THE UNSEEN WONDERS OF RADIANT HEATING, COOLING, AND SNOWMELTING

Engineers at Viega use simulation applications to share results of finite element modeling with their customers, offering them valuable engineering support as they design radiant heating and cooling systems for both residential and commercial applications.

by NICOLAS HUC

Imagine the race against time that emergency workers compete in on a daily basis, as well as, the panic, stress, adrenaline, and rush that comes with driving an ambulance or emergency helicopter. Now, imagine the emergency worker arriving on scene in the dead of winter, only to find the helicopter landing zone covered in ice and snow. Under such intense time constraints, can this area be shoveled quickly enough? What about emergency vehicles slipping on hidden ice? Is it worth the risk to be held at the mercy of these arctic conditions with such high stakes?

Fortunately, there is technology that can safeguard against these issues, and it is becoming increasingly prominent: hydronic snowmelt systems. Piping encased in a thermal mass (typically concrete) allows for warm water to circulate throughout the area requiring snowmelt. With regards to an emergency situation, when designed properly, the system will prevent the buildup of ice and snow, thus alleviating the need for manual cleanup.

When it comes to applications where heating or cooling is required, radiant floor systems use a similar piping design to control space temperature and comfort by regulating the flow and temperature of water in tubing installed beneath the floor (Figure 2).

Viega, a company that both designs and manufactures radiant heating systems, helps tackle situations where special methods of temperature control are needed.

FIGURE 1. Emergency helicopter hangar for patient transport.

⇨ RADIANT FLOOR SYSTEMS

Although they have existed in various forms since the Roman Empire, radiant systems are turning out to be particularly useful in modern society for both commercial and residential applications. Radiant heating is used not only for floor warming applications but also to control the temperature of a room. When the floor can be kept at a warm temperature, it will give off thermal radiation in the room. This radiation will only be absorbed by opaque surfaces; in other words, it will be absorbed by our bodies (but not the air), creating a feeling of warmth.

A tubing layout is designed in a specific configuration by Viega. The tubing is then laid beneath the flooring in a panel system. Hot water (or cold water in cooling applications) runs through the tubing and heats the surrounding material. The uppermost surface of the floor then radiates heat to the rest of the room. This is just like when you move from a shady spot to a sunbathed one; although the air temperature is the same, your skin feels much warmer because of the absorption of thermal radiation. The special tubing is made of a cross-linked, high-density polyethylene (known commonly as PEX). The cross-linking benefits are two-fold: It provides the capability to withstand higher temperatures and pressures and increases its resistance to stress cracking. These tubes are vigorously tested, adhering to standards for temperature and pressure ratings, minimum bending radii, and pipe wall thickness.

The recent emergence of environmental consciousness and energy efficiency at the forefront of building design has contributed strongly to the increased popularity in radiant heating. Radiant heating systems pair quite well with modern, high-efficiency water boilers, and since they don't circulate air and utilize lower water temperatures than a baseboard system (115°F vs. 180°F), they optimize the energy consumption. The water temperature in the tubing distribution is simply controlled by the opening and closing of valves and even yields a more constant temperature throughout the room.

⇨ SYSTEM DESIGN

Brett Austin, supervisor of heating and cooling design at Viega, uses the COMSOL Multiphysics® software to design a system to meet their customers' needs. "COMSOL® supplements our heating and cooling design and layout program," Austin says. "We draw the layout on floor plans, move it into COMSOL, and eventually share it with customers. Simulation allows us to provide engineering data to support our designs." When a project is proposed to them, a mechanical engineer from the site provides requirements for heating and cooling outputs, structural specifications, floor covering materials, and usually a range of acceptable water temperatures. They then use simulation to determine tube placement and spacing, temperature distributions (Figure 3), and heating or cooling capacity to make sure the customers' needs are met. COMSOL is primarily helpful for nonstandard applications where there is multidirectional output or more complex structures," Austin says.

Viega truly benefits from multiphysics simulation through the use of simulation applications and COMSOL Server™ to share them with their customers. When Viega's team is at meetings with prospective customers, they can now quickly adjust parameters, like water temperature or tubing diameter, and show the output of the heating or cooling system on the spot. "Prospective customers often have many initial questions involving multiple iterations," Austin explains. "But the simulation applications allow us to go above and beyond and offer them the invaluable service of visualization. It is a great tool that allows us to share data virtually anywhere in the world from our office."

