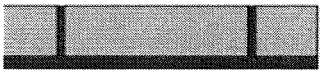
Table 5.2: Maximum Temperatures and R-values for Typical Floor Coverings

Finished Floor Surface		Maximum Subfloor Surface Temp* °F (°C)	Thickness in (mm)	Resistance R-value h•ft²•°F/BTU (m²•K/W)
Bare floor		N/A	N/A	0
Solid hardwood		85° (27°)	3/4 in (19 mm)	0.68 (.12)
Laminated hardwood with adhesive		90° (32°)	11/16 in (17 mm)	0.87 (.15)
PVC/linoleum with adhesive		100° (38°)	3/16 in (4 mm)	0.26 (.05)
Ceramic tile floor with mortar bed (elastometric bonding agent)		100° (38°)	1/4 in (6 mm)	0.23 (.04)
Natural stone with mortar bed		100° (38°)	1 1/2 in (38 mm)	0.21 (.03)
Carpet (polyester) with rubber pad		88° (31°)	3/8 in (9 mm)	1.17 (.21)

*Note: Typical values presented; the designer must verify actual limits of the selected finish flooring materials with the manufacturer

Solid Hardwood

Radiant heating can be installed with solid hardwood flooring with very good results as long as the radiant panel design adheres to moisture limits, floor temperature limits and installation considerations. Many species of solid hardwood flooring can withstand the radiant panel surface temperatures. Information on a specific species of hardwood may be obtained from the manufacturer as well as from the Radiant Panel Association (www.radiantpanelassociation.org), the National Wood Flooring Association (http://www.nwfa.org) and The Hardwood Council (www.hardwoodcouncil.com).

Engineered Hardwood or Laminate Hardwood

Engineered hardwood and laminate hardwood floors are an excellent choice for use with radiant heated floors. With higher density and lower thickness, these flooring solutions are often more conductive (lower R-value) than solid hardwood flooring. This flooring is usually compatible with radiant panel surface temperatures, and because it absorbs less moisture than solid hardwoods, it is more suitable for wet construction methods.

Engineered hardwood flooring has a thin top layer of solid hardwood, typically 1/16 to 1/8 in (2 to 3 mm) thick, bonded to plywood underneath. With a solid hardwood surface, engineered hardwood floors are available in many species and colors yet offer the structural stability of plywood.

Laminate flooring is usually melamine-infused paper bonded to a fiberboard core. Laminate floors are available in patterns and colors, and offer the structural stability of the fiberboard material. Additional information may be obtained from the Laminate Flooring Site (www.thelaminateflooringsite.com) or Laminate Floorings (www.Laminate-Floorings.net).

Vinyl and Linoleum

Vinyl tiles are highly affected by floor temperatures. Consult with the manufacturer to determine the maximum radiant panel surface temperature allowable for the adhesive and the covering.

Ceramic Tile, Natural Stone or Bare Concrete

Ceramic tile, pavers, marble, stamped or stained bare concrete, and other stone finishes are ideal for radiant surfaces. An underlayment (e.g., backerboard or isolation membrane) is installed between the radiant panel and the tile/stone to reduce movement and isolate cracks. Tile cement with high heat capability should be used.

Carpeting and Padding

Carpeting and padding may be used over a radiant heated floor if properly selected. Carpet and carpet pads with relatively high R-values, such as urethane carpet and pads, will significantly reduce the radiant heating performance, and are not recommended. Typical carpet pads suitable for radiant floors are made from thin slab rubber, synthetic fiber, or styrene butadiene rubber (SBR). Consult with the manufacturer to determine the maximum radiant panel surface temperature allowable for the carpet, pad and adhesives, if used. Additional information may be obtained from the Carpet and Rug Institute (www.carpet-rug.org).

5.7 Wet Construction Joints

A heated slab, which is one type of thermal mass, is subject to movement. This can be caused by shrinkage, which occurs only once when the thermal mass dries, or as a result of expansion and contraction from heating the thermal mass. Typically, these movements occur in the width and length of the flooring surface. However, vertical movements (bowing) may also be caused by differences in expansion at the surface and base of the thermal mass.

Movement resulting from the temperature difference due to heating can be estimated using the linear expansion formula in Section 4.1.4:

Example, given:

$L = 25$ ft, $\Delta T = 55°F$, $\alpha = 6.1 \times 10^{-6}/°F$

(α value changes with thermal mass type)

Longitudinal expansion of the thermal mass layer

$\Delta L = .0084$ ft or .10 in (3 mm)

The design must allow for absorption of the movement of the thermal mass. To prevent uncontrolled cracking, the architect may segment the thermal mass into smaller sections called thermal bays by employing an appropriate arrangement of movement joints.

