Rochester Concrete Products

Tech Spec 12

icpi Interlocking Concrete Pavement Institute

Snow Melting Systems for Interlocking Concrete Pavements

A mobile and ambulatory population requires reduction of pedestrian-related accidents. Snow melting systems for pavements can reduce accidents as well as liability exposure from injuries due to slipping on ice and snow. Moreover, snow melting systems reduce the fatigue and expense related to removing snow. In addition, they can reduce the damaging effects of freeze-thaw cycles, and of de-icing salts experienced by most pavements in cold climates. The inconvenience of spreading de-icing salts is eliminated and interior floor materials are kept cleaner and last longer.

Snow melting systems for interlocking concrete pavements can be used on patios, walkways, residential driveways, building entrances, sidewalks, crosswalks, and streets. A successful project in downtown Holland, Michigan includes a snow melting system in three blocks of concrete paver sidewalks and in the asphalt street (see Figure 1). Holland receives about 75 to 100 inches (190 to 250 cm) of snow each year. By melting the snow, the 167,000 ft^2 (15,500 m^2) heated pavements reduce pedestrian and vehicular accidents. They also reduce wear on the pavements because practically no de-icing salts are

Figure 1. A snow melting system under concrete pavers in downtown Holland, Michigan has performed well since 1988.

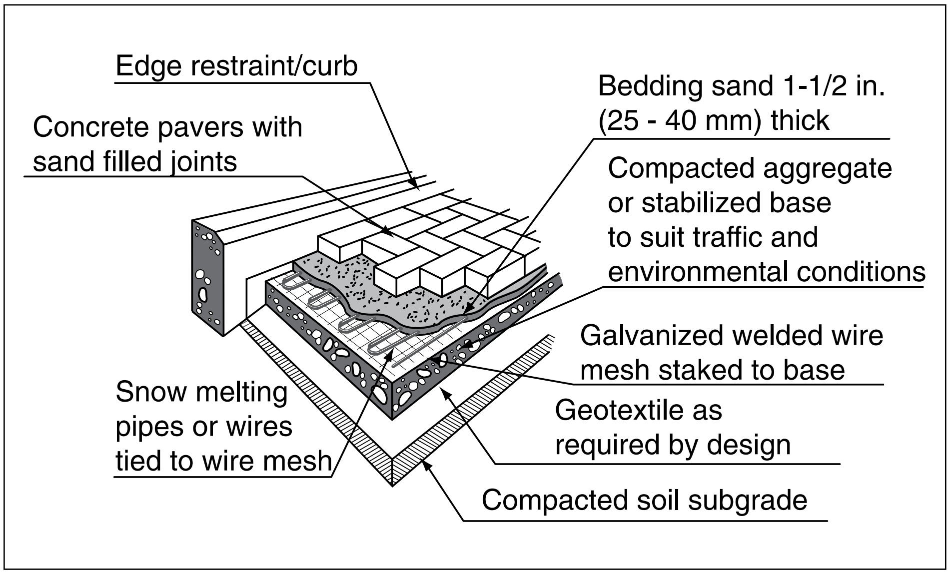


Figure 2. Typical components of a snow melting system for interlocking concrete pavements

needed. Neither the merchants nor the city crews remove snow in this area of the business district, and the floors inside the stores are kept cleaner.

In addition to exterior applications, heating systems under concrete pavers have been used in interior areas such as around swimming pools, hot tubs, and saunas. The heat creates a comfortable, low-slip walking surface for bare feet and it also warms the room.

Types of Systems

Two kinds of systems are used to convey heat to the pavement surface: electric or liquid. Electric systems use wires to radiate heat. Generally, electric systems have a lower initial cost, but a substantial operating cost. They involve a series of control switches, thermostats, and snow-sensing apparatus. One electric system consists of heat tapes (flat wires) that automatically stop heating when sufficient energy is released. When they cool, the wires automatically allow more heat through them.

Liquid systems (also known as hydronic systems) use a mix of hot water and ethylene or propylene glycol mix in flexible pipes. They have a higher initial cost but a lower operating cost. Hot water systems consist of flexible pipes, pipe manifolds, pumps, switches, a water heater, thermostats, and snow sensors. They typically rely on a boiler that heats a building. Figure 2 illustrates the typical components of an interlocking concrete pavement with a snow melting system.

