



# The Next Generation

**Thermally Activated Slab (TAS) technology offers a comprehensive heating and cooling solution.**

**F**or decades, architects, engineers and contractors have acknowledged the benefits of hydronic radiant technology as an efficient, energy-saving and highly comfortable means of heating. These same advocates are now discovering that a radiant heating system, once considered "single-season" in nature, can circulate cooled fluid to provide superior energy savings and comfort during periods of warm weather as well. Thanks to a conceptual shift regarding its limited application in the most arid of climates (for instance, southern California), radiant cooling has gained notable traction over the last decade.

When installed via the most common method – embedded within the concrete floor atop rigid foam EPS insulation – one quickly sees that while under ideal conditions, radiant floor heating capacities flirt with outputs exceeding 30 Btuh•ft<sup>2</sup>, radiant floor cooling capacities are significantly lower, often barely hitting double digits, and are maxing out in ideal installations at 16 Btuh•ft<sup>2</sup>. The same network of crosslinked polyethylene (PEX) pipes embedded in a layer of concrete floor is much more effective in the heating mode than in the cooling mode, as, in the former, there is a slight boost from convective warm air rising off the slab. This increase in convection that



Interior space at the Earth Rangers Centre in Woodbridge, ON, illustrating the exposed concrete ceiling, ductwork and drop lighting required for radiant cooling.

increases the output of the slab (with units of  $\text{Btuh}\cdot\text{ft}^2$  or  $\text{W}/\text{m}^2$ ) is represented by:

$$\dot{q} = HTC|(T_{\text{SURFACE}} - T_{\text{AIR}})|$$

in which the heat transfer coefficient, or HTC, for a floor system increases from about  $1.2 \text{ Btuh}\cdot\text{ft}^2\cdot^\circ\text{F}$  in cooling mode to just over  $1.9 \text{ Btuh}\cdot\text{ft}^2\cdot^\circ\text{F}$  in heating mode.

Augmenting this gap between heating and cooling heat transfer coefficients is the temperature differential that drives the slab capacity equation. Largely due to limitations on comfort (see ASHRAE Standard 55), the difference between a heated floor slab and the space setpoint temperature (maxing out at  $\sim 16\text{F}$ ) tends to be greater than the temperature of a cooled floor slab and the setpoint temperature in cooling mode (rarely exceeding  $12\text{F}$ ). The end result is the aforementioned stark difference in a radi-

ant floor system's capacity when operated between heating and cooling modes.

### THE YEAR-ROUND SOLUTION

For many applications, especially in the northern climates of North America, the use of a year-round hydronic radiant system has been sufficient to justify adopting a combined radiant floor heating and cooling system. But, adoption of radiant cooling into all climates is often hampered by a lack of meaningful capacity. Since virtually all radiant cooling systems are operated in combination with downsized forced-air systems, the more the load can be shifted from the air-based side to the hydronic side, the closer one can come to not only minimizing the payback period, but also effectively eliminating added costs via the downsizing of air components such as fans and ductwork.

Understanding this challenge, North American archi-

pects and engineers have looked to European radiant experts who, unlike their North American counterparts, remained consistent in their use of hydronics over the last several decades while other air conditioning methods became dominant in North America, particularly in the U.S.

Over the years, European, and specifically German- and Swiss-based radiant companies, have adopted a method of installation that provides customers with the best of both worlds; the high heating capacity of a radiant floor system with the high cooling capacity of a radiant ceiling system. Rather than focusing on the surface as a unidirectional heat emitter, specifiers have started to grasp the full potential of converting the slab into a bidirectional radiant system, especially given the thermal storage potential of internal slabs in multi-storey structures. By removing the insulation typically placed below the PEX piping, heat is allowed to conduct to and from both the top and bottom surfaces of the slab. This alternate type of bidirectional radiant system is often referred to as a thermally-activated slab (TAS) system.

Thermally activated slabs are known by several different names and acronyms around the world. In Germany they are referred to as BKT systems, while the French-speaking portions of Switzerland have dubbed them BATISO systems. Other English-speaking countries are also referring to the concept as TABS (Thermally Activated Building Systems) at an increasing rate.

Regardless of the terminology, these configurations point to a common strategy – that of controlling the temperature of a building's interior slabs to temper conditioned spaces.

In its heating mode, a TAS system supplies much of its heat from the top of the slab as an apparent radiant floor application, and this heat is further supplemented by the warmed radiant ceiling from the level above. Likewise, in the cooling mode, the bulk of the system's capacity is sourced from the ceiling side of the slab, with a small additional amount coming from the floor side.

*Figure 1* shows an FEA image of a traditional radiant floor cooling system installed with insulation below. In this scenario, the floor is capable of producing an approximate average capacity of just under nine Btuh•ft<sup>2</sup> [or 28 W/m<sup>2</sup>].

