation potentials, was extremely significant because it constituted a basis for further work and had an impact on investigating the most suitable approach to presentation and emphasising tangible and intangible values of a site, as well as understanding it in the interaction with its natural environment.

After thoroughly conducted analyses and valorisations, the next step was defining a protection concept for archaeological remains and arrangement of the site ensemble. In their group work on urban concept of the site ensemble, the students created a future presentation of the archaeological remains and a character of the area purpose. They analysed the arrangement, shapes and volume of newly built structures. Special attention was paid to arranging green, vegetation and common areas, traffic, pedestrian paths, small piazzas, benches, lighting, information billboards, etc.

The final purpose of these students' activities was an elaboration of certain area sections, as well as preliminary detailed designs of archaeological remains of old structures presentation or designing new modern structures for housing new contents. Depending on how they relate to historic heritage and natural qualities of the area, the students selected their own methods of protection of archaeological remains – conservation, restoration, ideal reconstructions or building protective structures. In newly designed structures, they had an opportunity to express their own approach to shaping them within a historic context, to selecting a structure and materials and to an appearance of the newly built structures.

Students' approach to integration of archaeological remains into a cultural landscape

Although the issue of historic site treated in the students' project was quite difficult, the final outcome of the activity showed that they all students had similar views on the issue of revitalising archaeological sites and their integration into the modern course of life. A desire for changes and creative approach to the natural and architectural environment were common to all the offered designs.

Figure 6: Student' project of revitalization of Village of Ravna, new structures situated between archaeological and ethno complex (design: J.Brajković and D. Vojinović)

The project carried out with the students had its particularities of presenting archaeological remains of a Roman military camp as part of a cultural landscape, connecting exquisite natural values of the area along the Beli Timok river banks and Stara Planina mountain with the tradition and ethnographic features of the life and activities of the people who lived there. The task of the students' projects was to revitalise the area around the present village of Ravna by means of connecting it with the remains of the Roman military camp and other ancient structures and with a newly established ethno park where the traditional village cottages had been moved to and presented.

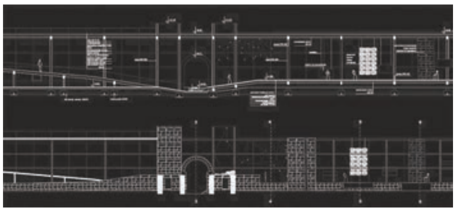


Figure 7: Student' project of the presenting archaeological remains of a Roman military camp (design: J.Brajković and D. Vojinović)

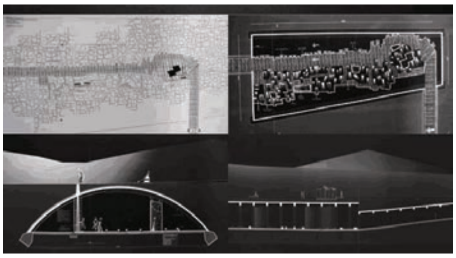
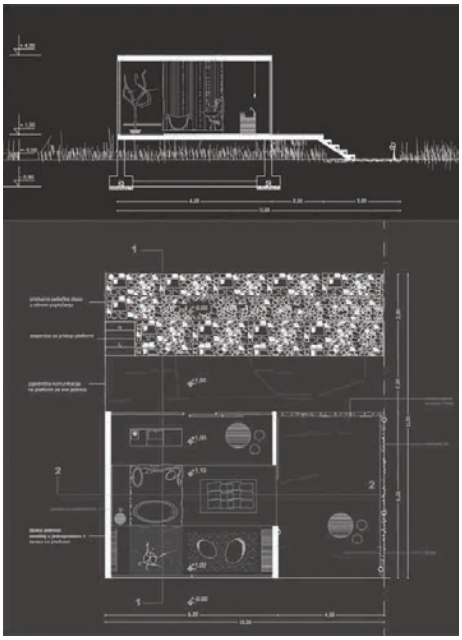


Figure 8: Student' projects of the presenting archaeological remains of a necropolis (design: J. Brajković and D. Vojinović)



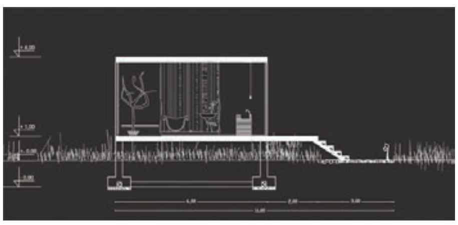


Figure 9 and 9 a: Student' projects of the new houses for tourists accommodation

(design: J. Brajković and D. Vojinović)

The aim was not only to protect and present the historic remains dating from the times of antiquity, but to revitalise traditional features of the place through restoring a link between the structures built in the ancient times and those of modern ones. This would transform the place into a cultural, scientific ensemble of tourist interest, a future centre of cultural tourism of a broader area.

In their work, the students focused on reviving the tradition of growing grapevine and making wine, the activity that has been going on since the ancient times, which may contribute to an economic development by means of creating small private wineries. In addition, the favourable environmental conditions, the vicinity of the river and the presence of ancient baths inspired the students to propose revitalisation of the area through providing a recreational function and building a spa centre. In shaping the tourist facilities, they looked into a possibility of creating a reinterpretation of an ancient house with an atrium or traditional village cottages. A desire to preserve the natural values of the place and its rural character led the students to propose a minimum of interventions on conservation and partial restoration area of the military camp with a storehouse at its centre, which would help visitors understand an authentic look of the structures and their purpose.

CONCLUSION

At archaeological sites, numerous problems are initiated in the protection activities and in attempts to include them in the modern way of life. The insistence on the significance of the authenticity of preservation of the structure remains had its influence in the past to make a presentation of the preserved building remains a primary goal, and restoration and ideal reconstruction to be just a secondary activity. But the modern times and a need for site revitalization and utilisation ask for a more active approach, meaning restoration or ideal reconstruction of structures, as well as building new structures at archaeological sites so that they could be utilised in a more active fashion. In revitalising archaeological sites and in their inclusion in modern-age activities, an interconnection of cultural and natural heritage could be made manifest, as the foundation of an identity of a place.

Observing historic sites in their interaction with the environment has its influence on a change of the way we relate to areas with archaeological remains of structures, particularly those outside the modern settlements. Erection of various protective structures – from provisional or permanent ones over the conserved remains of structures – today is an obsolete form of protection and presentation because it interrupts integrity of the site and gets in the way of viewing its authenticity and entirety. Furthermore, it is considered that archaeological parks arrangement solely as tourist and recreational zones - where the conserved remains of structures are presented, or the remains of structure parts of particular style are exhibited in specially and newly erected buildings exhibiting stone fragments, sculptures and other items - does not help in having an insight into the real values and meanings of the site, its erstwhile appearance and understanding of the functions and meanings of the preserved structures. Supporting an active role of the places with the preserved cultural heritage is an expression of a desire to make them active participants in the modern life, to bring to life their significance and the function of an initiator of economic, social and cultural development of the whole community.

The projects showed that the students' involvement on resolving complex issues of presentation and revitalisation of archaeological remains was fruitful because numerous fresh ideas were obtained in numerous subjects, and some of them have been accepted by the local authorities and their realisation has been arranged. The focus was on a concept that significant cultural and historic areas with ancient remains were to be presented to both the domestic and foreign public in a modern manner and in interaction with the environment, the natural beauties of the landscape. The projects also showed that an appealing presentation and active use of the remains of ancient structures, integrated in the modern way of life, would enable certain economic gains for a local community, which could be a source of means for the area maintenance, research and protection.

The whole concept promoted a necessity of co-operating between a local community and education and scientific institutions. At the same time, the idea encourages participation and training of the future professionals who, in their practice, are to encounter restoration and revitalisation of old structures or design new ones within a protected area. Furthermore, the projects help develop the public awareness of the significance of safeguarding architectural heritage as an element of cultural identity and a source of inspiration and creativeness of the present and future generations. Thereby the programme of safeguarding and presenting archaeological heritage was significantly improved because it revealed a need for understanding the natural and cultural heritage as an important factor that defines the future politics of the region development planning.

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Review paper

THE INFLUENCE OF PROTECTED NATURAL AND CULTURAL HERITAGE ON LAND MANAGEMENT/MARKET – THE CASE OF SLOVENIAN NATURAL PROTECTED AREAS

Anka Lisec[1], University of Ljubljana, Faculty of Civil and Geodetic Engineering, Ljubljana, Slovenia
Samo Drobne, University of Ljubljana, Faculty of Civil and Geodetic Engineering, Ljubljana, Slovenia

This article is focused on finding problems in land use domain in the areas of protected natural and cultural heritage. In the paper, the influence of special regulation in the natural and cultural protected areas on land management is presented. The paper gives an overview on history of cultural heritage and nature protection initiatives in Slovenia and provides a review on basic EU and international initiatives, conventions in this field. For the case of Slovenian rural land market, it highlights the problem of complex institutional regulations relating to land management in the protected areas, which affect mostly local people. Here, the impact of the protected regimes, the case of pre-emption right, on land management and consequently spatial development in local communities is stressed, which is an important topic in particular in less developed regions since restriction of land use often means more complex, costly and time lasting procedures in land management and less opportunities as the consequence.

Key words: land management, pre-emption right, land market, protected areas, national park, landscape park, Natura 2000, Slovenia

INTRODUCTION

Nowadays, environmental issues are still often presented within the framework of natural sciences and the major problems are most commonly described as ecological threats in the form of pollution of the air, water and soil. Despite several studies and international conventions about the suitable spatial development and land management for sustainable development of the society, there is often a missing link between environmental issue and spatial planning/ land management domains. Here it has to be highlighted, that the influence of real property restrictions on land/ property management procedures due to environmental protection regimes is often neglected in the environmental protection initiatives, strategies and consequently also in legislation. On the other hand, from the land management perspective, the environmental issue is rather subordinate to land development, establishment human settlements, urbanization as well as intensive use of rural land, which brings about many types of environmental change, including landscape degradation. These discrepancies in environmental and spatial development policy are being reflecting at the local, national as well as world scale – just to mention problems with food security and water supply, environmental degradation including deforestation, desertification etc.

Environmental issues differ from country to country in association with the environmental setting, the characteristics of development and national preferences and priorities. However, policies promoting sustainable development and preservation of a qualitative environment have become a common issue worldwide. To create a balance between development and conservation interests is consequently one of the most crusial planning tasks, including in spatial planning and land management. Here, it is obviously impossible to look only at the conservation aspects, as already stressed by Larsson (1997). They must be instead considered in the light of possible disadvantages for activities that are normally carried out in the community. The most common aim of conservation is multiple land use, which is clearly better if the conservation requirement can be fulfilled without drastic infringement on the normal activities in the area. Therefore, conservation does not mean retention of a status quo. Goals for keeping a landscape or an environment intact for posterity have museum or antiquarian purpose only in special cases. It is more common to

[1]Jamova 2, 1000 Ljubljana, Slovenia
anka.lisec@fgg.uni-lj.si

include a certain amount of development in the term "conservation". The aim of conservation should not be to place a dead hand over an area, but to make it function in an active and natural way, while preserving the qualities that have made it worthy of protection. For these reasons, preservation of our environment, cultural and natural heritage is a complex term and is not a sector task, but rather an objective that should permeate all activities in a community. An enormous number of aspects is involved here (Larsson, 1997).

In our paper, only some of conservation aspects are studied, primarily those that affect land management and in particular restriction of property right due to protection policy. World Commission on Environment and Development states that the principal concern of any country in the world is to define and better understand the interrelationships between population, environment, natural resources and economic development for the purpose of realising, collectively known, sustainable development (United Nations, 1987). From these perspectives, we try to highlight the impact of real property rights restrictions due to protection of natural and cultural heritage on land management procedures. Legal/ institutional framework in protected areas might significantly affect land management procedure and consequently influence environmental, economic as well as social development of the community. For the case of Slovenian protected areas (natural protected areas) we analysed the procedure of rural land sale and compared with the procedure of rural land transactions in non-protected areas.

Land and right to land use

Traditional connection between a human and land derives from the fact that land has always been the elementary source for human in the way of providing the space to live and to act. Here, land must be seen not as an isolated physical unit of the surface of the Earth or part of the diverse landscape, but as something integrated into the whole of society with its rule, institutions, and socio-economic characteristics. The relationship between human beings and the land is of fundamental importance in every society and is evident in the form of property right, which is one of the elementary human rights. Rights describe what may be done with property; they are abstract but none the less real in their effect. However, property right is not an absolute right. Governments determine how land is to be developed and used in a variety of ways (Dale and McLaughlin, 1999). Various incentive instruments are available for encouraging land to be used or developed, such as preserving prime agricultural lands, natural and cultural heritage, biodiversity etc. through the restricted property rights and land use control (*Fig. 1*), in support of public policy objectives, which nowadays follow the concept of sustainable development.

Land use control and sustainable spatial development

Efforts to control land use date back to civilisations in Mesopotamia and the Nile delta when the earliest recorded land surveys for the control of land use were evident. Modern concepts of land use planning and control date back to the middle of the nineteenth century and to the rapid growth of urban populations resulting from urbanization in Europe. After the Second World War, support for community planning and land use control grew rapidly in the developed world, which was partly the consequence of post-war economic development and urbanization (Dale and McLaughlin, 1999). During the 1970s people became more concerned about the environment and at the first Conference on Human Environment the concept of sustainability was adopted (United Nations, 1972). Prior to this time, development was assessed mainly on the basis of engineering and economic feasibility (often through the use of cost-benefit analysis) with limited concern for the impact on the environment at large ways (Dale and McLaughlin, 1999). While the first initiatives of environmental assessment had been manly focused on ecological aspects of land use change as an example, the reviewed concept of sustainability brought a new dimension of sustainability in the beginning of nineties, officially at the United Nations Conference on Environment and Development (the Earth Summit) in 1992, by adoption of Agenda 21 (United Nations, 1992). There remains no consensus in the exact meaning of the term; the most widely cited definition of sustainable development is provided in so called Bruntland Report (United Nations, 1987) as "development that meets the needs of the present generations without compromising tha ability of future generations to meet their own needs".

The needs of property rights holder as well as the need of the society, trying to follow the guidelines of the sustainable development, call for harmonization, effectiveness and transparency of the procedures in spatial planning and land management fields. A special challenge refers to the protected areas where additional restrictions of land use are usually shaping development of the area. Numerous regulations of land use and land development are often fragmented among different institutions, communities and are consequently untransparent for property rights or land use rights holders. If land resources are to be used in an optimum fashion then the management of land and its associated resources must operate within an integrated state land policy, supported by efficient and transparent legal/ institutional framework. As such it should service the needs both of the individual and of the community at large.

