RECONSTRUCTION FOR SLOVENE ETHNOGRAPHIC MUSEUM

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ABSTRACT

Reconstruction of late 19th century building for new Slovene Ethnographic Museum is presented. Interventions into building envelope and heating, cooling and lighting system from exhibits and visitor's comfort and rational use of energy point of view were treated in the framework of EU and SI research programmes. An innovative heating-cooling system have been designed and tested.

KEYWORDS

Reconstruction, constructional complexes, heating, cooling, daylight.

INTRODUCTION

The building of the new Slovene Ethnographic Museum – SEM in Ljubljana, Slovenia was built at the end of 19th century as a part of a system of army barracks. In 1991 the complex was left empty and devastated by Yugoslav army. In 1994 the Government of Republic of Slovenia allocated two buildings of the complex to SEM. The first administration building with 1900 m2 was refurbished in 1997. The second exhibition building with surface of 4209 m2, 2604 m2 of exhibition area becomes part of the EU 5th framework project Museums – Energy efficiency and Sustainability in Retrofitted and New Museum Buildings in 1999.

The origins of the ethnographic museum go back to the "ethnographic" or "folk" collections of the Carniolan Provincial Museum in Ljubljana, funded in 1821. From the first and the oldest collection of "ethnographic objects" from North America, belonging to Ochipwa and Ottawa Indians tribes, donated by the missionary and bishop Frederik Baraga, the Slovene collection have grown to more than 30000 objects and non-European collections to more than 9500 objects.

The goal of the project is to assure optimal conditions for exhibitions and for storage of museum objects in acordance with international standards and appropriate environment for visitors from the visual and from thermal point of view. The priorities for both objects and visitors are: optimal daylight and rational use of energy without prejudice to quality of use.

PRELIMINARY ENERGY ANALYSIS

Preliminary heating energy consumption analysis was made for different temperature regimes for external walls U-value 1.05 W/m^{2}K, windows 3.2 W/m^{2}K, 0.5 ACH and 160 persons (visitors). Calculated data are presented in Table 1. Specific energy consumption for heating is between 134 and 240 kWh/m^{2}a. Measured heating energy consumption in the existing administrative building was 141 kWh/m^{2}a in the last heating season (2001-2002).

TABLE 1
Preliminary heating energy consumption analysis

	Heating Regime - Energy Consumption									
	18 Const.		20 Const.		22 Const.		20/16 12h		18/16 12h	
	kWh	kWh/m^{2}a	kWh	kWh/m^{2}a	kWh	kWh/m^{2}a	kWh	kWh/m^{2}a	kWh	kWh/m^{2}a
EN 832	600691	**165**	731513	**201**	875729	**240**	503861	**138**	489520	**134**
Enerbed	471921	**137**	572575	**165**	681985	**197**	532462	**154**	463169	**135**

First intervention

On the basis of measurements during summer 2000 the air condition system foreseen in the existing project is totally excluded. Monitoring took place in the 1st phase in two parallel experimental rooms on the 3rd floor, SE and SW part in the free run mode. This set free of 158 m^2 of space for depository area.

The investment budget in the field of HVAC was reduced from 112.958.000,00 SIT (530.319 €) to 92.458.000,00 SIT (434.075 €) i.e. cca 18%.

The quantity of blown in air is reduced from 36500 m^3/h to 10000 m^3/h and the power of heating station is diminished for 110 kW, for cooling for 62 kW.