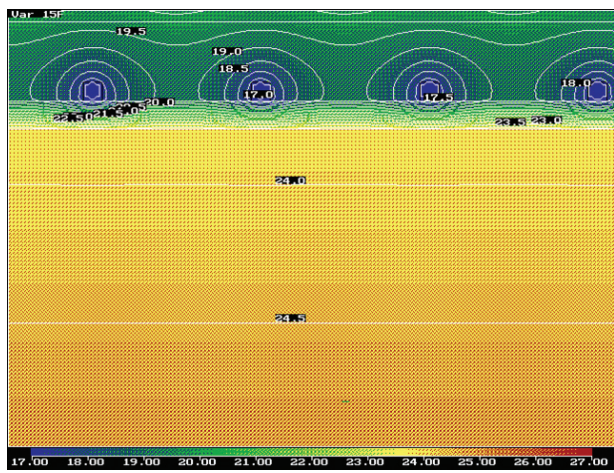
Switching to a TAS configuration, as shown in *Figure 2*, the clear advantage of a bidirectional TAS system versus a unidirectional radiant floor cooling system begins to emerge as the system's capacity is approximately doubled to 20 Btuh•ft<sup>2</sup> [or 63 W/m<sup>2</sup>]. In addition, nearly 60 per cent of the system's total cooling capacity is now coming from the cooled ceiling surface.

Where more capacity is desired when in cooling mode, PEX loops in a TAS can be placed in the lower third of the slab, allowing more heat to be absorbed through the more efficient ceiling side of the slab. When the loops are installed in this manner, upward and downward capacity is optimized via heat absorption in the cooling mode (up to about 25 Btuh•ft<sup>2</sup>), and heat delivery (emission) in the heating mode (a significant 50 Btuh•ft<sup>2</sup>).

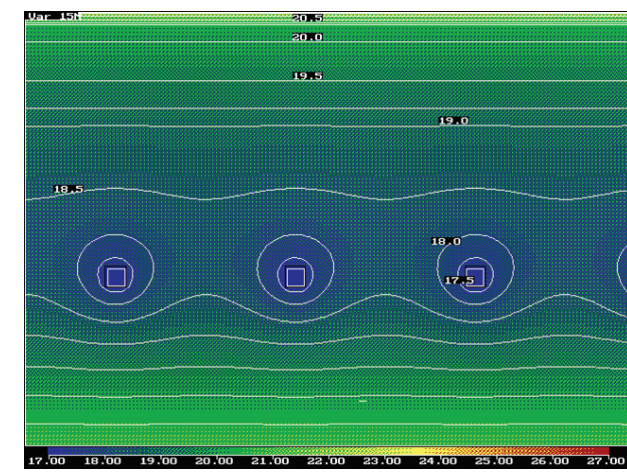
### APPLYING TAS IN TODAY'S INFRASTRUCTURE

The building technology field has come a long way from the days of thinking that a single black-box solution would solve all the world's HVAC needs. Likewise, with a

**Figure 1** Cooling capacity is limited in unidirectional radiant floor cooling system installed with insulation below.



**Figure 2** Cooling capacity is significantly increased in bidirectional thermally-activated slab configuration, due to both the top and bottom surfaces of the slab being cooled.



*“Over the years, European, and specifically German- and Swiss-based radiant companies, have adopted a method of installation that provides customers with the best of both worlds.”*

TAS system, it is important to understand that the radiant cooling component is an optimized method of countering sensible loads within a space. The downsized forced-air system is thus allowed to be optimized for latent cooling, fresh air requirements and abrupt shifts in conditioning requirements.

Simulated buildings have shown 40-per cent energy savings for this hybrid TAS/downsized forced-air system when compared with a traditional all forced-air baseline case. This supports the overall theme that two optimized smaller systems can condition a space more efficiently than the conventional "single-box solution." Although not the focus of this article, this concept leads to other system advantages, such as increased thermal comfort, reduced maintenance costs and even reduced upfront costs in certain applications.

While it can be easy to get caught up in the clear advantages of TAS systems, project experience and market skeptics have identified many challenges in their implementation. First, controlling a system that effectively conditions two adjacent spaces has its complexities.

Projects such as the Pond Road Residence at York University in Toronto, ON, however, exemplify a simplified solution. Rather than approaching the system design at a peak scenario, engineers sized the radiant system to be the core tempering system for the building and allowed the downsized air system to handle the trim and peak loads. Another immediate response from architects who have analyzed the TAS concept is "what about the exposed concrete ceiling?" In scenarios where exposed ductwork and suspended pendant/drop lighting are used,

clearly an architect could look favourably on TAS.

Unfortunately, it is very hard to advocate for TAS when a drop ceiling has been specified. This highlights the need for the integrated design process (IDP) advocated by both AIA and ASHRAE, through which TAS provides clear benefits as a mechanical system that transcends the traditional design approach. Of utmost importance is a discussion on integrating a TAS system, as early in the design phases as possible, among the project architect, structural engineer, MEP and even contractor to determine its effect on thermal comfort, room height, space build-out and acoustics.

#### THE EVOLUTION OF RADIANT COOLING SYSTEM DESIGN

Although North American architects and engineers are only beginning to design with integrated TAS systems, several projects exist to highlight the traction of alternative radiant installations and the evolution of radiant cooling system design. Installations including the aforementioned York University residence project and the recently completed YWCA Toronto, ON, Elm Centre illustrate that this is very much a "now" versus "future" concept, which is expected to become increasingly prevalent throughout North America. **- RYAN WESTLUND**



*Ryan Westlund, EIT, is a systems engineering specialist with REHAU North America. Before joining REHAU in 2009, he was employed as an intern at the U.S. Environmental Protection Agency (EPA) after which he took a position as a representative with a small mechanical manufacturer.*