Nowadays, nations are building genuine partnerships between communities and land owners, so that environmental and business

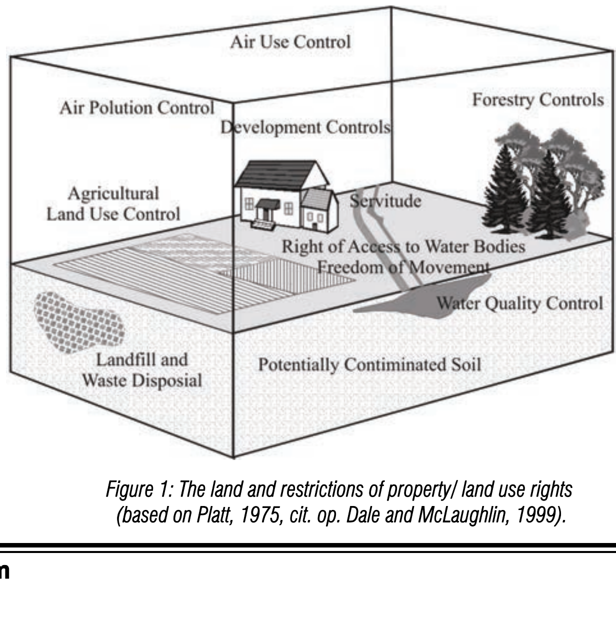

Figure 1: The land and restrictions of property/ land use rights (based on Platt, 1975, cit. op. Dale and McLaughlin, 1999).

controls are more mutual endeavours. Rather than approach controls as restrictions, the nature of ownership is redesigned to define opportunities of owners within a framework of responsible land uses for delivery of environmental and other gains. This stewardship concept is familiar to Europeans long used to the historical, social and environmental importance of land (Williamson et al., 2006). In the protected areas, the individual interests of the land owner are additionally limited and have to be harmonized with the guidelines and regulation of protection policy. Trends of cultural heritage and nature protection show that sectors link different policies by implementing measures proposed by concerted, however still independent, programmes for management of different protected areas.

Considering the above mentioned facts, the protection policy might significantly influence spatial development programmes and consequently land management when looking bottom-up. The concept of land management is a comprehensive expression for activities aiming to fulfil established goals for the use of certain land resources, following institutional regulations. Land management is thus a game with many actors, all having different roles and only when this roles are known and transparent, the system can function as it should.

PROTECTION OF NATURAL AND CULTURAL HERITAGE FOR SUSTAINABLE DEVELOPMENT

Interanational initiatives for protection of natural and cultural heritage

There is a tremendous need for careful and skilled management of all systems which affect the quality of life in order to provide opportunities for environmentally sound development (FIG, 1991) as well as for socially development, where landscape protection, including preservation of natural and cultural heritage, has a special place in each society. It is interesting, that the roots of protecting the natural and cultural heritage in the human living space were mainly due national identity and not so much because of environmental or natural protection policy. However, while the concept of cultural and natural heritage only recently comes into being, the conservation efforts date back into 19 century. As stated by Jax and Rozzi (2004), it started around the protection of the home country or home landscape. The cultural heritage can provide the basis to understand the identity and traditions of the community, nations (Mazzanati, 2002). On the other side, the natural heritage can contribute to comprehension of the environment where we live, and relation between communities and their environment.

The leading role in the world scale in the field of conservation of nature has been played by the International Union for Conservation of Nature (IUCN) and the World Commission on Protected Areas (WCPA) within the IUCN. The current IUCN Programme 2009-2012 "Shaping a sustainable future" is aiming to contribute directly to targets agreed internationally by governments to reduce the rate of loss of biodiversity, and contribute an environmental perspective to the achievement of the Millennium Development Goals (United Nations, 2000), the Plan of Implementation of the World Summit on Sustainable Development (United Nations, 1992), and other relevant international commitments (IUCN, 2008). IUCN provided also definition of an protected area, which is an area of land or sea, specifically intended for the protection and conservation of biodiversity and the natural and associated cultural wealth, and the administration of which is governed by law or any other effective form of governance.

In the field of protecting natural and cultural heritage, the UNESCO (United Nations Educational, Scientific and Cultural Organization), which was established after the Second World War with the main aim of protecting the world heritage, holds a significant role in the world scale. Although at the beginning the world heritage mainly referred to archaeological sites, historical buildings (architectural heritage) and museums' collections, the notion of heritage changed with the Convention for the Protection of the World Cultural and Natural Heritage declared by the UNESCO in 1972. With this declaration, the notion of the heritage expanded in a great extent to natural heritage as well (UNESCO, 1972). In the following decades, the idea of heritage was popularized. Nowadays, the heritage is generally understood as those we inherited from the past and we should, enriched by our knowledge and value system, pass to the future generations. In the framework of UNESCO, the World Heritage Centre (WHC) was established in 1992, which works closely with the technical advisory body on natural heritage IUCN to ensure the long term protection and conservation of natural heritage sites and their World Heritage values.

Nature protection policy in Slovenia

The origins of the nature conservation in the territory of Slovenia date back to the Illyrian Provinces (1809-1814). In the second half of the 19th century, when Slovenia was part of Austrian-Hungarian monarchy, the Virgin Forest of Rajenhaf in the area of Kočevje, southern part of Slovenia was protected. At the end of the 19th century some province enacted legal provisions concerning the menaced species of plants and birds (Piskernik, 1965; Peterlin, 1975).

Most likely stimulated by establishment of the first national park in the world in the United States of America in 1888, the Slovenian seismologist and naturalist Albin Belar (1864-1936) proposed the conservation of the region above mighty cliffs of Komarča in 1908. The idea matured until 1920, when the Slovenian Musemu Society prepared the Spomenica Memorandum, the first comprehensive Slovenian natural protection programme, which set initiatives to establish several parks, including a proposal for a nature park in the Valley of the Triglav Lakes. The first result of this proposal was in 1922 with protection of the menaced species of plants and animals, as well as the caves. With the acceptance of the proposal for establishment a nature park in the Valley of Triglav Lakes in 1924 for 20 years, Slovenia became the fifth European country, after Sweden, Switzerland, Spain and Italy to have a national park. During the Second World War the validity of contract expired and the national park formally ceased to exist. The protection was restored in a somewhat enlarged scope in 1961. However there were technical plans and discussion for enlargement of the national protected area. Today known as Triglav National Park has been protected in its present extent with 83,807 ha since 1981 (Piskernik, 1965; Fabjan, 1985; Skoberne, 1991; Lukan Klavžer and Šolar, 2003).

The improvements and systematic regulation of nature protection after the Second World War led to new protected areas in Slovenia. In 1945, the Presidency of the Slovenian Nation Liberation Council Issued its Decree on Protection of Cultural Monuments and Distinguished Natural Features, which was the basis for the in 1948 adopted the Cultural Heritage Monument and Outstanding Natural Features Protected Act. Based on this act, the first landscape park Rakov Škocjan was established in 1949. While the act from 1948 did not allow the possibility of promulgation of protected areas at a local level, the Cultural Heritage Monument and Outstanding Natural Features Protected Act from 1958 proposed this option. In 1970 Slovenia continued tradition with natural protection and adopted the Natural Protection Act which set the framework for the development of a system of nature conservation and divided responsibilities between republic and municipality level. The Natural and Cultural Protection Act from 1981 further brought new challenges – it introduced the term "natural heritage", whereby natural and cultural heritage were being delt with within the same Act. Special parts of natural heritage could be declared as outstanding natural features according to the Natural and Cultural Protection Act (1981), which was the legal basis for the protection of most today's regional and landscape parks in Slovenia (Elliott and Udovč, 2005; Mikuš, 2006).

The legislation from 1981 served as the implementing institutions for the National Spatial Plan adopted in 1986, mainly in proposing and later safeguarding designated areas against other competing sector or development interests. Despite their weakness in capacity and implementation, they have survived the political changes in the early 1990s and transition period from planned to market economy. The National Spatial Plan, although adopted before independence of Slovenia, was the key framework for spatial development in 1986-2000. There were of course several changes of the document due to the transition to the market economy. However, with its long term goals it included guidance on the development of settlements, spatial planning, protection of agricultural land and forests, and balancing development of the human environment with conservation (Elliott and Udovč, 2005).

The new legal framework for nature conservation in Slovenia brought the Nature Conservation Act (1999), which was latter upgraded in 2004 and its official consolidated version is the law in force regulating nature protection. The adoption of the Nature Conservation Act in Slovenia provided a basis for the overall conservation of biodiversity and protection of valuable natural features as part of Slovenia' s natural heritage. The current legislation in the field of nature protection policy introduced so called natural value protection system which defines the procedures and methods for determining the status of natural values, as well as the implementation of natural value protection. Aiming to conserve biodiversity and good condition of natural values, protected areas, parks, are established, which can be used also as one of the natural protection measures for international comparison. Protected areas as defined by the Nature Conservation Act (2004) are: National parks, Regional parks, Landscape parks, Dedicated nature reserves, Nature reserves, Natural monuments (*Fig. 2*).

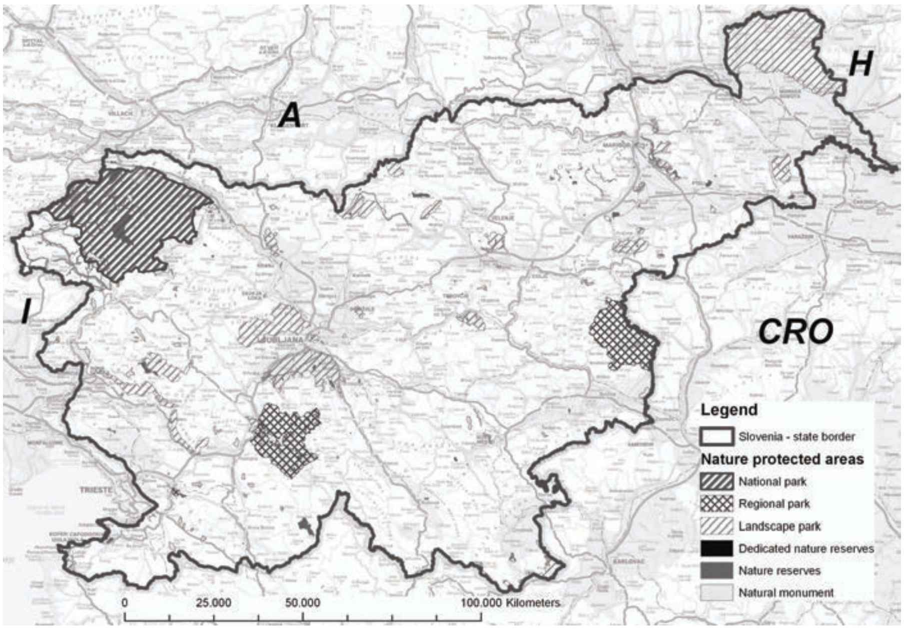

Figure 2: Nature protected areas in Slovenia – national park, regional and landscape parks (data acquired from Environmental Agency of the Republic of Slovenia).

Data for the period up until 2009 show a continued increase in the share of protected areas in Slovenia. An important portion of these areas is covered by the Triglav National Park, the only national park in Slovenia, declared in its current size already in 1981. At present, there 12.6% of Slovenian territory protected one way or the other for the purposes of nature conservation, which presents 256,120 ha. At the moment, Slovenia has 1 National park, 3 Regional parks, 44 Landscape parks, 1 Dedicated nature reserves, 56 Nature reserves and 1191 Natural monuments. The protected areas are well organized with elaborated management plans and appointed managers (ARSO, 2009).

Protected areas partially overlap with the Natura 2000 protection areas. Natura 2000 is a European network of ecologically significant areas of nature, as specified on the basis of the EU's Bird (European Commission, 1979) and Habitat Directives (European Commission, 1992). Together, the two directives present an international legal basis and a professional framework of European nature conservation. The Habitats Directive (together with the Birds Directive) forms the cornerstone of Europe's nature conservation policy. It is built around two pillars: the Natura 2000 network of protected sites and the strict system of species protection. Due to different natural conditions and preserved state of nature, the definition is flexible enough to allow for various interpretations of the Directive among the EU countries (European Commission, 2009). Today, areas under nature protection including Natura 2000 network of areas and protected areas (national park, regional park, landscape park, strict nature reserve, natural reserve and natural monument), represented almost 40 % of the whole territory of Slovenia (*Fig. 3*).

Slovenia is rich with an exceptionally variegated landscape, varied plant and animal diversity and most of all with people, who foster a lasting relationship with nature and who long ago came to the fundamental realization and awareness of the inevitable co-dependence between man and nature. Designated protected areas are among the most important (and oldest) mechanisms for preserving plant and animal species as well as their habitats. However, the common wishes of inhabitants that live in the protected areas are relating to development of the area and may often arises conflict situation and dissatisfaction on public as well as individual site. Here, the clearly defined guidelines for

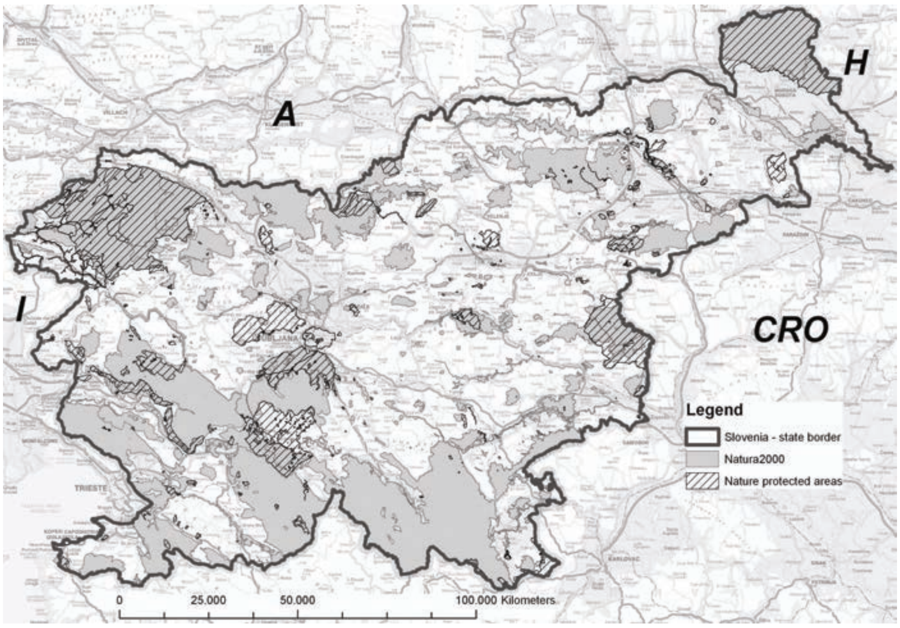

Figure 3: Protected areas and areas of Natura2000 in Slovenia (data acquired from Environmental Agency of the Republic of Slovenia).

protected area management (top-down) as well as transparent and effective procedures in land, property management (bottom-up) have to be developed. In continuation, rural land transaction procedure in the nature protected areas according to Slovenian legislation is discussed and compared to the transactions of land outside the protected areas.

THE INFLUENCE OF PROTECTED AREAS ON RURAL LAND MARKET IN SLOVENIA

Modelling rural land transaction procedures

As an example of rural land transaction, we will discuss the procedure of the ownership transaction as the elementary right that referrs to the land. The transaction of the ownership is here presented as a system of actors, activities and institutions that interact in order to achieve the final state – the legal registration of the new owner. For better understanding, Unified Modelling Language (UML) was used. The used methodological approach was already used in the framework of the European COST G9 project – Modelling Real Property Transaction, where the methodologies for describing and modelling real property transactions were introduced and some examples of models were developed. Modelling was mainly done in UML activity diagrams, but there were some examples of class and use case diagrams with the UML notation as well. The descriptions, modelling and comparison between different countries were concentrated very much on the processes of the real property transaction and subdivision of the urban land (Šumrada, 2002; Arvantiis and Hamilou, 2004; Šumrada, 2006; Lisec, 2007; Lisec, Ferlan and Šumrada, 2007; Lisec et al., 2008).

Rural land market in Slovenia

Land market is the environment in which real properties, considered as legal concepts of the land, are traded between vendors and buyers. In our research we focused on a specific right – the ownership, as the elementary right to land in the Slovenian legislation. The process of purchase of a land plot (for example land plot for building purposes) as the elementary unit in the Slovenian real property legislation can be initiated by the owner (vendor) as well as the purchaser. The vendor must be the owner shown by the Land Registry. The vendor as well as the purchaser can be a group of people (physical persons) and/or juridical persons. The transfer of ownership of a whole land plot basically means registration of title in the Land Registry based on the signed contract and is carried out among the vendor, purchaser, notary and the Land Registry. The pure transaction procedure of land plot is therefore the transfer of the ownership from vendor's offer to the registration of the new buyer's ownership in the Land Registry.