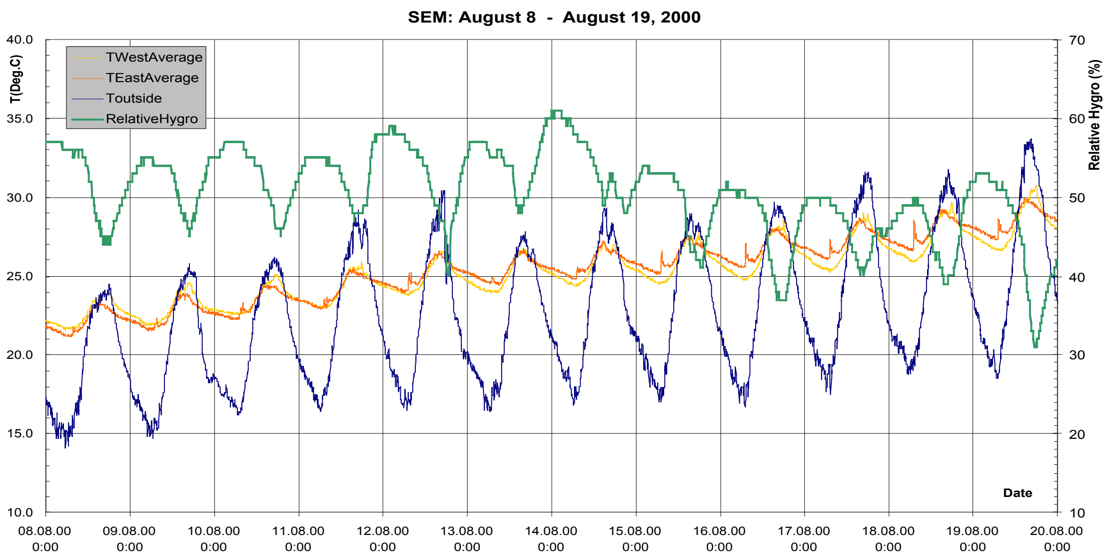

Fig. 1: Monitoring 1st phase 2000-08-08/19. Temperatures over 30^{0}C are rare in Ljubljana. Peak inside air temperature was 30^{0}C in room without solar protection and without ventilation.

Monitoring

Monitoring took place in the 1st phase in two parallel experimental rooms on the 3rd floor, SE and SW part. (Fig. 1) in the free run mode from July to December 2000.
Monitoring in 2 and 3rd phase took place in two parallel experimental rooms on the 1st and 2nd floor, SW part. This one was selected because of higher temperatures during summer period compared to the SE one (Fig. 5,6).

On the basis of these measurements final decisions on the selection of interventions was made.

CONCEPT

Main interventions in the framework of the project were made in heating and cooling system in connection with the structure of constructional complexes, in ventilation, in daylight and shading, in control and in monitoring.

For heating and cooling a new innovative outer wall system is designed. Its main characteristics are quick response constructional complex system with thermal insulation inside and low temperature heating&cooling vertical concrete panel system. The thermal mass of concrete panel is excluded from the wall's thermal energy conduction transport system with ventilated air space. Thus surface temperature of the outer wall can be controlled, surface – air temperature proportion can be reversed and from the thermal comfort point of view lateral radiation effect on human body is achieved.

For heating and cooling control each floor is divided into two zones on the western and on the eastern side.

Ventilation is based on bi-directional temperature/time sensitive system with 0.5 ACH during opening hours and increased night ventilation during summer period for cooling purposes.
Small tangential fans are integrated into the lower part of the window. There are two ventilated cones in each floor with four connected rooms without doors. Two different directions of air movement are foreseen. The direction of airflow is selected on the basis of ventilation and/or cooling demand and outside temperature. The building is divided for shading into four zones, South, North, West and East elevation (Fig. 2).

