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EXPERIMENTAL RESEARCH ON THE TEMPERATURE DISTRIBUTION OF THERMALLY ACTIVATED BUILDING SYSTEMS (TABS)

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Abstract: The ussage of the cooling systems that use earth's natural enery potential has increased over the last years dn with it the need for radiant systems.The efficiency of the radiant surfaces , expecially the TABS systems is influenced by the temperature variation over their surface This article studies the effects of the thermal agent velocity in ducts and ventilation system present on the temperature field of the radiating surfaces TABS system.

Key words: *TABS, temperature vaiation,radiant surface.*

1. Introduction

Cooling buildings during warm seasons increases significantly the electricity bill. To guarantee thermal comfort in residential and tertiary buildings during summer, the most common method spread worldwide is the ussage of air-conditioning systems [4].

Lately, a particular emphasis, worldwide spread, is the energy consumption of ventilation and air conditioning systems. An efficient alternative to the energy used by the air conditioning systems is the mixed systems: cooling/heating that use radiation and ventilation [2].

In the early 1990s, Swiss engineer Robert Meierhans realised two successful projects: thermal baths at Vals in Switzerland (1996) and Kunsthaus Bregenz in Bregenz, Austria (1997) which represent the foundation for modern thermal activated building systems (TABS) [3]. Structural elements such as walls, floors, ceilings, can be thermaly actviated by means of electric, water or air circuits. TABS systems are specifically designed to be an integrate part of the overall building structure and its energy strategy The main parameters that influence the functionality and thermal comfort provided by the radiant surfaces are: cooling/heating capacity, uniform temperature distribution, minimum and average temperature of the radiant surface.

2. Research objectives

In order to be able to operate optimally a radiant cooling system and in particular TABS it is important to determine the average temperature of the radiating surface, used to determine the heat flow,

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and in particular the lowest temperature value on the radiating surface.

The temperature of the radiant surface is influenced by several factors such as the diameter and configuration of the pipe, the mounting distance, the thermal carachteristics of the surface's top layer ventilation of the surface, the flow rate of the heating and convection type on the surface. Research aimes to highlight the influence of the velocity of circulation inside the tubes , the convection type of the thempetature field distribution on the radiant surface and indirect heat flow recived from the ambient environment.

3.Experimental conditions

Experiments were performed in the radiating surface laboratory of the Building Services Faculty in Brasov, fig. 1.

Fig. 1. *TABS radiant surface in the faculty laboratory*

The TABS system in the laboratory has an area of 6 m^2 having a pipe coil made of PEXA 20×2,2 mm diameter and 28 m length.

The laying pipe is in the form of double coil assembly having a 20 cm mounting pitch.

The concrete slab that containes the pipe has a thickness of 20 cm and the following thermotehnic properties

$$\lambda = 2{,}00\ W/_{m^2 \cdot K},\ \rho = 2600\ kg/_{m^3}$$

The schematic of the slab is presented in figure 2.

The thermal agent is supplied to TABS from a manifold, type HKV-D, witch also feeds the othe radiant surfaces in the laboratory.

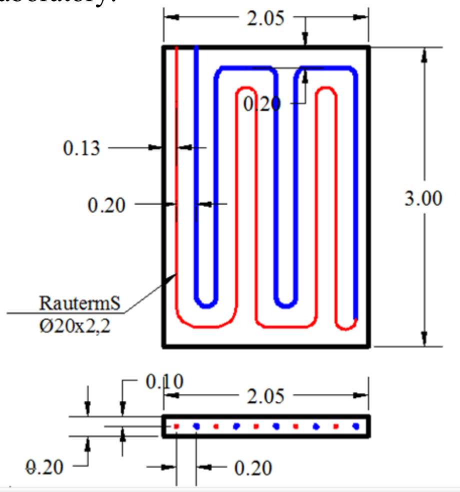

Fig. 2. *Schematics of the TABS in the radiant surface laboratory*

The source for the thermal agent is a heat pump and an absorption chiller mounted near the faculty building of the Faculty.

Measurement and processing system for the TABS is embedded in a complex system that monitors all radiant surfaces and also the entire laboratory envelope .

The sensors used in the laboratory are described below:

- Sensors used to measure the temperature on the pipe surface both for system flow and return, type ALTF_PT1000_PVC1, 5, THERMASGARD according to DIN EN 60751, Class B , measurement range -30 ÷ 180 ° C;

- Sensors used to measure relative inside air humidity RPFF-I, HYGRASGARD according to DIN EN 60751, class B, range 0 ÷ 100%;-

- Sensors used to measure indoor air temperature, type RTF1_PT1000 FRIJA I THERMASGARD, range -30 ÷ + 70 ° C;

- Mean radiant temperature measurement sensor, pendulum type RPTM2-I PT1000, THERMASGARD, adjustable measuring range from -50 to + 150 ° C, figure 3;

Energy meter, type microCLIMA MI1429.0-00_00, Precision Class EN 1434-1: 2007, class3; Mechanical Class M1; Electromagnetic Class E1; Protection class IP54; Hydraulic disorder class U0; Temperature range +1 to + 150 ° C; Temperature difference 3 ... 100 K.