Comparing rural land sale to the sale of a plot for building purposes, a special legislation regulates property transfer procedures due the multipurpose function of rural land, rural landscape. In Slovenia, the sale of rural land is mainly regulated by The Agricultural Land Act (2003). According to the Slovenian legislation, the four main cases of rural land transactions are: transaction of agricultural land; transaction of water land; transaction of forestland, and transaction of a farm holding. The rural land sale can be divided in two parts (*Fig. 4*):

- the activity concerning pre-emption rights, which means determination of the pre-emption conditions, including approval of the purchase (public obligations);
- the title (ownership) transfer, which means registration of the new owner in the Land Registry, which is the same procedure as the sale of land plot for building purposes.

Each intended transaction of rural land has to be announced publicly. The relevant local

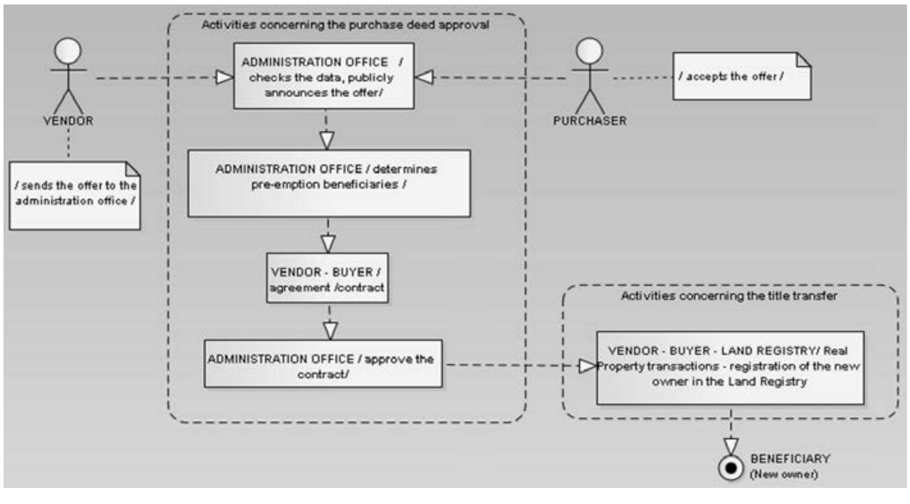

Figure 4: Generalized UML flow chart, presenting the two main parts of the sale of rural land plot in Slovenia.

office, which represents the state administration office, Department of Agriculture, has to approve the purchase with a special provision that resolves pre-emption rights. In compliance with The Agricultural Land Act (2003), the pre-emption right may be claimed in the purchase of agricultural land by pre-emptors in the following order: (1) the co-owner, (2) the farmer whose land is adjacent to the land to be sold, (3) the leaseholder of the land to be sold, (4) another farmer, (5) agricultural co-operative or a self-employed person that requires land or a farm holding to perform their agricultural and/or (6) forestry activities and the National Farmland and Forest Fund of the Republic of Slovenia. If none of the pre-emption beneficiaries asserts the right of pre-emption and if the contract is approved by the administration office, the vendor may sell the land to any person who accepts the offer in time and in compliance with The Agricultural Land Act (2003). Approval of the purchase is not required in some specific cases. There are some regulations of rural land market from the institutional point of view which have to be adjusted to the current problems referring to the sustainable land management (land fragmentation, small farms, protected areas etc.). With the approval of the contract by the administration office, the process of registration of the new owner in the Land Registry is the same as for the above mentioned case of building land plot sale.

It has been argued that already process of the rural land outside the special protected areas in Slovenia is slow, rather bureaucratic, and several actors appear in the process of the rural land sale in Slovenia (see Lisec, 2007; Lisec, Ferlan and Šumrada, 2007; Lisec et al., 2008).

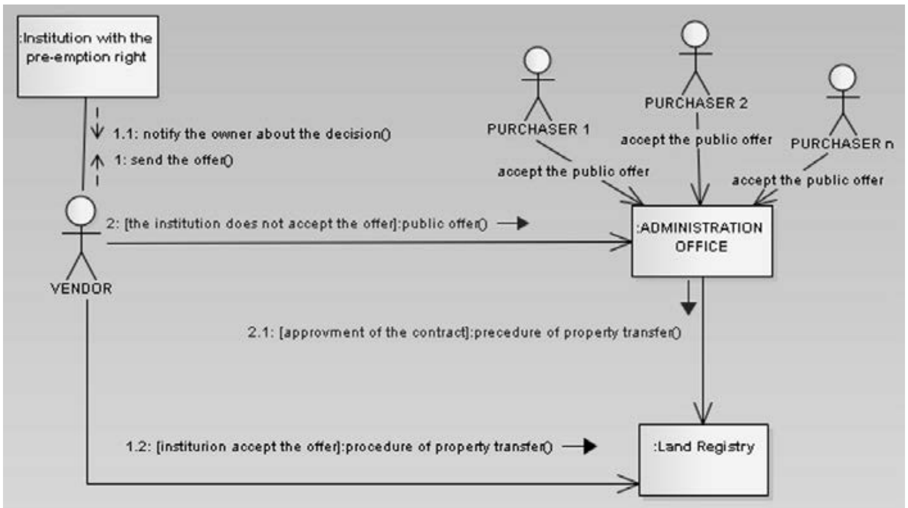

Figure 5: Generalized UML communication flow diagram of the rural land transaction in the protected areas in Slovenia.

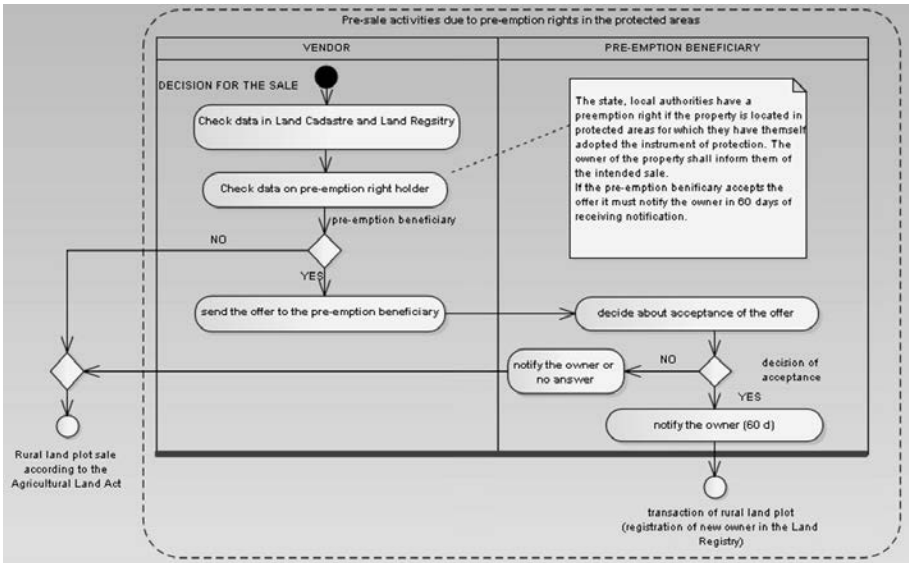

Figure 6: UML activity diagram for pre-activities of the rural land transaction in the protected areas in Slovenia.

Rural land market in the protected areas

A special entangled procedure is enacted for the sale of rural land in protected areas, which are: special protected area, protected forestland, water land and land of special importance for defence purposes. Here, we will focus on the special protected areas according to the Nature Conservation Act (2004). In the protected areas, the state or local community has the pre-emption right if the property is located in protected areas, for which they have themselves adopted the instrument of protection. In the protected areas, such as national park, regional parks etc., the state or local community (protected area manager) have the pre-emption right in real property transactions, notwithstanding the provisions in other acts regulating pre-emption rights to agricultural, forest, water or building land. The owner of the property shall, by sending an offer to the manager of the protected area inform them of the intended sale before publicly announced the offer for the sale (*Fig. 5*).

In case of the acceptance of the offer, the pre-emption beneficiary has to notify the owner about the decision within 60 days from receiving the notification. This is the basis for further land title registration procedure in the Land Registry (*Fig. 6*).

If the state or local community does not exercise the pre-emption right, the sale of the rural land follows the above mentioned procedures, firstly with sending the offer to the administration office. Here, the next pre-emption beneficiary is defined in accordance with The Agricultural Land Act (2003).

It is evident, that already complex and time lasting procedure of rural land plot sale is additionally expended, up to three months, if a special protection regimes (example of nature protected areas, but similar goes also for cultural protected areas and other areas with special protection regimes). The problem of complex and time lasting procedure can be illustrated by considering the case of transaction of rural land between two neighbour farmers. Even for rather small and inexpensive land plot, the vendor and the buyer have to go through the procedures presented, which may take up to 1 year.

CONCLUSION

Sustainable development is not just an environmental issue; it has to follow free aspects of sustainable development: economic sustainability, environmental sustainability and social sustainability. The latter includes values such as equity, empowerment, accessibility and integration. From this perspective, a special challenge appears in the field of sustainable spatial development in the areas of special purposes, such as areas of protected natural and cultural heritage. Such an area brings the values and benefits to society in general terms, but it might be unacceptable or at least disliked by locals due to restrictions of the rights to land use, land management. Although there is still weakness of protection regimes influencing land management procedures, nature and landscape conservation issues are given much higher priority in spatial planning, land management as well as in other development programmes than a few decades ago – the main aim is to follow the guidelines for sustainable development.

Effectiveness and transparency of land management and administration procedures are despite its admittedly lesser recognition one of more significant aspects that need to be considered in sustainable development of the society. In the formation of the new legislation as well as in new strategic documents in spatial planning the importance of effective procedures relating to the land and real property management has to be considered. This is in particular of high importance in the areas with special property restrictions, such as areas of protected cultural and natural heritage. In the paper, a special attention has been given to the case of rural land plot sale in the nature protected area as an example. Here, the complex and untransparent procedures have been highlighted, which in particular affect local people.

In Slovenia, the responsibilities for rural land transactions in the protected areas, as the study case, are heavily fragmented across the institutions and largely decentralized. Here, effective legislation and institutions will have to play an important role by supporting locals in the way of transparent and effective procedures in land management, aiming to provide the basis for development of the society in spite of limitation due to protection regimes in the future. In addition, the legislation through the institutional framework should recognise and encourage the sustainable land management in the protected areas, particularly in places that have been shaped by people over long periods of time, and support human communities, locals by adopting sustainable practices.

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Review paper

DEGRADATION OF LANDSCAPE IN SERBIAN SKI RESORTS-ASPECTS OF SCALE AND TRANSFER OF IMPACTS

Ratko Ristić [1], University of Belgrade, Faculty of Forestry, Belgrade, Serbia
Nevena Vasiljević, University of Belgrade, Faculty of Forestry, Belgrade, Serbia
Boris Radić, University of Belgrade, Faculty of Forestry, Belgrade, Serbia
Sandra Radivojević, State Owned Company "Ski Resorts of Serbia", Belgrade, Serbia

The environmental impacts in Serbian ski resorts (Kopaonik, Zlatibor, Stara planina, Divčibare) are very strong, leading to degradation of unique mountain landscape, and functionality losses. Processes of urbanization, construction or improvement works, cause hard degradation of topsoil and native vegetation. The logging, large excavation activities, erosion, noise and water pollution constantly impact the habitats of all animal and plant species residing in small areas. The process leads to severe fragmentation of the remaining old-growth forests, endangering future subsistence. Consequences of mismanagement in ski areas are noticeable in downstream sections of river beds, causing floods and bed-load deposition, with high concentration of pollutants, in reservoirs for water supply. Legal nature-protection standards are weakly implemented in regional ski areas. Effective protection of landscape in Serbian ski-areas is based on careful considerations of impact assessment at all levels of planning (spatial and urban planning) and designing activities, which enables application of restoration concept, in accordance with general goals of environmental protection (preserving biodiversity, CO_2 sequestration, attenuation of effects of global climate changes).

Key words: landscape, degradation, impacts, protection, restoration concept.

INTRODUCTION

Construction of new and improvement of existing ski resorts, is very attractive activity in transition societies of Balkan region (Serbia, Montenegro, Bulgaria), but involves numerous environmental violations during and after work (Ristić, 2007; Matto, 2007). The logging and construction works, large excavations, erosion, noise and water pollution constantly impact the habitats of all animal species. The process leads to severe fragmentation of the remaining old-growth forests, endangering future subsistence. The shallow soil coverage on the steep slopes starts to be stripped away with the onset of a short, intensive rainfall, snowmelt or their coincidence, thus creating a source of sediment that can be easily transported into streams, lakes or wetlands. The large excavation works on the steep slopes cause debris flows and land slides, leading to degradation of the unique mountain landscape, functional and aesthetic problems. At the same time, downstream channel sections became more exposed to flooding.

SKI RESORTS OF SERBIA

In former development of mountain areas a few ski resorts were formed (*Figure 1*). A major and the oldest ski resort in Serbia is located on the Kopaonik mountain, in the area of the National Park. This ski resort offers about 50 km ski slopes for alpine skiing, about 18 km ski slopes for cross-country skiing, interconnected with 24 chairlifts and ski lifts. The total investment in the construction of new ski runs and chairlifts, between December 2004 and August 2009, amounts to about 20,000,000 **€**. Second largest ski resort is **"**Brezovica**"**, on the mountain Šara, which is located along the border between Serbia and Macedonia. Ski center comprises about 16 km ski slopes equipped with 5 chairlifts and 5 ski lifts. Ski resort "Stara planina" is being built on the biggest mountain in East Serbia - Stara

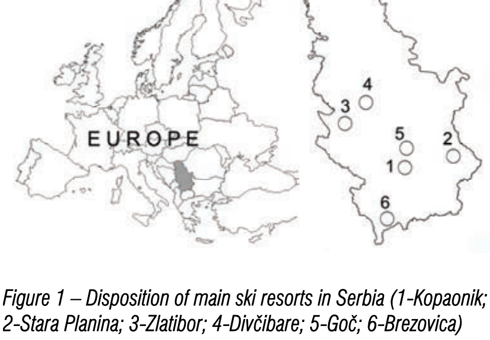

Figure 1 – Disposition of main ski resorts in Serbia (1-Kopaonik; 2-Stara Planina; 3-Zlatibor; 4-Divčibare; 5-Goč; 6-Brezovica)

[1]Kneza Višeslava 1, 11 000 Belgrade, Serbia
ratko.risticc@gmail.com

planina, which runs along the Serbian-Bulgarian border. Three ski slopes of 3,700m in length and appropriate installations (water reservoir for artificial snow making, 10,000m^3; pipeline, snow-guns) were completed during the first construction phase. In December 2007, a new detachable quad chair lift and one ski lift were started up. Total value of these investments surpasses 15,000,000 **€**. Ski-resort „Zlatibor" was renovated in period 2006-2009, with 4km ski runs and a new detachable six chair lift. Construction of another new ski slope has been started in the proximity of the locality Divčibare, on the Maljen mountain in 2006. By the end of 2006, a construction of one 850 m long ski slope with double chair lift had begun, totaling to approximate 1,500,000 **€** investment.

