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

G. DRAGOMIR 1 A. BREZEAU 1 V. CIOFOAIA 1

Abstract: The usage of the cooling systems that use earth’s natural energy potential has increased over the last years, in line with the need for radiant systems. The efficiency of the radiant surfaces, especially 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 variation, radiant surface.

1 Building Services Department, Faculty of Civil Engineering, Transilvania University of Brasov
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 characteristics of the surface’s top layer ventilation of the surface, the flow rate of the heating and convection type on the surface. Research aims to highlight the influence of the velocity of circulation inside the tubes, the convection type of the temperature field distribution on the radiant surface and indirect heat flow received from the ambient environment.

3. Experimental conditions

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

The TABS system in the laboratory has an area of 6 m² 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 contains the pipe has a thickness of 20 cm and the following thermotechnic properties:

\[ \lambda = 2,00 \frac{W}{m^2 \cdot K}, \rho = 2600 \frac{kg}{m^3} \]

The schematic of the slab is presented in figure 2.

The thermal agent is supplied to TABS from a manifold, type HKV-D, which also feeds other radiant surfaces in the 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, 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, class 3; 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.

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 inertia.

An important parameter which has been monitored during the research time was in
which 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, which 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 conditions (interior air temperature and thermal agent temperature) are presented in figure 6.

![Fig.6. Temperature variation for TABS surfaces, both for laminar and turbulent flow regime.](image)

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 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.](image)
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 with the following properties:
- Weight 3120 kg.
- Specific heat 963 J/kgK
- Density of 2600 kg/m³
- TABS volume 1.2 m³.

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 schedule. 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 usage with or without a ventilation system.

Due to different performance and to difficulty in automation of these systems energy waste will result from their malfunction.

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 accumulated heat transfer is performed during nights these systems can be 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.

Acknowledgement:

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), ID134378 financed from the European Social Fund and by the Romanian Government

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