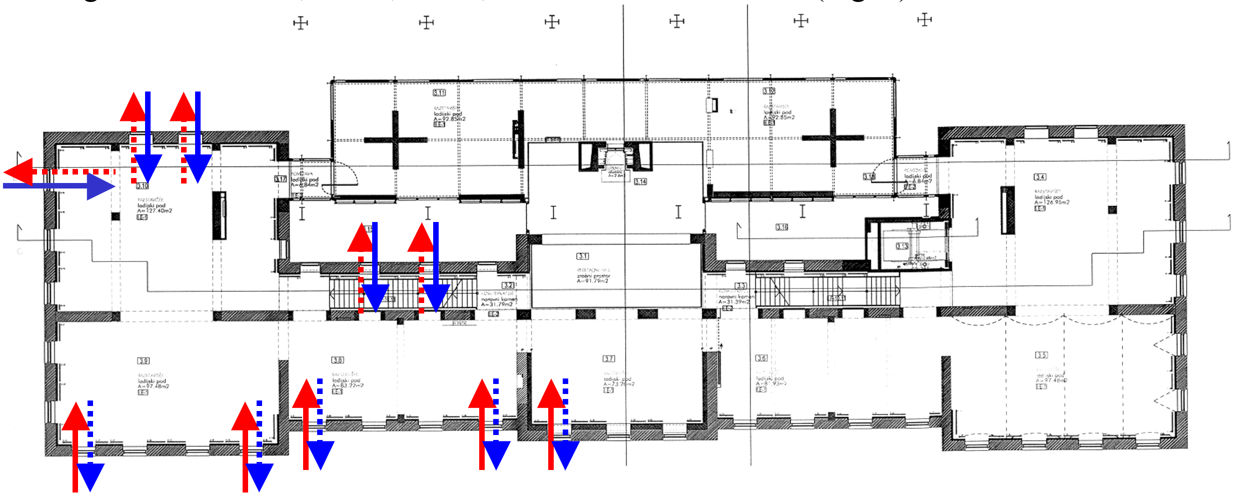

Fig. 2: Ventilation system in typical floor.

Daylight is integrated into illumination system in exhibition areas with time controlled daylight Multisenzors. In window integrated BMS controlled roller blinds are used for glare protection and for dimming in case of special illumination demands. There is a possibility to control each exhibition space manually on site. For general illumination high efficiency lamps – linear fluorescent T8 and for exhibits illumination low voltage lamps, UV radiation < 20 mW/m^2 will be used. General lighting control in exhibition areas will be made with time controlled daylighting sensors and occupancy sensors in other areas with time control/occupancy sensors.