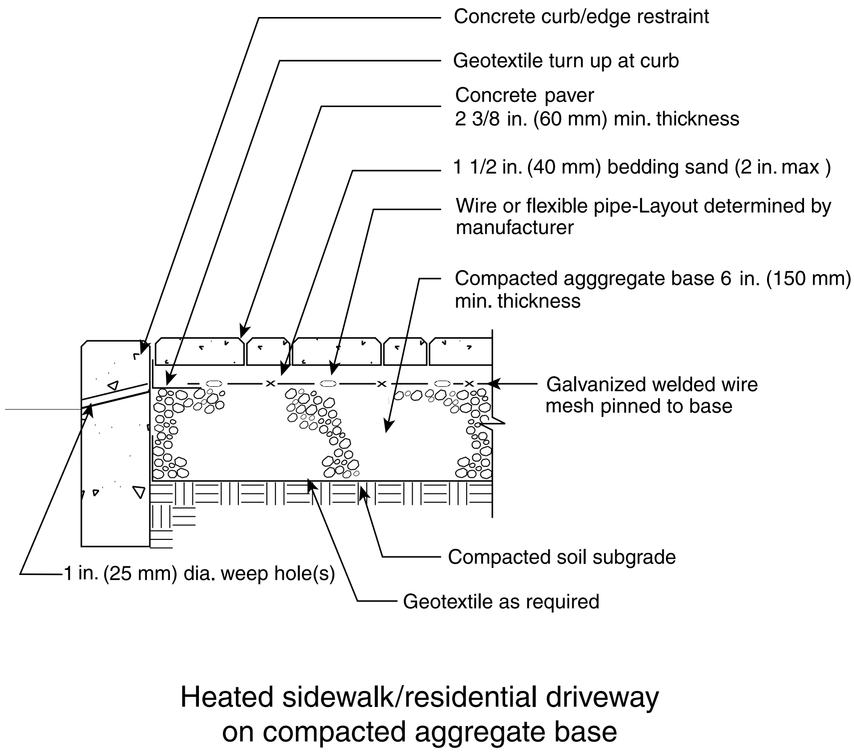
Snow melting systems generally do not completely dry the pavement surface. Rather, they melt the snow to water which drains away. Completely evaporating the water on the pavement surface is not economically practical since it requires more energy than for melting snow to water. Occasionally, snowfall or drifting may exceed the heat output of the snow melting system. While some snow remains, it will be easier to remove due to the warm pavement surface.

Snow melting systems can be part of new construction or added later. For driveways, pipes or wires can be placed in the wheel tracks to reduce installation costs. However, the remaining snow may require removal if it blocks the movement of vehicles.

The performance of a snow melting system is measured in inches (cm) of snow melted per hour. Its performance is based on heat output measured in BTUs (British Thermal Units) or watts per square meter (m^2) of pavement. Performance depends on consideration of three overall design factors. First is the rate of snowfall. Second is the temperature of the snow influenced by the air temperature. About 90% of all snow falls between 35° F (2 C°) and 10° F (-12° C). On average, snow falls at about 26° F (-3° C). The lower the air temperature, the less dense the snow. For warmer, wetter, and more dense snow, more energy per area of pavement is required to melt it. Third, wind conditions greatly influence performance of a snow melting system. Strong winds remove heat from

Table 1. Gradation for Crushed Stone Aggregate Base

ASTM D 2490	
Sieve Size	**Percent Passing**
2 in. (50 mm)	100
1 in. (377.5 mm)	95 to 100
3/4 in. (19.0 mm)	70 to 92
3/8 in. (9.5 mm)	50 to 70
No. 4 (4.75 mm)	35 to 55
No. 30 (0.600 mm)	12 to 25
No. 200 (0.075 mm)	0 to 8