Ski resorts in Serbia were formed without conceptual level guidelines for erosion control projects, in accordance with BMP's (Best Management Practices). Construction activities involved numerous environmental violations during and after work, with huge damages. After massive clearings and machine grading of slopes erosion damaged surface soil layer, thus creating a source of sediment that was easily transported into local streams (Macan *et al*., 1997; Ristić et al., 2005). Disturbances caused functional and aesthetic problems along and around all the newly-built ski runs (Ristić *et al*., 2007). The logging, large excavation activities, construction works on steep slopes, caused appearance of furrows, gullies, debris flows and shallow land slides, especially in period April-October. Fast surface runoff starts to strip away the shallow soil coverage on the steep slopes, with the onset of a short, intensive rainfall, snowmelt or their coincidence, thus endangering skiing infrastructure and road system.

Legal nature-protection standards are weakly implemented in regional ski areas. Some activities such as clear cuttings in National parks are contradicted two main park management objectives: conservation of ecosystems and preservation of biodiversity (ski resort „Stara planina" is located in Park of nature; ski resort „Kopaonik" is located in National Park). However, environmental violations were not so dramatic like in neighboring Bulgaria („For Earth", 2007), but enough provocative to become object of scientific research (Perović, 2008) and theme for numerous critical articles in daily news.

EROSION PROCESSES AND LANDSCAPE DEGRADATION AT THE SKI RESORT „STARA PLANINA"

Representative (negative) example was the beginning of building of ski resort „Stara planina", although the numerous negative impacts have been noticed in another ski resorts. The hardest forms of terrain degradation were recorded in the proximity of locality Babin Zub, in the zone of ski runs, ski lifts and access roads. Destruction of autochthonous beech forest and meadows (over 1600 m.a.s.l.) produced anthropogenic bare land as dominant surface in upper part of Zubska river watershed (*Figures 2, 9*). Intensive erosion processes caused appearance of furrows and gullies, almost 3.5m deep (*Figure 4*).

In the region of Stara Planina, sediment yields ranged from 6460 $m^3 \cdot km^{-2} \cdot year^{-1}$ on disturbed surfaces (ski run „Konjarnik 1", Zubska river watershed), to 450 $m^3 \cdot km^{-2} \cdot year^{-1}$ on undisturbed surfaces (Repuški stream watershed). Sediment production was calculated using a method of „Erosion Potential" (method prof. Gavrilović). Sediment yields were nearly 14 times greater from red sand and granite ski-run soils than from undisturbed (native) sites (Ristić *et al.*, 2009). In North America, sediment yields were nearly four times greater from disturbed granite ski-run soils than from native sites (Grismer and Eliss, 2006.). Even thinnings carried out as salvage silvicultural cuttings, increase sediment yields 28-45 times (Macan *at al.,* 1997.).

Zubska river follows ski run "Konjarnik 1" (K_1), in which inflow ski runs "Konjarnik 2" (K_2) and

Figure 2 – Anthropogenic bare land on Stara planina

Figure 3 – Network of access roads

Figure 4 – Deep gullies on ski run „Konjarnik 2" (Stara planina)

Figure 5 – Products of erosion on ski run „Konjarnik (Stara planina)

Figure 6 – Torrential flood in Zubska river bed

Figure 7 – Deposition of bed load in Zubska river bed

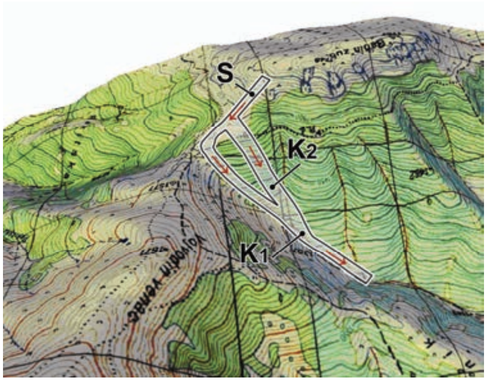

Figure 8 – Disposition of ski runs on Stara Planina

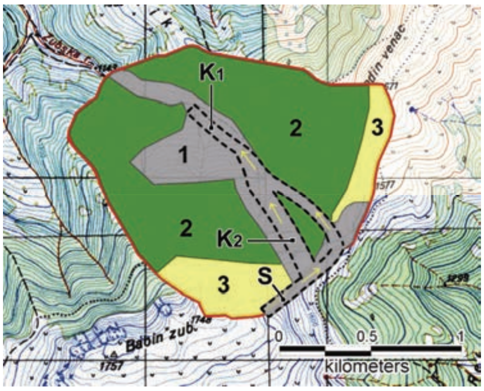

Figure 9 – Composition of surfaces on upper part of Zubska river watershed (1-anthropogenic bare land; 2-forest; 3-meadows)

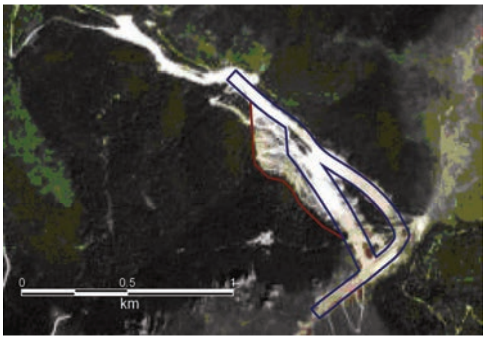

Figure 10 – Immediate zone of ski resort „Stara Planina"

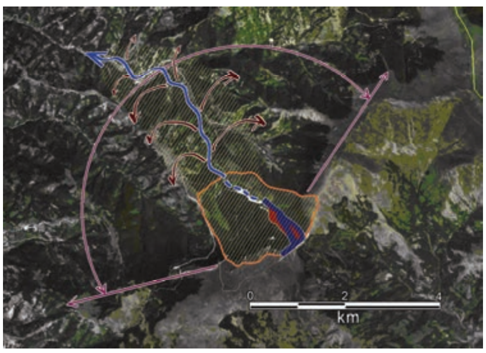

Figure 11 – Wider zone of ski resort „Stara Planina"

gravitates to Zubska river and its tributaries, has expressive slope of terrain (I_m= 47.57%), and erosion products reach ski runs or hydrographic system very easy. Fast surface runoff accelerates transport process. Network of access roads (*Figure 3*) helps concentration of runoff: roads had been built without asphalt cover and structures for evacuation of water: road culverts and channels. Fast concentration of rainfall water increases frequency of torrential floods, with high content of sediment (*Figures 6, 7*).

ASPECTS OF SCALE AND TRANSFER OF IMPACTS

Ski resort „Stara planina" was formed in upper part of the Zubska river watershed, on very steep terrain, in the area with a few local streams (*Figure 8*).

Destruction of vegetation cover (forest and meadow stands) caused hard soil degradation (humus-silicate soil; red send skeleton), thus creating unfavorable composition of surfaces (*Figure 9*), with 46 hectares of anthropogenic bare land (almost 25% of Zubska river watershed, in relation to profile in the proximity of ski run „Konjarnik 1", about 1.5 km far away from peak point).

Next forms of degradation were noticed in immediate zone of ski resort (*Figure 10*):

- destruction of vegetation cover (forest and meadow stands);
- endangering of animal and plant species;
- excessive erosion (network of furrows, deep gullies, shallow land slides, debris flows);
- intensive production of erosive material and fast transport to hydrographic system;
- fast forming of torrential flood waves;
- degradation of visual and aesthetic characteristics of landscape.

Immediate zone of ski resort comprises spatial diameter of about 1.5 km (*Figure 10*). Elements of degradation are easy noticeable, negative impacts have strong, synergy intensity, thus creating conditions for extreme spatial destruction (*Figures 2-5*).

Next forms of degradation were noticed in wider zone of ski resort (Figure 11):

- more frequent appearance of torrential floods;
- increased concentrations of sediment and pollutants in streams;
- endangering of road system and residential objects;
- disturbing of common economy activities of local dwellers.

Wider zone of ski resort (*Figure 11*), comprises spatial diameter of about 5 km. Elements of degradation are not easy noticeable, negative influences dominate in the zone equivalent to narrow zone of ski resort (source of impacts and starting area for their transfer). Anthropogenic bare land takes less than 5% of Zubska river watershed (in the relation to the profile 4.7 km far away from the peak point), but it is zone of forming torrential flood waves. Transfer of impacts is going on through Zubska river bed, with following effects: demolishing of bridges; fulfillment of road culverts by sediment; destruction of road system. Entire area is very isolated (the nearest small city is Knjaževac, 60 km far away), and in this way becomes additionally marginalized with interruptions of already weak economical activities. Visual degradation of landscape is noticeable from remarkable view points of neighboring relief.

DISCUSSION

The lack of planned and organized erosion control activities during designing, building, maintaining or improvement activities had strong impacts on ski-runs in Serbia. Restoration and erosion control works, carried out during 2008 in ski-resorts „Kopaonik", „Stara planina", „Zlatibor" and „ Divčibare", were the first of that kind in Serbia. Lack of investments for erosion control works

Table 1: Review of expenses for restoration and erosion control works

Ski resort	Ski-run	Expenses for restoration and erosion control works	
		RSD	**€**
Stara planina	„Konjarnik 1"	85,500,000	900,000
Stara planina	„Konjarnik 2"	9,500,000	100,000
Stara planina	„Sunčana dolina"	28,500,000	300,000
Divčibare	„Crni vrh"	28,500,000	300,000
Zlatibor	„Čigota"	14,250,000	150,000
Zlatibor	„Tornik"	19,000,000	200,000
Zlatibor	„Zmajevac"	33,250,000	350,000
total:		218,500,000	2,300,000

(immediately after basic construction works) produced later expenses (*Table 1*).

The onset and completion of all activities fell within period May-October, 2008, in accordance with basic restoration (Krautzer *et al.*, 2006) and erosion control works principles (Ristić *et al.*, 2007): technical works were finished until the end of September, biotechnical until the middle of October (Ristić, 2008.).

Restoration and erosion control works were carried out in conditions of hard terrain degradation, after completion of basic construction works (ski lifts, access roads, ski runs). Presented expenses are the most expensive variant. Preventive activities, before and during basic construction works, reduce expenses for 75-80% (in comparison with amounts from Table 1).

CONCLUSIONS

- Construction and improvement works caused hard degradation of topsoil and native vegetation.
- The environmental impacts in ski resorts were very strong, leading to environmental degradation and functionality losses.
- Land degradation on ski-runs (the highest level of destruction) leads to transfer of impacts, usually downstream through beds of local streams.
- Providing of planning and designing documentation, with Environmental Impact Assessment Studies, minimize possible risk.
- Protection and reclamation of disturbed surfaces within same constructing season, in accordance with natural ambiance.
- Maintaining of ski-runs has to be based on determined BMP's (Best Management Practices).

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Scientific analisys or debate

URBS ET ORBIS: (RE)CHARTING THE CENTER, (RE)POSITIONING THE LIMITS

Aleksandra Stupar [1], University of Belgrade, Faculty of Architecture, Belgrade, Serbia

The paper examines the concept of finiteness and its implications on urban space focusing on the relation between urban(ized) environment, social context and spatiotemporal perception. Furthermore, it analyzes and evaluates various roles which the notion of the center and the limit has had through history - representing an inseparable part of traditional city planning or being completely transformed in order to transmit and express contemporary identity. Considered as a residue of a particular mythical narrative and a distinctive feature of the first philosophical speculations, this concept was rooted in primordial technical matrices of archaic and classical cities, but its latest manifestation has distorted previous models. Consequently, the original significance has been manipulated - shaping a new urban geography as a post-modern, multi-scale setting for our future life.

INTRODUCTION

Since the dawn of civilization, the notion of the limit (boundary) and the center has always been an omnipresent constant - molded by different beliefs, materialized in various scales and embedded in the mythical as well as the rational system of thought. From the pre-historic shelters, megalith structures and first urban settlements, to the powerful urban nodes of the modern network society, the concept of finiteness i.e. centralization and delimitation represented an important intellectual stimulus, both within philosophy and built environment. At the same time, it was the *locus classicus* of every myth and its application revealed a significant interrelation of mythology, ideology, philosophy and urban structure. However, during the centuries, the limit and the center have lost their magical meaning and the rituals of demarcation have gradually become a mundane public performance deprived of cosmic prerogatives.

[1]Bulevar kralja Aleksandra 73/II, 11 000 Belgrade, Serbia
stupar@rcub.bg.ac.rs

Nevertheless, our unconscious inheritance still influences our needs and behavior, seeking a new envelope which should protect us from the uncountable stimulations of the third millennium. Therefore, the notion of the limit and the center is redefined, offering a new anchor in the tempestuous landscape of global flows.

Delusive limits and virtual centers - are they sufficient to mark off the urban future?

THE MYTHICAL ORIGINS

Representing a fundamental category of any conceptual relation within a mythical mind, the finiteness ('border') could be conceived as a root of primeval opposition - a distinction to the *sacred* and the *profane*. Consequently, everything is subordinate to it: space, time, quantity and quality of things. Additionally, every segment of mythical space reflects the quality of the whole, underlining the micro-macrocosm unity. Therefore, the myths of creation, although stemming from diverse geographical and cultural backgrounds, are a clear demonstration of this analogy recognized in the structure of the universe, the earth and the human.

The Creation

According to a large number of mythical narratives, the act of creation represented the end of emptiness, darkness and confusion and the beginning of existence. Starting spontaneously - from the original void, the expanse of water or a cosmogonic egg, the process resulted in an organized and self-structured system with several entities and a specific hierarchy (Long, 1963).

The egg, as the primordial entity in Egyptian, Indian, Chinese, Tibetan and Japanese mythology, symbolized a perfect, self-sufficient totality, composed of male and female principle. When the egg was opened or split, its halves became the Heaven and the Earth (Siberia, Borneo, ancient Greece) or they revealed a deity - like the Chinese Pangu (or P'an Ku)[2]. At the same time, some myths

[2]According to the myth, Pangu pushed the earth and sky apart and continued to grow three meters every day. After he died, his body formed the world - the flesh became the soil, the hair gave the vegetation, the eyes transformed into the sun and the moon. Rivers and seas originated from his fat, while the parasites on his body became human beings.

emphasize the role of a creator-god[3], a primal couple[4] or a giant[5], but most of them actually combine all these elements. The exception of this practice can be found among Buddhists, Taoist and Confucians, who perceive the world as the work of spirits. However, no matter who takes the leading role, the process of creation depicts a complex path of transformation whose final result represents the Universe, composed of the basic elements - the Earth, the Heaven/Sky, the rivers/water, the stars, the Sun, the Moon and the Man.

Therefore, it is evident that from the hymns of the Rig Veda, through ancient Egyptian and Mesopotamian mythologies, to the first cosmogonies of the ancient Greeks, the mythical cosmo-anatomy and mytho-geography introduced the essential principle of the mythical logic - *pars pro toto*, using the clearly definable and delimited entities, as well as the notion of the limit and the centre.

Delimitation of Reality

The first boundaries on the Earth were the environmental ones - rivers, mountains or seashores. The discovery of fire led to the second important element of spatial and social demarcation since the hearth represented a new center of social gathering and protection. Gradually, the space became the place, getting its identity and role through limitation and accentuation, establishing shelters and sanctuaries - at first within the natural frames and then rearranging them according to human needs. The land was circumscribed as a proof of new division and community initiation, while the gigantic stones were used as a direct connection between the terrestrial and the celestial, being the symbol of community, its durability and technological development. On a larger, monumental scale, the same symbolic was given to menhirs. They were usually organized as alignments or circles (Carnac, Stonehenge) creating an exceptional scenery for the sacred rituals with the magical and cosmic role (Kostof, 1995). Therefore, each one of them was and still is a unique monument of human efforts, a mundane projection of imagined cosmic order and, above all, the materialized notion of the limit and the center which confirmed Man's place on earth.