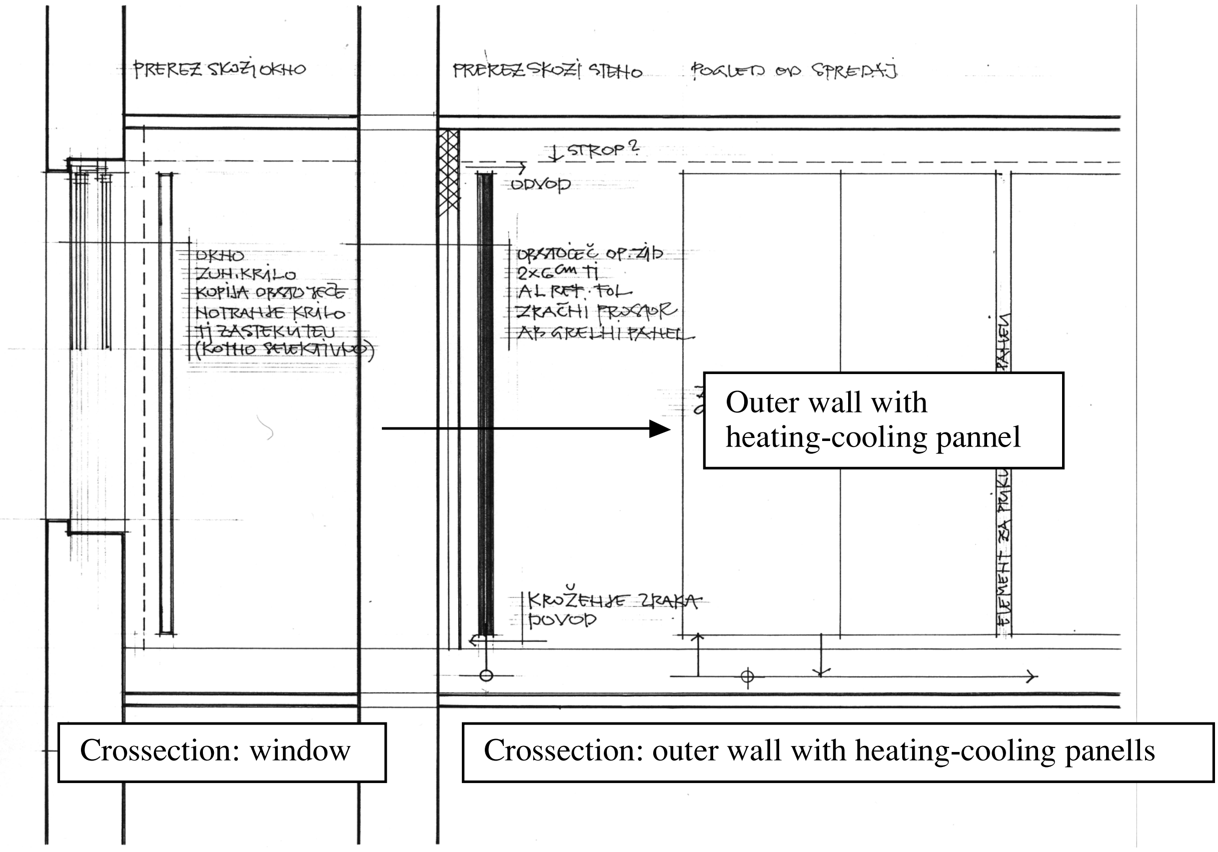

Fig. 3: System of heating-cooling concrete panells in the structure of the outside wall.

Fig. 4: View of heating-cooling concrete panells in experimental room.

Temperature, ventilation and shading will be controlled by central BMS while daylight-artificial light harmonisation will be controlled locally.

Monitoring system is embodied in the control system for permanent use, not only for the purpose of this project. Ambient air temperature, ambient air humidity, heating and cooling consumption, lighting consumption, indoor air temperature, indoor air humidity and illumination levels are foreseen monitoring parameters.

RESULTS

On the basis of measurements during summer 2000 and consideration of foreseen interventions resulted from new design of combined heating-cooling system the air condition system foreseen in the existing project is totally excluded.

This set free of 158 m^2 of space for depository area.

The quantity of blown in air is reduced from 36500 m^3/h to 10000 m^3/h and the Heating: power of heating station diminished for 110 kW, for cooling for 62 kW. reduced The investment budget in the field of HVAC was reduced from 112.958.000,00 SIT (530.319 €) to 92.458.000,00 SIT (434.075 €) i.e. cca 18%.

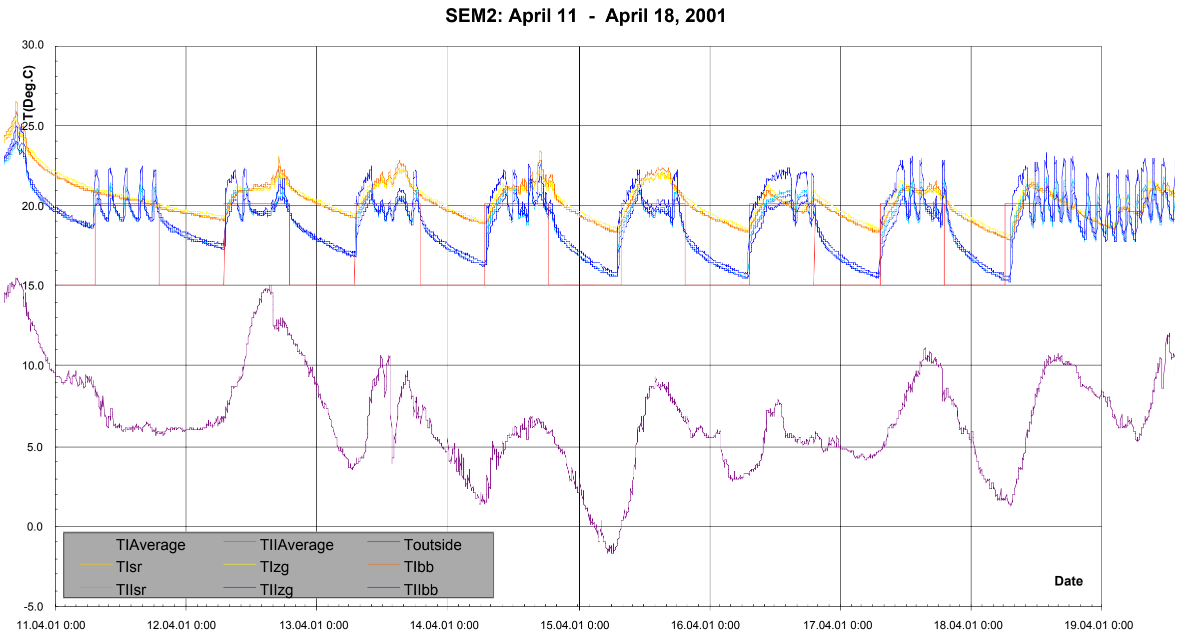

Fig. 5: Example of temperature oscillations during heating period.