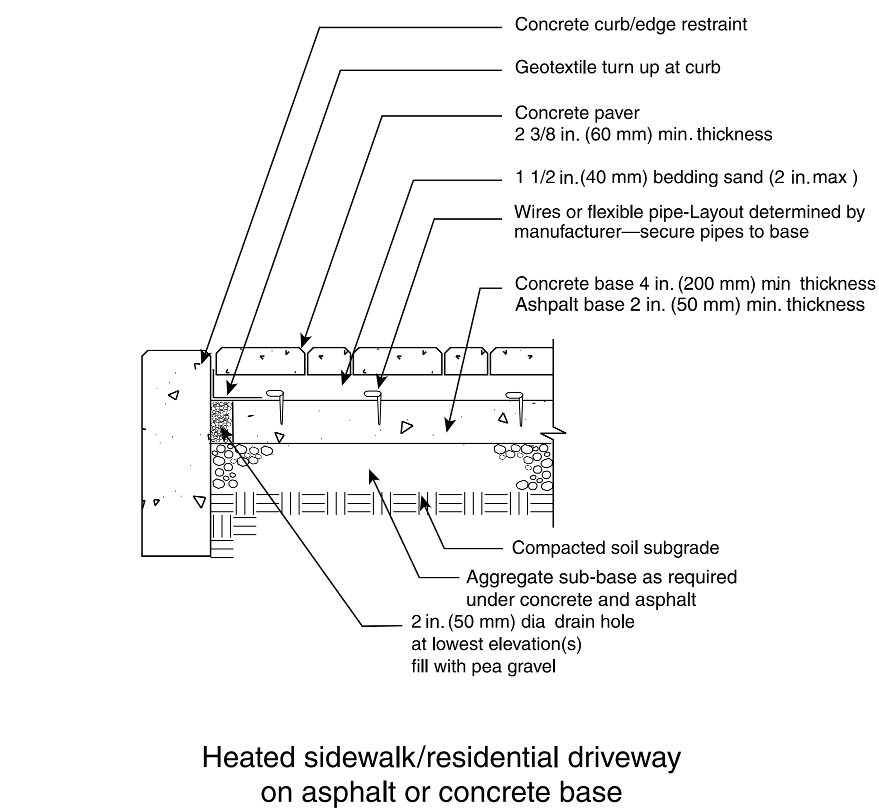


Figure 3. Cross sections of a typical heated interlocking concrete pavement for pedestrian and driveway applications

Figure 4. Pipes for a hydronic (liquid) heating system are placed on wire mesh and fastened to it with plastic ties prior to spreading the bedding sand and installing the pavers.

a pavement faster than calm air. Location of buildings, walls, landscaping, and fences will influence the amount of wind across a pavement, heat loss, and ultimately the design and performance of snow melting systems.

Rate of snow melting will vary with the application. For example, "Melting 1 in. (25 mm) of snow per hour is usually acceptable for a residence but may be unacceptable for a sidewalk in front of a store. Hospital entrances and parking ramp inclines need to be free of snow and ice at all times"(1). Most manufacturers of liquid and electric snow melting systems also provide design guidelines and/or software to calculate the BTUs per square foot (watts/m2) required to melt a range of snow storms for a given region. The guidelines work through a series of calculations that consider the snow temperature (density), ambient temperature, exposure of the pavement to wind, and unusual site conditions. They provide recommendations on the size and spacing of pipes or wires required, as well as the temperature of the fluid, its rate of flow, or the electricity required. The Radiant Panel Association (radiantpanelassociation.org) provides design guidelines for liquid snow melt systems.

Controls for activating the snow melting system can include a thermostat in the bedding sand to maintain its temperature above freezing. Another kind of control is located near the pavement and activates the heating system when snow or ice falls. Sometimes a low level of heat is maintained in the pipes or wires and is increased by the sensor when snow falls.

Construction Guidelines

Snow melting systems with concrete pavers can be built with three types of bases: concrete, asphalt, or crushed stone aggregate. Concrete and asphalt bases are recommended for roads and crosswalks. While these bases may be used for driveways and pedestrian applications, a crushed stone aggregate base may be more cost-effective.

Aggregate Bases for Pedestrian and Driveway Applications

Subgrade Preparation—*ICPI Tech Spec 2–Construction of Interlocking Concrete Pavements* should be reviewed with this technical bulletin, as it offers guidelines for subgrade preparation, base materials, and installation of bedding sand and concrete pavers. Preparation and monitored compaction of the soil subgrade and the aggregate base are essential to long-term performance. The soil subgrade and base aggregate should be compacted to a minimum of 98% standard Proctor density, per ASTM D 698 (2). Geotextile is recommended over compacted clay soils and silty soils. The geotextile separates the aggregate from the soil, keeping the base consolidated through long-term changes in moisture and temperature, as well as freezing and thawing. Drain pipes may be required in slow draining soils, especially under vehicular applications.

Base materials and preparation—Recommended gradations for aggregate base materials are those typically used under asphalt pavements that meet standards published by the local, state, or provincial departments of transportation. If no standards exist, the gradation shown per ASTM D 2490, *Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports* in Table 1 is recommended (3).

The minimum thickness of the base should be at least 6 in. (150 mm) for pedestrian areas and 10 in. (250 mm) for driveways. Thicker bases, or those stabilized with cement or asphalt, may be required in areas of weak soils subgrades (California Bearing Ratio < 4), in low-lying areas where the soil drains slowly, or in areas of extreme cold and frost penetration. The minimum surface tolerance of the compacted base should be ± 3/8 in. over a 10 ft (±10 mm over a 3 m) straightedge. Density and surface tolerances should be checked before proceeding with installation of the snow melting wires or pipes.