The urban revolution, which started between ten and five thousand years ago in the valleys of the Nile, the Tigris and Euphrates and the Indus, brought a new material interpretation of the concept of finiteness as well as its mythical backup. The ancient tradition narrates that the act of city-making - its initiation, planning and building, was a work of gods. However, later on, the first autocratic rulers, enlightened by a divine prophecy, became the transmitters of gods' intentions. They respected the heavenly instructions and emulated the celestial model which was a guarantee of the successful and long lasting reign (Djukic and Stupar, 2001).

The first planned cities, such as Mohenjo-Daro in the Indus valley, reveal exactly the logic of the cosmic harmony (Jansen, 1991). Oriented along the north-south axis, this city had an orthogonal layout divided into twelve blocks (1200x800 feet), with three wide streets running north and south and two streets crossing them. The grid plan, which probably followed the system of twelve lunar months, was not the only one in the pre-Classical antiquity. For example, some of the cities in the Fertile Crescent, like Babylon at the time of Hammurabi, also accepted the ordered urban layout. However, their patterns were not so rigid and precisely coordinated. Most of them applied the elements of the 'cosmic harmony' only in the plans of temples and palaces, since they were the first and the most important signs of divine prominence and glory.

At the same time, the image of a city was based upon two symbols - the enclosure and the center. According to the traditional interpretation, all enclosing forms are considered as the symbols of the Great Mother, responsible for protection, sheltering and nourishment. Additionally, they could be also seen as a clear representation of fertility which is related to the symbolic of the womb. On the other hand, a center, as a symbol, represents a totality, the origin of all existence and the intersection of macrocosm and microcosm. It is, as well, the point around which everything revolves, uniting the cosmos vertically and horizontally.

Having these two symbols united and combined, the ancient city had no chance for failure. The future, although quite turbulent, was in front of it.

The Magic of Diagram

The process of a city foundation was accompanied by various magical rituals necessary to ensure the well-being of the ruler, city and its citizens. The result was a properly oriented, ordered and symmetrical layout of the new microcosms, used as a frame for social and ideological organization and division.

The urban limit was often materialized as a wall structure which had a protective role caused by military reasons or even by the local weather conditions (for example the city of Amarna in Egypt). However, some cities from the Indus valley (Mohenjo-Daro, Harrapa) remained without city walls, which was probably the result of their mostly peaceful existence and surrounding. Being orthogonal (Sumerian - Uruk and Nippur; Egyptian - El-Amarna) or circular (Hittite - Zincirli, Assyrian - Quala), the city walls also clearly displayed a high level of technological development and astronomical knowledge. Simultaneously, they followed the mythical and astrological guidelines set up by previous generations.

The cities of the Near East civilizations projected their cosmology on spatial hierarchy and urban structure. For example, the city of Nippur had, according to the city plan found on a clay tablet (1500 BC), a strong fortification wall with access to the river. The temple of the supreme god, who was the protector of the city, was placed near the canal and represented the metaphorical, physical and visual center. The zone around the temple, which was the actual religious, political and economic heart of the city, also had its own delimitation - a wall representing the last line of defense.

During the history, two basic models of temples evolved in Mesopotamia - the urban and the ziggurat type, which - each in its own way - were able to create the experience of transition between the sacred and the profane. The first one used the axial progress through open and enclosed spaces towards the elevated sanctuary, while the second one was based upon the vertical ascent, symbolically connecting the earth and the heavens. However, as soon as a king received the prerogatives of a divinity, the palace became the focus of the city. As an accurately structured complex, it was placed within the citadel, usually situated at the top of the plan. In this case, the whole city was playing the role

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[3]For example - Ptah, Ra or Amen-Ra and Atum - Khepri (Egypt); Anu, Apsu or Marduk (Akkad); Brahma (India); Yahweh or Elohim (Israel); Wele (Bantus, Kenya); Eskeri (Siberia).
[4]In Japanese mythology, the primal couple, Izanagi and Izanami, brought into the world the islands of Japan and numerous gods and goddesses.
[5]Prajapati (India) or Ymir (ancient Germany).could be used to illustrate this model.

of ceremonial scenery - a dramatic approach was provided, while the ritual climax was hidden behind the palace walls (Polock, 1999).

The historical advent of the autocratic rulers also brought the exploitation of the autocratic diagrams in the shape of heavenly circles. They were often used by Assyrians, Persians, Parthians and Sassanians and one of the best known examples was the city of Ecbatana (715 BC), which had a wall system made up of seven differently colored concentric circles representing the planets. The ruler and his suite occupied the central zones, while the ordinary people lived beyond the city walls (Kostof, 1991).

The first Sassanian capital, Ardashir-Kurra (3rd century AD), also followed a circular pattern, only this time the key of symbolism was to be found in astrology - the city had a radial organization with twelve main segments which carried the names of the zodiac. Again, the order of the universe was transposed into a terrestrial reality, announcing the power of the king and prophesying a prosperous future.

Quite to the contrary, the cities in the Ancient Egypt used the benefits of their natural surroundings to become a genuine materialization of the basic principles of the universe - as they knew it and perceived it. The urban settlements were mostly orthogonal and their orientation was conditioned by the direction of the Nile and the paths of the rising and setting sun (Gates, 2003). Therefore, it is not surprising that the hieroglyphic sign for city, 'niout', has a shape of circle (the limit/enclosure) with the cross-axis (the center/coordination). Influenced by the religious believes based on the eternal stability and regular natural cycles, the Egyptian cities were not planned and built just for the living but also for the dead.

The ideal city diagram in the old Hindu tradition consisted of concentric circles intersected by eight radial directions. The similar pattern was followed by some holy cities in the South and East Asia during the Middle Ages. The site for their construction was carefully identified by geomancy while the sacred diagrams were also used for orientation. The city had several concentric streets, four main gates marking the cardinal axes and a center - with the main palace and the temple. Sometimes, like in the case of the holy city Srirangam in South India, the city had seven walled concentric areas and a cross-axis marking the cardinal directions. The sanctity of the concentric segments was higher as they were closer to the holy center of the diagram.

The more spiritually advanced version of this model was the symbolic diagram of mandala. Depicted as a circle enclosing a square with a central symbol, it represented an *imago mundi* - the microcosm and integration, as well as a circumscribed area free from negative influences. It was based on 8x8 squares (celestial world on earth) or 9x9 squares (enclosing the universe). For Hindu people, the absolute order was lying in the square form which was the archetype of the ideal order of the universe. Being the perfect measure for man, it emitted the supreme principle of Brahma, the creator, who organized the world and was capable of total destruction.

Having all these divine premises, the mandala was used as a city diagram in order to create the centrally organized ideal city. The priests were responsible for the selection of the most suitable variant for every future city, applying the suggested layouts with a great attention and respect. The mandala shapes also directed social division - the center was reserved for the privileged ones - government, religion and higher castes, while the lower castes were placed in the peripheral zones.

The Chinese cities emphasized the north-south axis and their structure was very precise in order to establish a connection between the universe and the ruler. Based upon the cosmology in which the earth was a cube and the heavens were round, capitals were set up according to the points of compass and strictly ordered by the official codes. Of course, the primal cosmic scheme was again the work of the mythical figure, Yu, who was the first dynastic emperor. In the case of China capital(s), the center of the universe, placed in the imperial palace, was moving together with the capital and the ruler. However, the spatial arrangement simply followed two basic models which appeared in the first millennium BC - the earlier one, with the palace complex at the north end of the central axis (Chang'an), and the second one, with the palace placed in the city center (Beijing).

Certainly, it was not always possible to apply one of these cosmic models in their original purity, but the idea remained and survived various transformations caused by landscape, rhythm of everyday life and humane activities (Steinhardt, 1999). Finally, the Ming dynasty introduced again the strict rules of the cosmic model in Beijing. They used the ritual text from the first century BC which described the foundation ritual of the king Zhou. According to this text, the ruler is the one and only person responsible for the birth of a new capital, setting up the city form and orienting the main quarters. The first step of the city foundation was limitation, i.e. the building of the main orthogonal wall, with three gates on each side. Then the main axis (north-south, east-west) were established connecting the city gates, while the center of this composition belonged to the complex of the emperor's palace, with its own protecting and delimiting wall. The palace was oriented southwards in order to face the region of the 'Red Phoenix' which symbolized summer and fire. The temple, commemorating the ancestors, was placed in the east sector of the capital ('Blue Dragon'-spring and growth). Altars consecrated to the soil and harvest were situated in the west part, called 'White tiger' (symbolizing autumn, wars and memory), while the north sector, with its black color representing winter, was the place where markets and commerce were situated (Kostof, 1995).

Mostly oriented towards the secular aspect of everyday life, the Chinese cities respected the officially prescribed rules which could be found in the documents made by the Han dynasty. However, the story about the limit and the center could be seen in a different, larger scale as well.

The example of the Great Wall (3rd century BC) represents a symbol of delimitation, unification, protection and duration simultaneously being a border between both the outer and the inner world. It is a monumental structure of defense and, certainly, an impressive communication line. Maybe in this case, there was no intentional 'cosmic' link between the earth and the sky but, as we discovered in the 20th century, the visual connection is more then efficient and obvious - a work of the man indeed got closer to the eye of god(s).

The grandeur also happens to be an important attribute of the ritual scenery on the other side of the world, in Teotihuacan in the Middle America. (1st century BC - 8th century AD). Unlike some other contemporaries, the city, placed in the flatland and surrounded by mountain ranges, did not have any artificial boundaries. Instead, the layout of its main elements was sufficient to demarcate the place and establish it according to the cosmic and natural order. Therefore, the main south-north axis with the Sun and the Moon pyramids in the north and two monumental groups in the south[6], made its orientation synchronized with the position of natural and symbolic landmarks - the volcano of Cerro Gordo and the path of the sun during the summer solstice (Davies, 1982).

Evidently, each one of these examples confirms the ancient mode of existence, based upon universal wholeness and cosmic rules which were not always readable in urban fabric. In spite of this, the echoes of the mythical narratives, as well as the material evidences, testify about the entanglement of irrational and rational, making their invisible threads touchable and still resonant. Driven by the powers of nature and inspired by the words of the gods, our ancestors were playing their heroic role somewhere between the limit and the center. However, the time of gods was ceasing and the humanity needed some new explanations.

RATIONALIZING THE MYTH

The mythical and religious patterns of comprehension were gradually substituted by the first secular (philosophical) systems - the ancient Greek concepts of space, time and place. Yet the notion of finiteness had a central place and the mythical finiteness of the time was replaced with the finiteness of ethical and esthetical categories.

Becoming the source and the vital sprout of all Western metaphysics, the idea of finiteness was rooted in the primary and thorough dichotomies - of *périas/àpeiron*, *eunomia/dysnomia*, *ethos/hybris* and, surely, ideal/material. Additionally, it was the duality of sacred/profane, light/dark and cosmos/chaos, which stood as its stem. Both ancient myths and the cosmogonies of the Pre-Socratic philosophers narrated upon universal genesis, but, while the myth described primordial events in *illo tempore*, the Pre-Socratic philosophy comprised the activity, the force that was no more attached to a being (Freeman, 2003).

However, the mythical legacy could still be recognized in philosophy in the form of principles that structure reality - Heraclites' *logos,* Parmenides' *èón*, Pythagorean *number*, Empedocles' *philía* and *neîkos*, or Anaximander's *nous*. These concepts were pervaded by the finiteness, which is immanent both to mythical and rational mind. Nevertheless, the distinctiveness of the Pre-Socratic philosophy was in going beyond the myth and replacing mythology by an intellectual premise.

Materializing the Thought

According to Tales, every conceivable thing in cosmos is finite, and the world is *one* and *limited*. Since material reality always has a limit - as do the body - the finiteness is the first principle of human kind and of its culture. As such, it was also applied in the structure and layout of Greek colonies, which were spreading throughout Asia Minor during this period. Therefore, the ancient Greek *poleis* - colonies in Ionia and Sicily, were often characterized by determined planning. It reflected and underlined the conceptual division between infinity and finiteness through the acts of limitation, demarcation and subdivision.

The well-known example of this practice is Miletus, rebuilt in 480 BC on a rigid geometrical grid pattern, with a total coordination of urban activities within consistently organized urban blocks (Kostof, 1991). Designed by Hippodamus of Miletus, the city respected the land configuration and the shape of the peninsula, while its urban matrix was divided into three main sectors (residential clusters). Applying his own idea about the 'ideal city' populated by three classes of inhabitants - soldiers, artisans and farmers, Hippodamus also classified the urban land into three groups - sacred, public and private. The preferred tripartite subdivision was based upon the theoretical knowledge of geometry, which also influenced a comprehensive, well-ordered planning framework. The so-called 'Hippodamian system' was, consequently, noticeable in cities of Piraeus, Rhodes and Thurii.

There are some speculations (Akkerman, 1998) that the plan of Miletus also influenced the work of Plato, especially the concept of his ideal city-state Atlantis. It consisted of three classes of citizens (ruling guardians, warriors and laborers), but its spatial organization is quite different and related to Plato's ideas of orderly cosmology. Consequently, the uniform, concentric diagram reveals the acropolis (the center) surrounded by a circular wall and twelve concentric divisions which should house different groups.

In reality, the planned Greek cities mostly followed the orthogonal matrix, which proved to be a good stage for the future progress - controlled and predetermined. Every city had a spiritual center - *acropolis,* and a mundane one - *agora*, signifying the privileged position of gods and emphasizing the equality among mortals. At the same time, the grid was quite acceptable for the Greek perception of democracy and the limitations were mainly caused by the nature i.e. the surrounding and its resources. Therefore, the notion of the center and the limit was transferred to a larger scale - shaping a new spatial order of settlements in which a city could become the center of a group of urban nodes or a capital of a state.

In the Hellenistic realm, every city was treated as a place of artistic excellence and a lavish setting for the increasing personal and public wealth. However, the founding of a new colony/city was still a mixture of different elements, including the mythical and religious ones. According to the description given by Diodorus in the late 1st century BC (Kostof, 1991), the first step was the ritual consultation of an oracle, and after that the whole set of pragmatic positioning actions was to follow - the location of a spring, the erection of the city walls and determination of the grid system of streets and blocks. Additionally, each city had its own home God or Goddess and the legends about the mythic city founders remained. For instance, according to one of them, Cecrops was responsible for the foundation of the Athens' ancient Acropolis, while Theseus united twelve states of Attica and established Athens as the capital. Furthermore, another mythical hero - Ilus, son of Tros, set up Troy (Ilium) but the city walls were built by the gods - Poseidon and Apollo.

The Romans also continued to use a mixture of mythical narratives, rituals of delimitation and practical knowledge. It was, in a way, an assemblage of Etruscan and Greek influences and advanced Roman construction and composition techniques. Moreover, they accepted the pattern of the Etruscan foundation rite (*fondatio*) which consisted of several related actions - *inauguratio, contemplo, orientatio, limitatio* and *consecratio* (Jannot, 2005). For the Romans, the most important element was the *sulcus primigenius*, the first furrow, a ritual performed with a bronze plough attached to a white ox and a white cow. Although later considered more as a part of pragmatic superstition, it represented a way of

[6]The first group (The Great Compound to the west) was probably the administrative center with the marketplace, while the second one was the temple of Quetzalcoatl, the creator and the god of vegetation.

demarcation whose result was the *pomerium*, a strip of land associated with the city walls and marked as an inviolate zone. The privilege to move this sacred limit was given only to the conquerors that added new territories to the Roman Empire and expanded its influence.

Apart from Rome, allegedly founded by the mythic figure - Romulus, other Roman cities usually were 'labeled' by more profane origin. Based upon the influence of *castra* - military camps, new cities with their centuriation grid were positioned at the crossroad of the main north-south and east-west axis (*cardo* and *decumanus*). They had square city blocks and more or less unified architectural appearance.