Fig.3 *Sensors for measuring the relative humidity and radiant mean temperature.*

For temperature measurement on the TABS, there were mounted eighteen temperature sensors, type OFTF_Pt 1000_PVC1,5, THERMASGARD according to DIN EN 60751, Class B + range -30 ÷ 105 ° C. The Position of TABS in the radiant surface laboratory and the position of the sensors on the TABS are shown in figure 4.

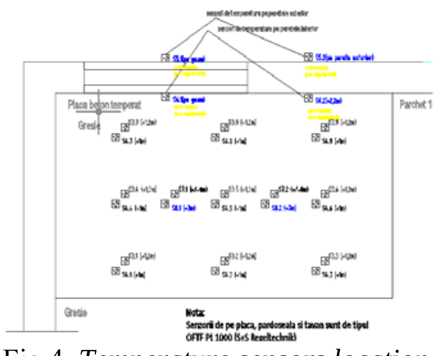

Fig.4. *Temperature sensors location on the TABS.*

4. Results

The research were performed on the TABS for a period of two summer months, from the 1st of july to 31st august. During this period were monitored both radiant surfaces temperatures and the heat gained by the TABS from the environment, for different operating conditions of the system. The measurements were carried out under various operating conditions of the system to highlight the influence of external factors on the performance of TABS.

In Figure 5 are shown the temperatures on TABS surface and indoor air temperature, inside radiating surface laboratory. There is a correlation between the radiant surface temperatures and the indoor air temperature, wich is similar to the existing radiant surface literature. Indoor air temperature inside radiant surface laboratory, during the monitoring and operation of the cooling system was maintained,most of the time, within standard acceptable comfort, EN ISO 7730 [5].

The only time when indoor air temperature exceeded the temperature recommended by the standard was the system boot time, this fact was largely due to the building's thermal inrtia.

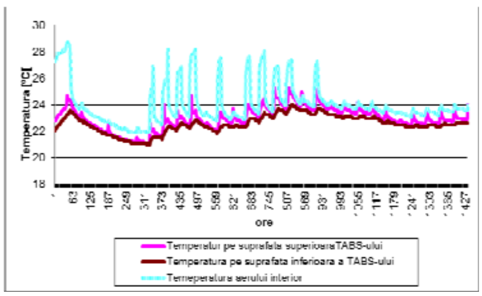

Fig.5. *Mean temperature variation on the TABS surface during monitoring period.*

An important parameter which has been monitored during the research time was in wich way the thermal agent speed rate inside the pipes, influences the radiant surface temperature. Measurements were performed for a speed of 0,5 l/s, characterized as a turbulent flow regime, and 0.08 m/s, characterized as laminar flow regime. The design of radiant cooling systems, wich also include TABS is performed for turbulent flow regime. The laminar flow is achieved only if the system isn't hydraulically balanced or has assembly errors.

The values measured for TABS in the same caonditions (interior air temperature and thermal agent temperaure) are presented in figure 6

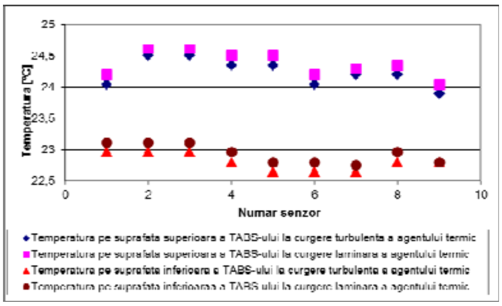

Fig.6. *Temperature variation for TABS surfaces, both for laminar and turbulent flow regime.*

The data revealed a insignificant influence of flow speed on the radiant surface temperature, the maximum temperature difference was only 0.16 ° C. The only notable difference resulting from the measurements was the increased temperature difference between flow and return for laminar flow. The different values indicated by the sensors on the same TABS surface is explained by the different distance between them pipeline inside the radiant surface.

The main conclusion that can be drawn from the above is that TABS can also be operated using a laminar flow regime without significant influence system performance, but would significantly decrease the energy required to circulate heat through the pipes.

Similar results obtained and Can [1] for capilar type radiant surfaces.

The heat is gained by TABS both by convection and radiation, usually consider that 40% by convection and the rest by radiation. The convection on the radiant surface can be natural or mixed (mixed convection is considered if the system is provided with mechanical ventilation).