5.7.1 Joint Types

Edge Joints

Edge joints surround the thermal mass and are formed by the installation of an edge insulating strip. It is important that edge insulating strips are rigid enough to withstand compression from the wet thermal mass and soft enough to absorb movements.

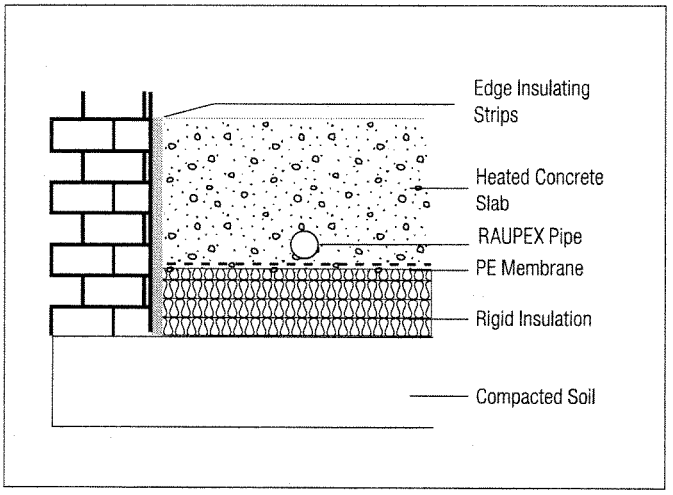


Fig. 5.1: Edge joint

Movement Joints

As a result of their construction, movement joints are capable of absorbing major horizontal and vertical (structural) movement. Movement joints are used to separate thermal mass bays and must always be incorporated above structural expansion joints in the building structure. Movement joints should have a width of at least 3/8 in (8 mm).

NOTICE: Whenever heating pipes cross movement joints, a protective sleeve must encase the pipe. Failure to encase the pipe may damage the pipe resulting in leaks and operational failures.

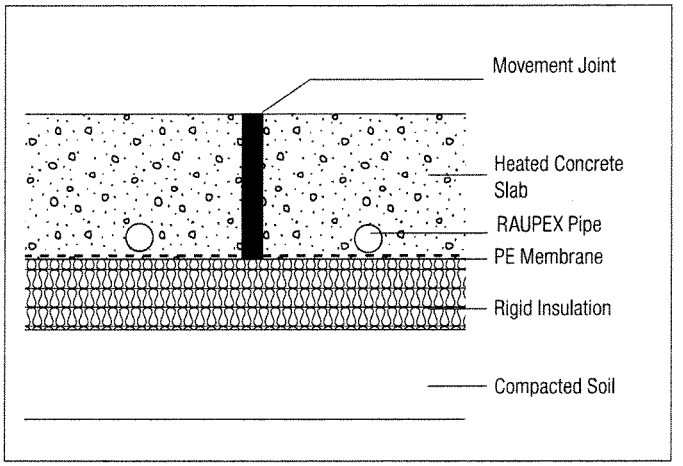


Fig. 5.2: Movement joint

Contraction Joints

Contraction joints are cut into the wet thermal mass down about one-third to one-half of the thermal mass depth. Their purpose is to prevent uncontrolled cracking. Contraction joints generally have a temporary function. They are only capable of absorbing movements resulting from thermal mass shrinkage and are filled with synthetic resin mortar or similar material after contraction has taken place. They are used to further divide areas already separated by movement joints. Contraction joints should not be used in doorways. Their use should be limited to bay sizes up to 16 x 16 ft = 256 ft² (25 m²), and cases where soft floor finishes are used.

5.7.2 Joint Arrangement and Design

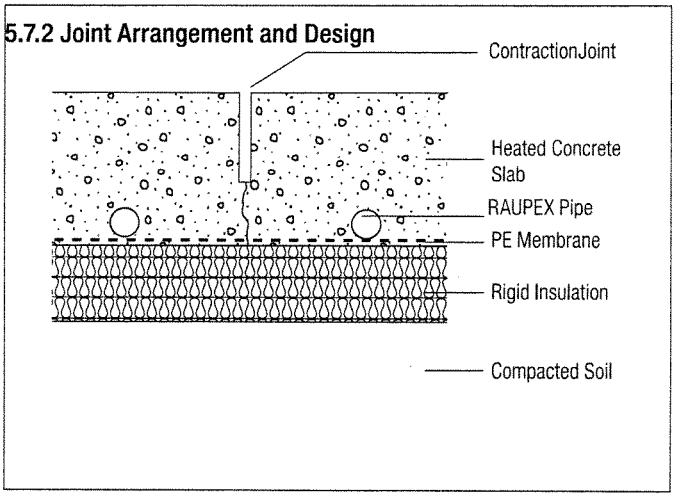


Fig. 5.3: Contraction joint