The Roman town planning was also under the influence of Stoicism and Cicero's principles of the natural order, shaping the urban environment with well-defined spatial configuration and elaborated links between all elements of the urban space. The public center was accentuated by the complex of forum with a basilica and a temple, while other public buildings created various nodes - for entertainment, commerce, administration and religious purposes.

The notion of the center and the limit was again manifested on the level of the Empire, with Rome as its epicenter, well connected even with the remotest towns and frontiers. On the other hand, maybe the most complex symbol of this powerful imperial 'machine' was the Pantheon (built around 120-27 AD) which materialized the analogy between the Empire and the Cosmos. Structured by many units and various materials from all over the Roman world, this unique monument was a strong political and religious statement of pervading unity, transmitted by the architectural language.

The decline of Rome, the embracement of Christianity and the creation of another center - Constantinople, opened some new perspectives of the space perception. In the meantime, the Stoic notion of Cosmopolis, where gods and men were fellow-citizens, was transposed into the Augustinian 'The City of God'. It was the divine city of worshipers and a model of the moral and cosmic equilibrium which emphasized the integration of the terrestrial places within the cosmic structure. However, the circumscription of Constantinople somehow recalls elements of ancient rites. According to the fifth-century historian Philostorgius (Maclagan, 1968), the Emperor Constantine traced the line of the walls himself with his spear, explaining their extent by the fact that he was lead by 'Him who walks ahead'. Constantine also laid out the plan of the city center, where, apart from the great forum, palace, public and official buildings, a special place was given to the Milion - a mile-post from which all distances were measured.

Elaborating the Ideas(s)

In Europe, during the early Middle Ages, the ideas of the ancient Greek philosophers, as well as the Augustinian doctrine, were gradually substituted by defense considerations. As a result, the urban tissue, well adjusted to the topography, became a total opposite of formalized diagrams. It revealed an irregular urban pattern concentrated around the castle or the church, creating a compact and limited structure with a city square delineated by the public buildings of the new society. The only escape towards the infinity and divine heights was possible through a religious dimension and therefore facades of Romanesque and Gothic churches underlined this effect with their appearance. However, by the end of the 13th century, geometry and astronomy reached a new level, which had a great impact on the planning of new towns, especially in Italy and France. These cities, usually placed within close proximity to a dominant city-state, were built on an orthogonal scheme. It often included a very precise social stratification and distribution, which was also visible in the land division i.e. in the size and position of blocks and lots (for ex. Terranuova and San Giovani).

The Renaissance, with the flourishing art, architecture and science, marked the revival of classical thought which further evolved in the work of Alberti, Filarete, di Giorgio Martini, Leonardo da Vinci and Palladio. The urban space became geometrically articulated, based upon the notion of the perspective and the vanishing point (Alberti). At the same time, the correlation between the human body and the city was again activated. The radial city plans were favored as a continuation of the classical principles of urban design, as well as the paragon of the humanist city and society. In reality, most of them remained as drawings and concepts of imaginary, ideal(ized) cities (for ex. Filarete's Sforzinda) and utopian communities (Campanella's Civitas Solis and Andrea's Christianopolis). The only exception to this centralized view was the utopian city of Amaurote (Thomas More), rooted in the Plato's ideas, but with the egalitarian democracy as its fundamental order (More, 1964).

However, during the late Renaissance and early Baroque, cities became a reflection of the centrist states, crowned by the undiluted absolute authority of a king. Simultaneously, the modern science, mathematics, geometry, physics and astronomy shaped the new comprehension of the nature and the universe, explaining the solar system, its laws and configuration. The concept of finiteness was perceived from two standpoints - political and scientific. They were united by the paradigm of the geometrically perfect world which had to be planned, symmetrical and ordered around a focal point. Furthermore, the critical thinking in modern philosophy and methodology, introduced by Descartes, also marked a new era of the reasoning and space perception, established upon analytical geometry and space coordination. Consequently, Cartesian philosophy, with its premise of dualism of matter and mind, also influenced the distinction between the perceptual and the conceptual aspects of beauty, encouraging the formalization and geometrization of space. Therefore, the prevailing urban patterns were orthogonal or radial, but unswervingly linear, with expansive vistas.

Paradoxically, even in the world of rising science, the ruler was, for a moment, metaphorically identified with the life-giving center of the human universe - the Sun. Yet, the rational thought was again stronger then any other belief and it continued its enlightening role.

The functional geometry, followed by practical questions of urban life, gradually became the imperative of the 19th and 20th century. Embraced by the architects as the most efficient tool of urban planning and the most prominent symbol of technological progress, Cartesian geometry and a mechanistic approach seemingly liberated the modern world of all natural obstacles and limitations. Moreover, the notion of the limit and the center was raised to another level - mostly economic and political. Unfortunately, the absolute harmony and balance, which should have been the result of applied rules, somehow vanished in the process of rapid urbanization. Finally, the purity of the idea (followed especially by the International Style in the 20th century) became quite meaningless in the ever-changing world, full of multiple divisions and pulsating centers.

Getting out of hand, the city, as a nucleus of our civilization development, mutated into an uncontrollable force, constrained only by its own sustainability.

CHANGING THE LIMITS

Spanning the millennia, the idea of finiteness and centrality has been transmitted and applied through various urban models. However, the challenges brought by the economical, political and cultural globalization have generated a completely new comprehension of space and time relations, as well as a changed perception of the ancient dichotomies.

Dematerializing the Space

The recently established control and command role of world cities (Friedman, 1986; Sassen, 1991; Mollenkopf, 1993) goes beyond national borders, opening countless channels of communication and interchange through global streams. The contemporary urban nodes reinforce themselves by the advanced technologies, evolving into the complex units of increased global efficiency. The importance of 'place' is minimized, while various networks and matrixes directly or indirectly shape multiplying faces of the growing 'global community'. Guided by the post-modern rhythm that supports disjunctions and continuous fragmentation our reality becomes an ambiguous whirl which contracts space and time.

Fortunately, in spite of its complexity and confusion our world still cannot disregard some essential physical limitations even though their perception is drastically changed. The modern, technologically advanced space-time continuum has nowadays multiple centers while the nature, shape and visibility of its confines depend on numerous variables. Consequently, the classical geography is ignored and the heliocentric system seems to be replaced by the city-centric one, described in the set of five new Atlases of City Network Connection (Stupar, 2008). Based on the Peter Taylor's concept of World City Network (Taylor, 2004) this 'landscape of globalization'(or 'world of connectivity') reveals just one of many parallel universes able to blur every center and stretch numerous folders - to infinity.

Circumscribing the Flows

Entangled in the fusion of the debatable Cartesian space, the poststructuralist thought and the ontology of movement, flows, fluids and folds, the global society and its urban geography have gradually overgrown the inherited reality and its linear character. Therefore, it is possible that the future emanations of our cities will become non-scalar and non-linear boundless entities, capable of intense transformations. Meanwhile, the intensified interaction between global citizens, activities and spatial formations, as well as their proclaimed integration and interconnectedness, produce numerous side-effects - from personal isolation to numerous phobias (De Cauter, 2004). Thus, overprotection of our real and virtual envelopes usually causes spatial and social inclusion of privileged ones, while the exclusion of others becomes the collateral damage of the latest demarcation method.

In spite of numerous challenges which we are facing, the notion of the center and the limit has not completely disappeared from our lives saturated by multilayered transformations and mutations. It is directly or indirectly embedded in scientific debates about the future of a universe, its contraction or expansion[7], new cosmological models and scenarios, or tackled by the theories developed in human geography[8], science and technology studies[9], mathematics and computer science[10].

Epilogue or Prologue?

The city of the 21st century, in spite of all its doubts, novelties and demands, follows the logic of old foundation rituals setting up its own center(s) and limitations. Consequently, the global initiation is marked by new city gates (airports, railway stations) and powerful economic and information contact zones. These global connectors, with attractive architectural envelopes and multi-scale character, define the actual position of a city in the global/regional hierarchy, temporarily anchoring its center(s) and extending or contracting its global influence.

The urban genome, seen as a comparative advantage or valuable *genius loci*, additionally reinforces a city image. It modifies collective memory (Boyer, 1995; Zukin, 1995) transmitting the preferred or often re-created messages of urban history. If necessary, the (urban) landscape should also be thoroughly purified and fulfilled with new, attractive activities and numerous excitation/inhibition points which present generators of capital, entertainment, consumption and promotion. However, besides these mundane impulses, the latest urban incarnation also contains 'oasis' dedicated to spirituality which, frequently, destroy their own mystical aura but increase the area of influence using extremely profane methods and the media.

Obviously, the process of globalization transposes the concept of finiteness into another framework and perspective but, as always through history, it mirrors and indicates the condition of our society, the most recent ideas, scientific speculations and existential doubts. The hyper-modernity, with all its opposing rules, bifurcating realities, synthetic concepts and fragmented future undoubtedly channels the next phase of urban (r)evolution and the new instant, ready-made city is about to appear. However, will it have a center and a limit?

CONCLUSION

The synergy of new flows and different modes of urban reality finally modified a large number of inherited physical and symbolical patterns, challenging the ancient concept of finiteness. The contemporary coordinates are elevated high above the three-dimensional image of traditional orientation, their new significance overflows new layers of reality, but the delicate equilibrium between geography and non-geography, place and non-place, human and non-human is still a utopia.

Additionally defined and (de)limited by numerous streams, frames and networks, our urban world and its nodes remain the most complex human artifact, continuously exposed to the process of space-time aggregation. At the same time, the relation between the center and the limits is no longer perceived as an eternal and unchangeable dichotomy. Its importance is raised to another level, applied on numerous scales but, being a variable instead of a constant, it causes increasing confusion and disorientation.

Technological progress, ideological background and the contemporary historical frame do not negate the idea of finiteness. They upgrade its understanding, verify its multi-dimensional recognition and continue the well-

[7]Discussions about scenarios such as 'big crunch', 'big bang' or 'big rip'.
[8]Non-representational theory (Thrift, 1996, 2000)
[9]Actor-network theory (ANT) (Latour, 1987, 2005; Law, 1999)
[10]Complexity theory (Byrne, 1998; Cilliers, 1998)

known mythical thread. After all, the key element of this ancient balance is still unchanged – a human being, as the center of the unique microcosm, always limited by its material body.

Is *urbis* our orbis?

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Professional report

RAILWAY TERMINALS - ACCESSIBILITY FOR PERSONS WITH REDUCED MOBILITY

Zdenka Popović[1], University of Belgrade, Faculty of Civil Engineering, Belgrade, Serbia
Ksenija Stevanović, University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Leposava Puzavac, University of Belgrade, Faculty of Civil Engineering, Belgrade, Serbia

In the era of integration of all means of transport, there is revived interest in railway transport, which cannot any long exist as a transport system on its own or as an independent part within the growing cities. This renaissance of railway transport, and its integration with other means of transportation, led to a great production of exclusive terminals in recent days. High demands and investments related to these objects gathered together the most prominent architects and constructors, and as result offered a diversity of modern terminals, which integrate the static and dynamic character of the building into a unified whole, and celebrate new technologies and speed. Removal of barriers for customers, abundance of daylight, space filled with views, easy orientation and safe passage through space are some of the most important imperatives for modern railway terminals. Among other things this includes accessibility of railway infrastructure for persons with reduced mobility. The paper explores conditions for implementation of "Technical Specification for Interoperability – People with Reduced Mobility" on Serbian Railways.

Key words: Railway terminals, interoperability, accessibility, people with reduced mobility

INTRODUCTION

At the beginning of the 21st century, the European Union defined a common transport policy in its document entitled EU White Paper "European Transport Policy for 2010: Time to decide". This policy is based on regulated competition and connecting various modes of transport, a reduction of congestion points in traffic systems and it puts users' needs in its focus (European Commission, 2001). Placing users in the focus of transportation policy enables the realization of transport which satisfies human needs.

In the field of designing a railway infrastructure, this approach may resemble, at first sight, a simple application of Le Corbusier's human measurements principle. However, the realization of railway transport in accordance with human needs represents a contemporary approach in the design of a railway infrastructure, which equally encompasses all categories of passengers. A modern railway infrastructure must provide equal conditions for all age categories of passengers: children, adults and the elderly. It must provide safe and simple use regardless of a potential visual, hearing, stature, mobility or intellectual impairment (European Commission, 2006). With regard to this, an intensive effort has been employed recently aiming to find and apply technical solutions for the equal participation of people with reduced mobility, the blind and the visually impaired, people with hearing impairment and the deaf. The application of such technical solutions should, at the same time, simplify and make the participation in railway transport easier for all the categories of passengers, especially those with heavy or bulky luggage, people with children, foreigners and others.

According to official statistical data, in Serbia today, there are around 800,000 people (around 10% of the total population) with various levels of impairment and around 16.5% are people above the age of 65. This data is similar to other European statistical data (Economic Commission for Europe, 2005). Specific studies into the determination of the number of railway passengers with reduced mobility have not been performed in Serbia until now. At present, the results of studies carried out in France and Germany are used in Serbia, bearing in mind the similarity of the Serbian statistical data on regarding the number of people with reduced mobility and the elderly to the European data. These studies show that 20-30% of passengers have some kind of reduced mobility. Further increases of in the number of people with reduced mobility can be expected, due to the changes in the age

[1]Bulevar kralja Aleksandra 73, 11000 Belgrade, Serbia
zdenka@grf.bg.ac.rs

structure of the Serbian population, as well as an increased percentage of the population over the age of 65.

The transportation needs of people with reduced mobility are directed to different modes of transportation. In that respect, new services provided by the railway should be defined, in order to be competitive within the transportation market. At present, the competitiveness of the Serbian railway in comparison with the other modes of passenger transport is based mainly on low fares, which in turn determines the structure of passengers, the highest percentage being passengers with low income: secondary school students, university students, low-paid people, pensioners, and people on social welfare. The extension of working life until the age of 65 also affects the number of people with reduced mobility in passenger transport.

By finding suitable technical solutions for vehicles and infrastructure as well as by applying telematics, the Serbian Railway is making an effort to increase the number of users in the regional and long distance passenger railway transport. Essential in to this process is the role of the designer, who needs to provide easy and safe transfer from one mode of transport to another, clear route identification, availability of information, effective ticket service, optimally equipped waiting rooms, parking facilities, toilets, shops, restaurants, and other services within stations, for all categories of passengers.

LEGAL AND TECHNICAL REGULATIONS IN THE REPUBLIC OF SERBIA

Unobstructed access to rolling stock for all passenger categories represents practical fulfilment of the requirements to facilitate safe access and egress and comfort for people with visual, hearing, stature, mobility or intellectual impairments. This prevents the discrimination of passengers in railway transport. The prevention of passenger discrimination is a part of Charter on Rail Passenger Services which was issued by CER - The Community of European Railway and Infrastructure Companies, and UIC - Union Internationale des Chemins de fer on 22nd October 2002.

In the Republic of Serbia, intensive efforts are being made to create legal basis for the introduction of accessibility standards (unlimited access for passengers with special needs) into all areas of social life. This paper shall be limited to the field of railway transport.

The right of all passengers to unobstructed access to transportation in the Republic of Serbia is stated in the Prevention of Discrimination of People with Disabilities Act which was passed by the National Parliament on 17th April 2006 (Prevention of Discrimination of People with Disabilities Act, 2006). The term people with disabilities, according to this Act is used for "people with congenital or acquired physical, sensory, intellectual or emotional disability who, due to social or other impediments, are unable or are partly able to participate in social activities on the same level as other people, regardless of whether they are able to perform the mentioned activities by using technical aids or support services."