In order to study the effects of the mixt convection, a ventilation system was mounted inside the laboratory, and the obtained data is shown in figure 7

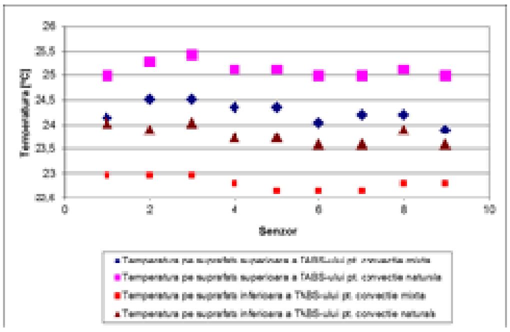

Fig.7. *TABS Surface temperature variation both for natural and mixed convection.*

Radiant surface temperature is significantly influenced by the type of heat transfer on it. The temperature difference between the two cases is about 0.9°C for the upper surface of the slab and a little bit higher, approximately 1°C for the lower part of the slab. Radiant surface temperature directly influences and heat flux gained by the TABS, therefore the system design must take into consideration the type of convection heat transfer and think the design differently for rooms with mechanical ventilation or without.

During the day, the temperatures on the TABS radiant surfaces change, influenced by indoor air temperature and indirectly by the required cooling load.

The chart for the average temperature for the radiant surface and indoor air over 24 hours is shown in figure 8.

The temperature increase rate on the TABS surface is much slower than the increase of indoor air temperature. During the day the thermal agent temperature provided to the system was constant, about 20-21°C. The radiant cooling system was able to maintain the temperature into thermal comfort limits using high temperature heat.

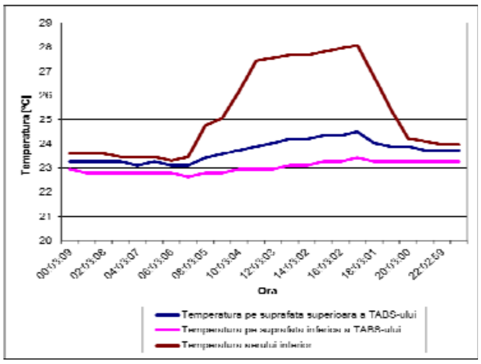

Fig.8. *The temperature variation on the TABS surface for a period of 24 hours.*

This highlights that TABS systems can be used with high efficiency with renewable energy sources such as heat pumps and systems using "natural cooling".

The increase of the TABS system temperature leads to an heat accumulation inside it, during the peak load and a decrease of the cooling equipment power.

To highlight the TABS heat accumulation during the day, it was calculated using the measured values and thermotehnic properties of the TABS materials.

TABS system is made of reinforced concrete witch has the following properties:

- Weight 3120 kg.
- Specific heat 963 J / kgK
- Density of 2600 kg / m3
- TABS volume 1.2 m^3.

Maximum heat gained in TABS was at 17 o'clock and had a value of about 3700 kJ as shown in figure 9., this value being limited by high enough temperature in TABS in the morning. This temperature was 23.11°C because the device producing cooling agent (absorption heat pump with absorption chiller) has the main function spaces cooling by using fancoil units.

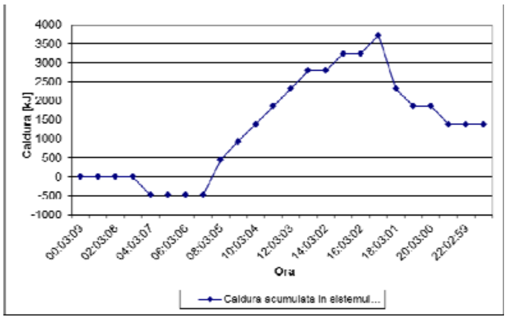

Fig.9. *Variation of heat accumulated by TABS for 24h.*

The heat pump and the chiller shut down after the working schedjule. For the same reason the system did not returned in the morning to its original state, the accumulated heat loss was achieved by releasing it to the indoor air during night. The large heat storage capacity of the TABS and the low temperatures during summer nights for Romania's fourth climate zone lead to a conclusion that these systems can be used with special advantages with natural night cooling or cooling towers.

5. Conclusions

Decreased circulation velocity in inside the system does not influence performance TABS but by reducing pressure losses inside the hydronic circuit, leads to a significant reduction of energy needed for the circulation pumps.

Currently, TABS design is identical and for ussage with or without a ventilation system.

Due to different performance and to difficulty in automation of theese systems enegy waste will result from their malefunction.

Therefore TABS must be sized differently for each case or be placed in different areas of automation. TABS heat accumulation during peak load leads to a decrease of power of the energy source.

Because, the acumulated heat transfer is performed during nights these systems can be s used profitable in a natural cooling systems during night.

Unlocking the potential of renewable soil for space cooling can be done in an efficient manner using TABS because they use high heat temperatures.

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