⇨ ARTIC

In environments like Southern California, cooling contributes more to comfort

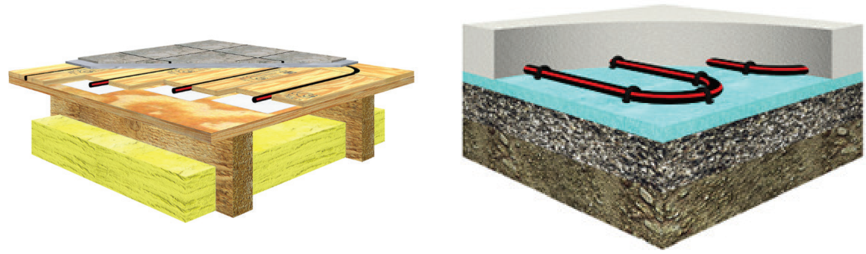

FIGURE 2. Radiant tubing in climate panel (left). Radiant tubing in concrete (right).

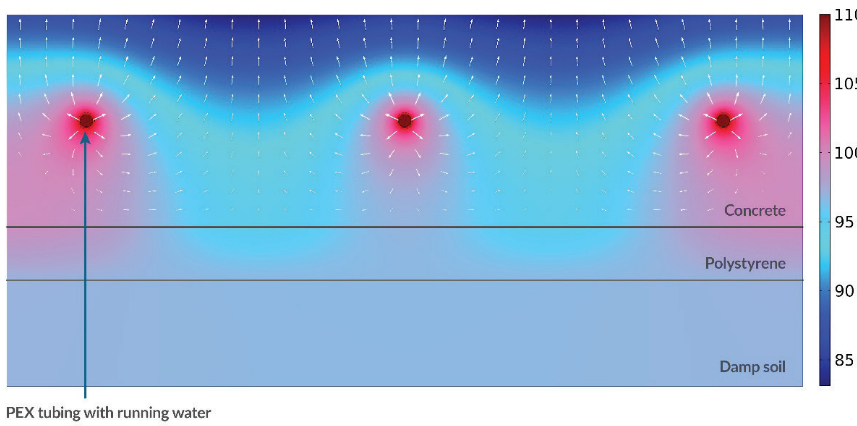

FIGURE 3. Cross-sectional temperature distribution of a radiant heating system. The arrows denote the direction of the conductive heat flux, showing the rate of heat transfer to the upper surface of the floor and thus the air above. Temperatures are shown in °F.

than heating. That's why the Anaheim Regional Transportation Intermodal Center (ARTIC, Figure 4) came to Viega about installing a radiant cooling system. Because of the massive size of the building, a forced-air circulation system would be near impossible to achieve and hopelessly expensive. Once again, the team underwent the task of modeling smaller sections of flooring and extrapolating the data to the entire layout. This scenario, however, had some added difficulty and required quite the balancing act from Austin. For starters, because of the dome-shaped structure and high amount of window space (Figure 5), there were abnormally high solar gains that added significant heat energy to the building. The cooling capacity, therefore, had to be very high to counteract this. On the flip side, because of constraints from the engineers on the ARTIC side, the water temperatures in the tubing had to be much lower than usual cooling systems (50°F vs. 58°F); but as temperatures neared dew point at the surface of the floor in some areas that had closely spaced tubing, Viega wanted to ensure peace of mind to the customer that condensation was not a concern.

Using COMSOL Multiphysics, they were able to determine what to do to prevent condensation from forming; installing a thin layer of insulation around the pipe. "We worked out a solution with the onsite engineer to add an insulation layer on top of the supply tubing to slightly reduce the output," Austin says. "It seems counterintuitive, but in this case, it prevents condensation in areas that had closely spaced tubing due to construction constraints." Additionally, on other projects, they have used COMSOL to run time-dependent simulations to help develop a control strategy where the slabs in the floor are cooled overnight to conserve energy. The chilled water is run throughout the night, cooling the concrete to a low temperature. In the morning, the water is turned off and the floor temperature stays cool for the remainder of the day. This contributes strongly to the reduction of necessary cooling power. Simulation was used to see how long the output will