Article 13 of the above mentioned Act bans discrimination based on disability with regard to availability of services and accessibility of public buildings and other public areas: parks, squares, streets, pedestrian crossings and other public traffic facilities, etc. Article 27 bans the discrimination due to disability in all types of transport. Act regarding the employment of people with disabilities was passed by the National Parliament on May 2009.

It should be noted that this Act was preceded by Regulations on conditions for planning and the design of buildings for unobstructed access of children, the elderly, the handicapped and the disabled in 1997 (The Official Gazette of Republic of Serbia, issue no, 18/97). These Regulations refer to technical conditions for planning and designing pavements, footpaths, pedestrian crossings, parking places, public transport stops and access to buildings (pedestrian and wheelchair ramps, steps and staircases, lift platforms).

The Planning and Construction Act passed in 2006 introduced new standards of accessibility in the form of mandatory technical measures, standards and conditions of design, planning and construction, which ensure unobstructed movement for people with disabilities, children and the elderly (Law on Planning and Construction, 2006). Article 42 of this Act introduces a new rule of construction i.e. special conditions which make public areas and public buildings accessible to people with disabilities in keeping with the accessibility standards. This Act prescribes a mandatory fine for the investor or the authorised person (Article 153) if there is no access to the building of public interest available, which is in accordance with accessibility standards.

A strict application of the accessibility standards increases the construction of infrastructure costs by a small fraction: 0% up to 2%. Later alterations demand a much higher investment (according to some research, as high as 30%, depending on the type of building or the type of alteration). Therefore, a timely application of accessibility standards is not only a humane and a legal obligation but it is also a profitable investment.

Respecting legal obligations and bearing in mind the public interest of accessible areas, the Serbian Railway has been performing new constructions as well as reconstructions in accordance with the accessibility standards. For that reason, the Railway Directorate has been formed, by the Railway Act in 2005, for

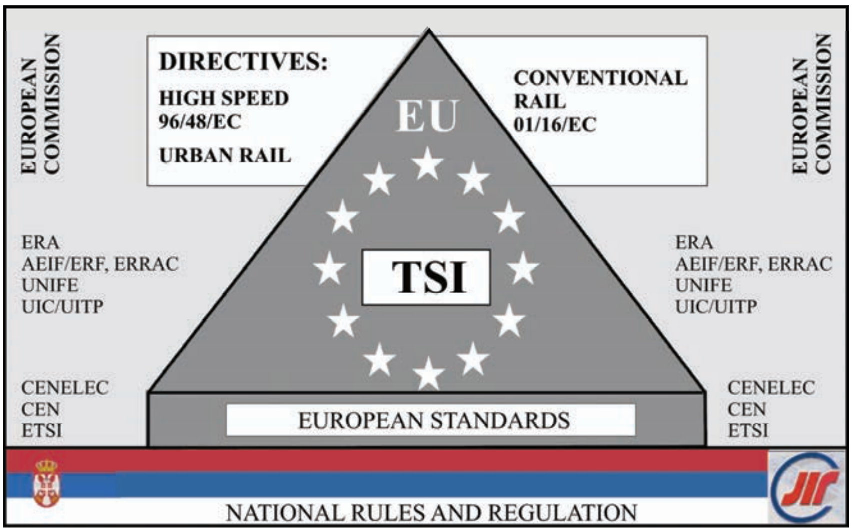

Figure 1: Harmonization of standards of the Republic of Serbia with EU standards in railway transport (Popović, 2007b)

the purpose of providing professional services in the field of railway transport, regulations and other tasks determined by this act (Railway Act, 2005). One of the tasks for the Directorate is drafting technical regulations, norms and standards in railway transport, as well as suggesting the measures to harmonize and increase the level of interoperability and modernization of the railway (Directive 96/48/EC, 1996; Directive 2001/13/EC, 2001) (*Figure 1*).

The document TSI PRM – Technical Specification for Interoperability – People with Reduced Mobility is used for the purpose of regulation of unobstructed access to rolling stock, in Pan-European and Trans-European railway corridors, therefore in Corridor X as well, passing through the Republic of Serbia, which comprises 17.6% of the railway network in the Republic of Serbia (*Figure 2*).

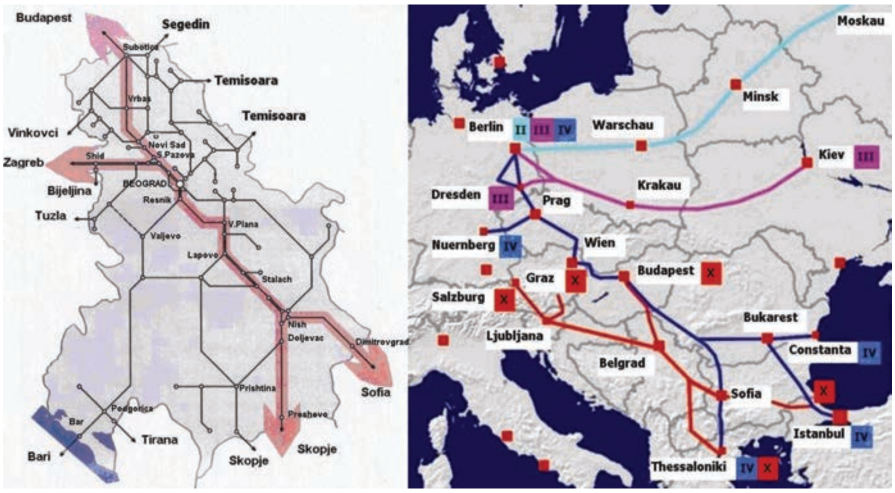

Figure 2: European Corridor X passing through the Republic of Serbia (Popović, 2007a)

The document TSI PRM covers the following scope of specific interest: the station infrastructure including platforms, rolling stock, the gap between platform edge and the vehicle, and regulations on gradual implementation of TSI. The TSI PRM regulations also refer to the conventional railway systems as well as the systems of high speed railway lines of the EU member states and Norway. However, the non-EU states have a common economic interest to apply the technical specifications of interoperability on main international lines and even further on. In this paper on TSI, we shall focus on the so called "infrastructure subsystem".

In order to apply the TSI PRM regulations, all new rolling stock and railway terminals must be in compliance with the accessibility standards and gradual adaptations must be planned for the existent railway infrastructure in Serbia.

Creating a legislative base and sanctions for failure to fulfil the legal obligations is a necessary but insufficient precondition for the application of accessibility standards in planning, designing and construction of the railway infrastructure. The current "Regulations on conditions for planning and the design of buildings for unobstructed access for children, the elderly, the handicapped and the disabled" from 1997 has not been made compliant with TSI PRM from 2006. For example, according to TSI PRM, the following categories of passengers have difficulties when using trains and the surrounding infrastructure: wheelchair users, other people with reduced mobility (people with broken limbs, people with difficulties in walking, people with children, people with heavy or bulky luggage, elderly people, pregnant women, visually impaired people, blind people, those with hearing impairment, and deaf people), people with communication impairment (people who have difficulties in communication or understanding written or spoken language, including foreigners with insufficient knowledge of a language, people with mental, psychological or intellectual difficulties), people with of small stature and children.

For all the above mentioned categories of passengers, according to TSI PRM, a safe and unobstructed access to rolling stock should necessarily be made possible, ensuring their preserved dignity and integrity. Also, the applied measures and technical solutions should contribute to the increase in safety for all categories of passengers (both people with or without reduced mobility), as well as a faster flow of passengers on platforms. In the economic sense, gradual investments into new and existing infrastructure should increase the number of passengers who can use the railway services, and it should also lower the expenses for damages paid to injured passengers or to the families of the railway casualties. The increase in comfort and safety for all categories of passengers should also increase the competitiveness of the railway in comparison with other means of transportation. For the effective and practical implementation of TSI PRM regulations in planning, design and construction of railway infrastructure in the Republic of Serbia, it is necessary to draw up a suitable set of regulations.

Apart from this, the media (the press, radio, TV) are used to promote the public importance of the accessibility to all types of transport without discrimination. In this way, the citizens of Serbia are provided with necessary information on the measures undertaken in order to make the entire surroundings accessible (eg information, etc.) to the benefit of the whole society. The media promote good examples in practice and point at cases of non-conformity with accessibility standards. Associations of citizens (The Association of the Blind and Visually Impaired, The Association of the Paraplegic and Quadriplegic of Serbia, etc.) as well as the professional associations also contribute to raising public awareness and to undertaking specific actions for the implementation of accessibility standards in transport.

The contents of accessibility standards for railway traffic have been included in the curricula of relevant technical faculties (The Faculties of Civil Engineering, Architecture, Traffic Engineering, and Mechanical Engineering) and in professional seminars in Serbia. The education of students and engineers is an important foundation for the introduction of uniform services and appearance of railway passenger terminals in Europe, in order to provide consistency in the application of measures for easy access for people with reduced mobility.

ANALYSIS OF PASSENGER TRANSPORT IN SERBIA

Two out of ten traffic corridors in the European territory, as defined at the Helsinki conference in 1997, pass through Serbia: the river corridor VII – The Danube Corridor and the road-railway

Corridor X Vienna – Zagreb – Belgrade – Niš – Thessaloniki, with a branch X1 Belgrade – Budapest. General objectives of the strategy development of multi-modal transport corridor X are defined in (Milijić et al., 2003).

The following international railway routes pass through Serbia, in accordance with AGC Agreement ("European Agreement on main international Rail Lines", Geneva, May 1985) (Economic Commission for Europe, 1985):

1. E 771 Subotica - Vinkovci - Strižívojne Vrpolje - Sarajevo-Ploče,
2. E 79 Beograd - Bar,
3. E 85 Budapest - Kelebija - Subotica - Beograd - Niš - Preševo - Skopje - Gevgelia - Idomeni - Thessaloniki - Athens,
4. E 66 Beograd - Vršac - Stamora Moravita - Timisoara,
5. E 70 Paris - Macon - Amberieu - Culoz - Modane - Torino - Rho - Milano - Verona - Trieste - Villa Opicina - Sežana - Ljubljana - Zidani Most - Zagreb - Šid - Beograd - Niš - Dimitrovgrad - Dragoman - Sofija - Plovdiv - Dimitrovgrad - Svilengrad - Kapikule - Istambul - Haydarpasa - Ankara - (Kapikoj (Razi - Iran)/Nusajbin (Kamichli - Syria)).

The basic characteristics of the railway lines in the Republic of Serbia are listed in *Table 1*.

Out of the total number of stations in the network which are open for passenger arrival and departure, more than a half (about 58%) are situated on international routes. About 36% of stations are in Corridor X together with those on Branch X1.

The percentage of participation of passenger railway transport in comparison with other forms of transport is declining in the Republic of Serbia as well as in the EU. Analyses show that the highest number of journeys is made by car, which means that for the majority of passengers, time spent on travelling is more important than the cost. A specific characteristic of the total passenger transport in the Republic of Serbia is certainly a remarkable dominance of the domestic transport over the international one. The reason for this is the unfavourable visa policy for the citizens of Serbia.

The predictions for the total passenger transport in the Republic of Serbia until 2012 (data taken from a study done by CIP- Institute of Transportation) show the same dominance of the domestic transport over the international one, as shown in *Figure 3*. The data include neither the influence of the world economic crises on the mobility of citizens in the Republic of Serbia, nor the possibility of liberalization of the visa policy for EU countries. The data also does not include urban public rail transport.

Figure 4 shows an irregular use of the existing network of different modes of transport in Serbia. One of the main aims of the transport policy in Serbia is the stimulation of long-distance railway transport. The realization of this aim requires the integration of Serbian Railway network into the European rail network, based on the concept of interoperability and harmonization of regulations, as well as on stimulation of multimodal transport of passengers and goods. The reconstruction and modernization of the railway infrastructure and the improvement of the railway transport would contribute to lower pollution of the environment, increased road safety and lower energy consumption. All this also contributes to the successful fulfilment of obligations which the Republic of Serbia has, according to international agreements and UIC Leaflets

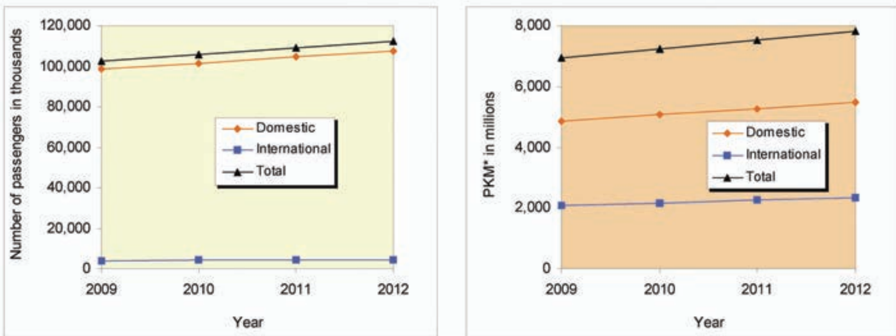

Figure 3: Predictions for the total passenger transport

PKM – the number of passengers multiplied by the number of kilometres

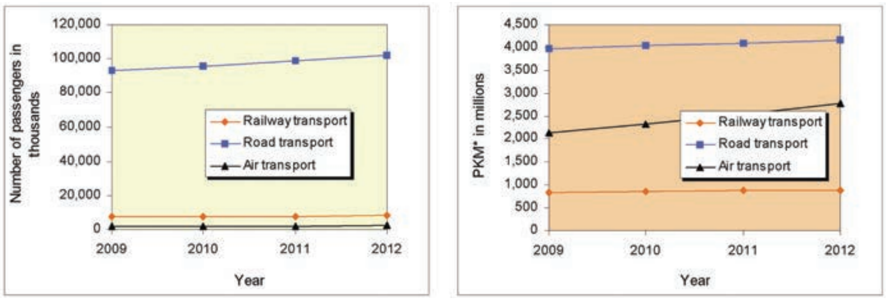

Figure 4: Predictions for the total passenger transport by modes of transport, excluding urban public transport

PKM – the number of passengers multiplied by the number of kilometres

Table 1: Basic characteristics of Serbian Railways lines

No.	Characteristics	Length (km)
1	Construction length	3,809
2	Single track railway	3,533
3	Double track railway	276
4	Main rail lines	1,767
5	Electrified railway (25kV, 50Hz AC)	1,247
6	The total number of stations for passenger transport on main international railway lines	324
7	The number of stations for passenger transport in Corridor X	176
8	The number of stations for passenger transport in Corridor X1	23
9	The number of stations for passenger transport in Corridor X and X1	199

(Economic Commission for Europe, 1985; Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1998; SEECP (South East European Cooperation Process, 2006; UIC Leaflet 140, 2001; UIC Leaflet 413, 2000).

The current situation in passenger railway transport in the Republic of Serbia, regarding the number of passengers, or the quality of services for all categories of passengers is unsatisfactory. The loss of customers' trust in the quality of railway services results in a decreased number of passengers which, in the long run, can cause very negative effects for the railway.

An increase in the quality of service for people with reduced mobility is to be primarily realised at railway passenger terminals. Bearing in mind that the improvement of accessibility must be done gradually, it is believed that the accessibility should be improved first at stations with the highest number of passengers. Analyses show that the highest number of local and international passengers per day leaves the Belgrade railway hub.

APPLICATION OF ACCESSIBILITY STANDARDS ON RAILWAY TERMINALS IN SERBIA

The application of accessibility standards in railway terminals is a legal obligation for the construction of new infrastructure. For the existing infrastructure, the gradual removal of obstacles for the purpose of accessibility for all categories of passengers without discrimination has been planned, bearing in mind financial and time limitations.