Two selected comparative measurements in the room with heating-cooling panels (R1) and in reference room (RR) are shown for intermittent heating and cooling modes respectively (Fig. 5). Set point temperature 20^0C in R1 during heating period can be diminished from 2^{nd} to 4^{th} day because of solar radiation effect and there is no danger that temperature fell bellow 15^0C during the reduced temperature phase, which is not the case in the RR. During summer period in August cooling system is able to support a very stable temperature profile around set point temperature of 22.5^0C (Fig. 6).

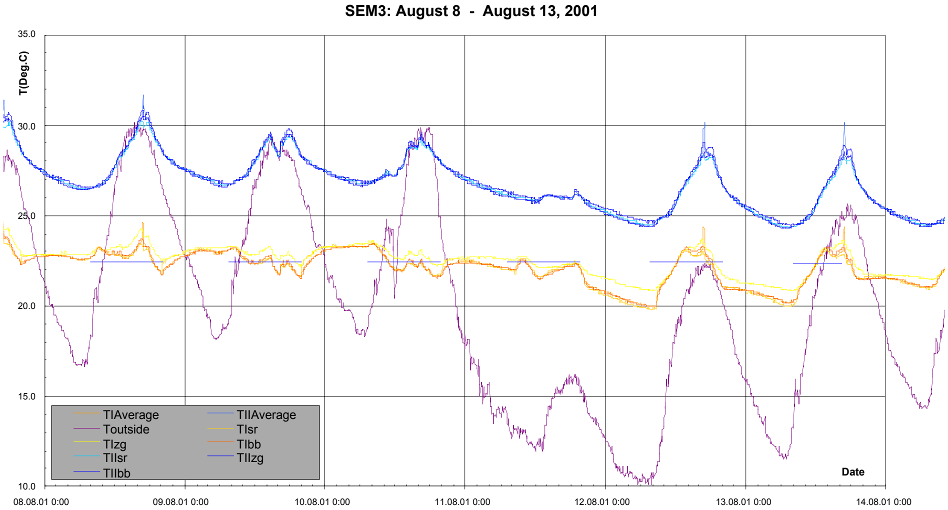

Fig. Example of temperature oscillations during cooling period.

TABLE 2

Heating: measured energy consumption in winter period 2001/2002 (kWh/m2)

	2001			2002				
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	**Season**
I. Floor	5.1	13.3	24.2	23.8	12.7	5.6	6.8	0.8	**92.3**
II. Floor	6.1	15.0	27.3	26.3	15.1	7.7	7.1	0.4	**105.1**

TABLE 3

Cooling: measured energy consumption in summer period 2001 & 2002 (kWh/m2)

	2001			2002	2001			2002
	Aug (kWh/m^{2}day)			Jun	**Season** (60 days, kWh/ m^2)			
	1	2	3	4	1	2	3	4
	24 h/day, no set point T	12 h/day, 8-20h 22.5^{0}C set point T	12 h/day, 8-20h 25^{0}C set point T	24 h/day, no set point T	24 h/day, no set point T	12 h/day, 8-20h 22.5^{0}C set point T	12 h/day, 8-20h 25^{0}C set point T	24 h/day, no set point T
I. Floor	0.48	0.25	0.17	0.42	**28.8**	**15**	**10.2**	**25.2**

Measured heating energy consumption of the experimental configuration in the building, presented in Table where two inside walls were in fact two outer walls was 92 kWh/m^2/winter period 2001-2002 for the room with heating panels and 105 kWh/m^2/winter period 2001-2002 for the room with conventional heating with radiators, i.e. 12% smaller consumption in panel heated room.

Measured specific energy consumption for cooling (kWh/m^{2}day) in the experimental configuration presented in Table is 0.42 – 0.48 kWh/m^{2}day for constant 24 hours operation without set point temperature and 0.25 and 0.17 kWh/m^{2}day for 12 hours operation per day from 08-20 with 22.5^{0}C and 25^{0}C respectively. This represents 10-15 kWh/m^2 specific consumption during cooling period of 60 days!

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