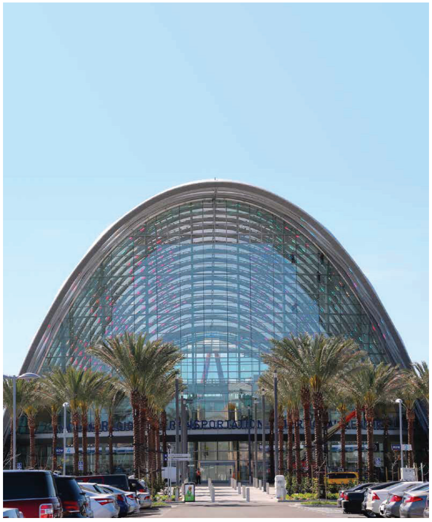

FIGURE 4. The Anaheim Regional Transportation Intermodal Center (ARTIC).

continue throughout the day and if this is a feasible strategy.

⇨ SUN VALLEY SKI RESORT

Even though snow-melting systems can act as a critical safety feature for emergency entrances and helicopter landing pads, they can be equally as useful at the other end of the spectrum: luxury. High-end ski resorts place extreme value on their customers' safety, and a sophisticated and reliable snow-melt system is essential to their experience. In a snow-melt system, the ground is kept at a warm temperature, which continuously melts snow and ice.

When Sun Valley Ski Resort, located in Ketchum, Idaho, came to Viega, Austin knew how sizeable a task they were about to undertake. The ski resort wanted to install a radiant snow-melting system throughout the entire resort, requiring more than 60,000 square feet of walk areas and driveways. To deal with such a large project using simulation, Austin and his team had to model sections of the system. "Fortunately, there are similar types of panels throughout most jobs," he explains. "We used our internal program to draw out a section in a CAD format. Then we'd draw a small cutpiece in the software, specify the radiant panel material properties and water temperatures, and then run the simulation." Simulation applications made it seamless to present the results to

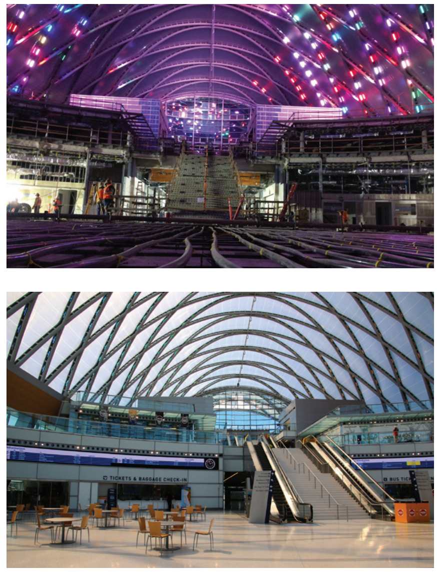

FIGURE 5. Top: ARTIC with radiant heating system installed, prior to the actual flooring being laid. Bottom: End result of the inside of ARTIC.

Sun Valley representatives and played a major part in completing this job.

Sun Valley Ski Resort benefitted tremendously from Viega's design and installation. All pathways and areas with high foot traffic were involved (Figure 6). As it was not always feasible to plow or shovel these areas, another method of snow removal was needed. A snow-melt system such as this minimizes any cleanup, reduces maintenance, and contributes to a professional appearance as there is no need for salt or chemicals.

FIGURE 6. The tubing installed at Sun Valley Ski Resort in Idaho.

It also, most importantly, adds an extra level of safety and reduces liability by allowing for "ice-free" zones.

⇨ CONTINUING WITH COMSOL SERVER™

COMSOL Server has provided a robust solution to couple Viega's services with their sales team. "COMSOL has given much added value to our work and extended finite element modeling to our sales team," Austin says. "It was very intuitive and easy to pick up the software and we plan on using more coupled physics interfaces in the future to increase our modeling capabilities." ❖

The team at Viega. From left to right: Liam Collins, Associate Radiant Design Engineer; Travis Simoneau, Associate Radiant Design Engineer; Josef Marcum, Radiant Design Engineer; and Brett Austin, Supervisor, Heating and Cooling Design.