Transportation of wheelchair users has been planned on all major railway terminals, at least 30 km apart. Other solutions would require an unacceptably high financial investment and delaying of the trains in stations. Therefore, it is necessary to organize "door to door" transport for the disabled in specialized vans. This solution has been applied in the territory of the City of Belgrade.

The adaptation of passenger trains for the transport of the disabled is already under way, which will enable the use of the existent infrastructure planned for an unobstructed access of the disabled to platforms. For example, in the "Vukov Spomenik" station, in the Belgrade railway hub, where more than 2,000 passengers leave daily, there is a special entrance for wheelchair users with nine

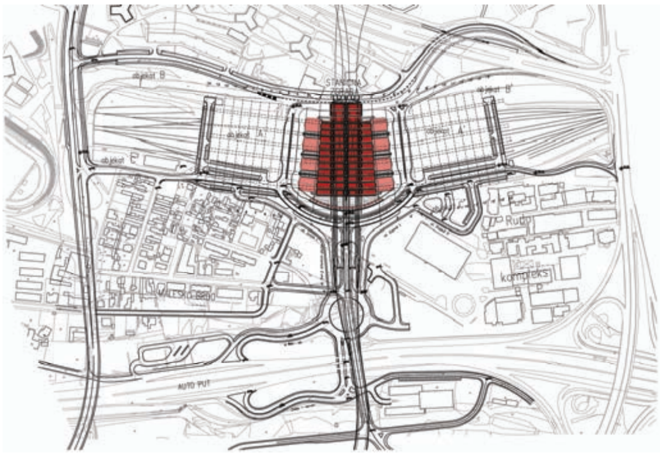

Figure 5: New station "Beograd centar" designed by Prof. S. Rogan and CIP – Institute of Transportation

Figure 6: Long distance passenger transport – existing situation

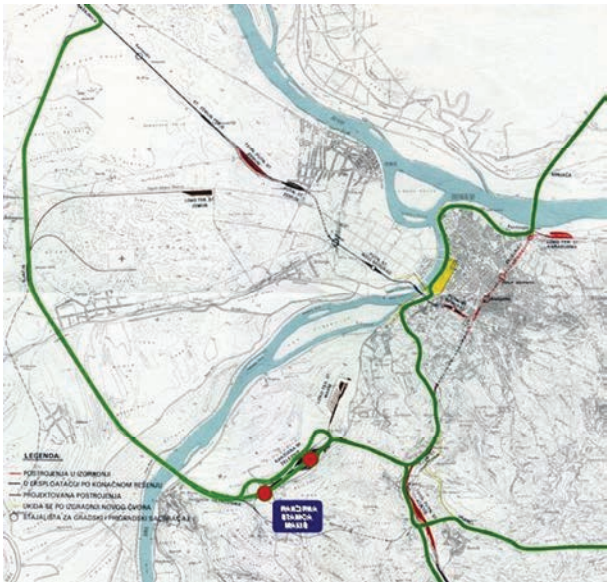

Figure 7: Freight transport - existing situation

parking places reserved for their vehicles and a lift for wheelchair users to descend to the platform.

The reconstruction of the Belgrade railway hub is under way, which should enable separation of the passenger and freight transport, as well as the dislocation of the main passenger railway station (*Figures 5, 6, 7, 8* and *9*).

The new station "Beograd centar" is planed to have a concept of transit type railway station which is more acceptable then the existing head type railway station. This transit type is more suitable for the city giving large abilities for smooth and easy interchanges. Generally, new railroad terminal are pass-through ones, and, through time, the pass-through type railway stations evolved into a developed vertical plan, where segments of the station premises are in vertical superposition (Stevanović, 2008b). These solutions emphasize studies of movement and facilitation of vertical communications in cases when the number of customers is big. Thus, solutions offering multiple accesses, from several sides and levels, are far better. The main goal is fading of obstacles, plenty of daylight, a pleasant ambience, easy resourcefulness and reliable visual aids, therefore all those becomes an categorical imperative (Stevanović, 2007; Stevanović, 2008a). New sophisticated concept is entirely in the service of a great number of customers. Special attention is given to proper orientation, shortest possible routes, as well as pleasant stay and movement through a space full of different views. Fluxes of great numbers of people were studied, entrances were cleared, parking spaces provided along with easy access from different modes of transportation. The new railway station "Beograd centar" complies with accessibility standards.

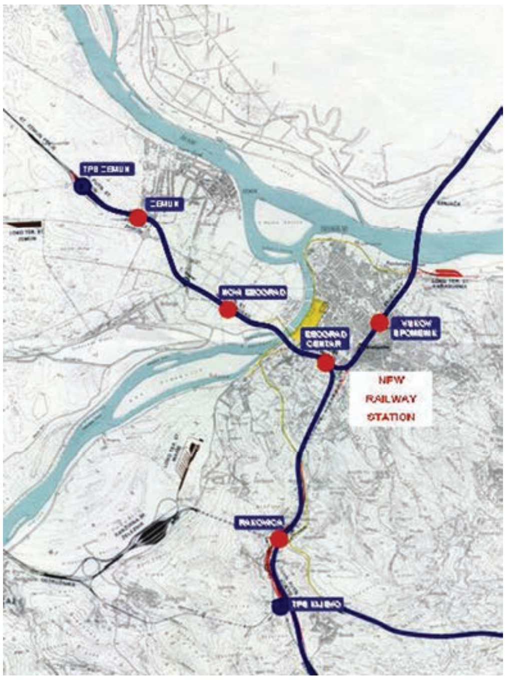

Figure 8: Long distance passenger transport – final solution

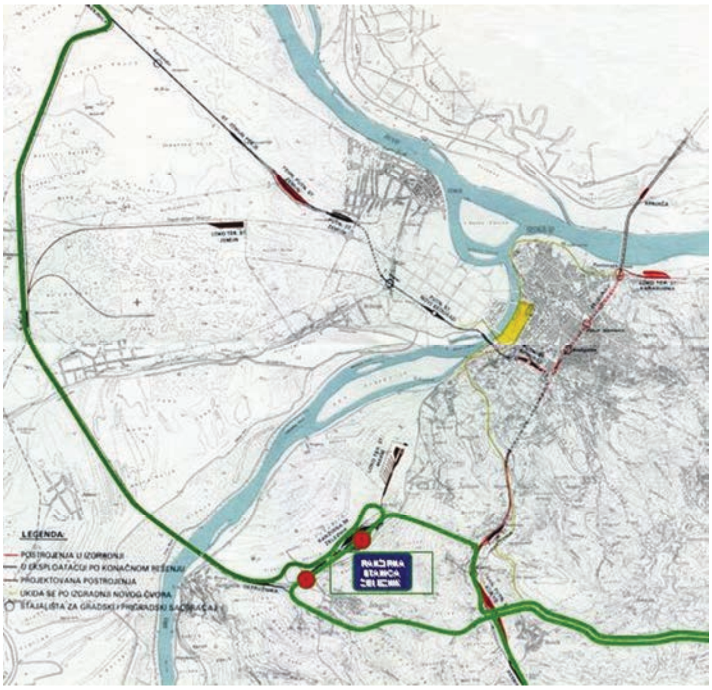

Figure 9: Freight transport – final solution

The reconstruction of the existing railway terminals in Serbia shall include sufficient parking facilities for wheelchair users (reserved and properly indicated) in the proximity of the entrances to railway stations (no further than 100 m away), designed in compliance with the regulations for unobstructed access for people with reduced mobility.

Passenger routes and footpaths with unobstructed access for people with reduced mobility must enable safe access from the station's front area i.e. the entrance to all services within the station, and finally, to the platforms (*Figure 10*). For this purpose, ramps or platform lifts must be provided in all access points with denivelation (different floor levels). All access points, subways, footbridges; staircases must have an obstacle-free area of a minimum of 2x800=1600 mm in width and headroom of 2300 m throughout.

All information for passengers must have a simple and unified concept for the purpose of easy comprehension. The process of introducing induction couplers is under way in all major railway stations. In the existing terminals, there is a problem of visibility of visual information signposts and their consistence with the spoken ones. Information boards in the Braille alphabet are currently being installed for blind and visually impaired people in all major terminals. In Serbia, tactile signage for the visually impaired is regulated in accordance with the domestic standard JUS U.A9.202.

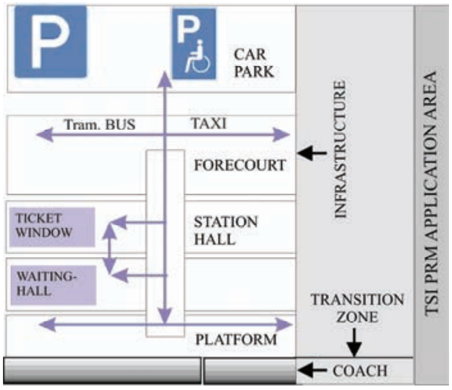

Figure 10: Communications scheme (European Commission, 2004)

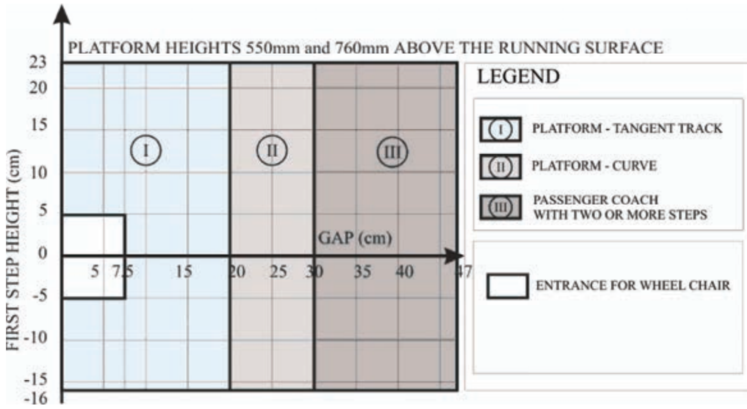

Figure 11: First step heights and gaps according to TSI PRM (Ernst and Kieffer, 2006)

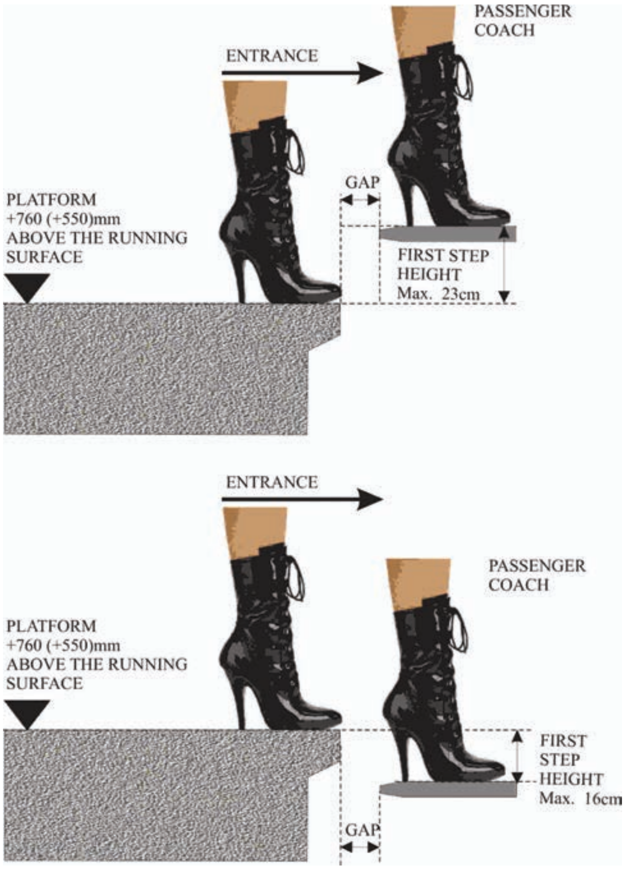

Figure 12: Position of the first step vis-à-vis the platform (TSI PRM) (Popović and Puzavac, 2008)

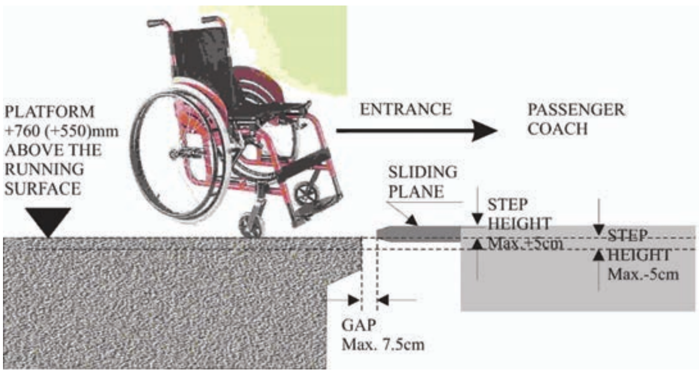

Figure 13: Ideal position of the train floor vis-à-vis the platform (TSI PRM) (Popović and Puzavac, 2008)

Mobile and free-standing devices are often placed as obstacles which disrupt the movement in the existing stations. Such obstacles must be easily detected with a stick for the blind and visually impaired. Transparent glass and Plexiglas obstacles (doors, boards, partitions, walls, etc.) constitute a danger. However, they are rare in the existing stations. In the new ones, they must be visibly marked at eye level, in accordance with TSI PRM, for the purpose of keeping the safety and dignity of the blind and visually impaired. The height of markings must be suitable for children, wheelchair users, and people of small stature as well as all other adult passengers. Therefore, lines should be placed on two standard levels, in order to protect all categories of passengers.

In the existing railway terminals there are no toilets for wheelchair users. At least one toilet wheelchair accessible cubicle must be provided at stations. Apart from pictograms on toilet doors, tactile markings are compulsory at a height of 900-1300mm.

All service counters (ticket sales, information desks, etc.) must be accessible for wheelchair users and other people with reduced mobility, and provided with seating facilities. On platforms, waiting areas and all other areas where people wait for trains, a weather-protected area fitted with ergonomic seating facilities and spaces for wheelchairs must be provided.

TSI PRM determines two nominal values permissible for platform height: 550mm and 760mm above the running surface. It also determines the allowed gap, and the position of the first step (*Figures 11, 12, 13*). The reconstruction of all stations in Corridor X shall include platform height adjustment and application of coaches with barrier-free passenger access (Ostermann and Rueger, 2006). Along the platform edge, at a distance of 80cm there should be a tactile line of warning.

Timely evacuation must be provided for all passengers in hazardous situations. These measures must particularly include all passengers with reduced mobility.

CONCLUSION

The European Union has enacted various legislative measures aimed at achieving the opening up, integration and harmonization of national railways to form a European railway network. One of the essential preconditions for the integration of the Serbian Railways with those of the European Union is to approximate Serbia's railway regulations and standards to those of the EU. The Railway modernization project is a strategic project for the development of transport infrastructure in the Republic of Serbia and connecting it to the European network. The project covers the railway lines in the European Corridor X that runs through Republic of Serbia and interconnects the railway routes of Central and Easter Europe with the Middle East and the Adriatic Sea. Among other things harmonizing includes accessibility of railway infrastructure for persons with reduced mobility.

Having analysed the existing legislative regulations in view of the rights of people with disabilities, we can conclude that the Republic of Serbia has harmonized its laws with the European regulations. However, a lack of technical regulations for the implementation of these regulations in railway infrastructure is apparent. The Railway Directorate is expected to take an initiative and adequate steps in order to set down Regulations for the accessibility of railway infrastructure for people with reduced mobility. In the construction of new railway terminals, it is mandatory to apply the accessibility standards.

The existing railway infrastructure is being gradually adjusted through measures of reconstruction and modernization of railway transport, in accordance with accessibility standards. The stations on main lines with the highest number of passengers are a priority in the process of compliance with accessibility standards.

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