Prior to placing the wires or pipes, a galvanized wire mesh is placed over the surface of the base. The wire mesh is secured to the base with stakes. The wires or pipes are tied with plastic ties to the wire mesh. Figure 3 illustrates a typical assembly for a pedestrian or drive-

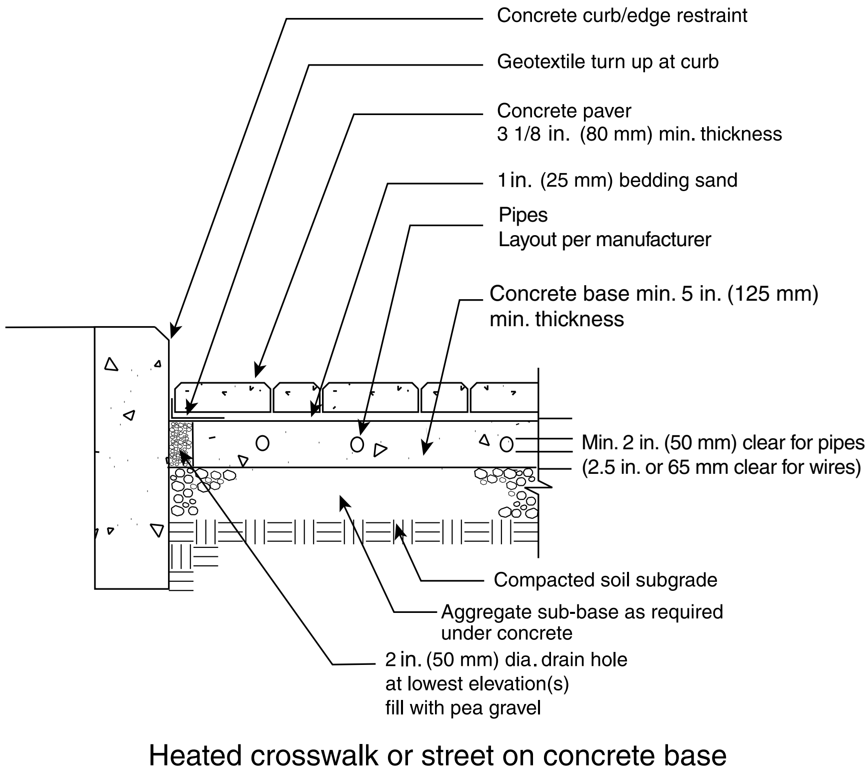


Figure 5. A typical cross section of a heated interlocking concrete pavement for crosswalks and roads subject to vehicluar traffic. For asphalt bases, pipes should be located at least 1½ in. (40 mm) under the asphalt.

way application. Figure 4 shows a heating system for a residential driveway tied to the wire mesh.

In some instances, rigid foam insulation may be required over the base. The insulation is placed under the bedding sand with wires or pipes in pedestrian applications only.

Insulation is not recommended in vehicular applications due to a high risk of breaking as well as trapping moisture above it. Insulation may be required on heated pavements over a high water table, when the heating system is operated manually, or when the perimeter of the heated area is large in relation to the total area, as with a long sidewalk. The manufacturer of the heating system should be consulted for specific guidance on insulation thickness, as well as when and where to use it.

Some contractors install the wires or pipe into the top of the base without wire mesh. This is accomplished by installing the pipes or wires in the last inch (25 mm) or so of compacted base surface. Base material is added and compacted to bring the level of the base to its final grade. The pipe or wire is exposed and flush with the compacted surface of the base. The absence of wire mesh will facilitate screeding of the bedding sand.

Asphalt and Concrete Bases for Vehicular Applications

For areas subject to constant vehicular traffic such as crosswalks or roads, wires or pipes should be placed in a concrete slab or in asphalt (rather than on top of these materials). This will protect the pipes or wires from damage due to wheel loads. Bedding sand and pavers are placed over them. Figure 5 illustrates a typical construction assembly.

Asphalt or concrete pavement materials and thicknesses should be designed to local standards. The manufacturer of the snow melting system can provide additional guidance on the location and detailing of wires or pipes in asphalt or concrete. Generally, they are placed within the concrete slab with a minimum 2 in. (50 mm) clearance from the top and bottom. For asphalt, the pipes are located at least 1½ in. (40 mm) below the bottom of the asphalt layer. Asphalt has a lower heat transfer rate than concrete so asphalt may require more costly, closer spacing of the pipes or wires.

When using an asphalt or concrete base, drainage of excess water in the bedding sand is recommended. Drainage can be achieved by weep holes through the

Figure 6. Experienced electrical and plumbing contractors should install snow melting systems.

Figure 7. Spreading and screeding bedding sand must be done without moving or damaging pipes or wires for melting snow.

pavement and base at the lowest points. These holes should be 2 in. (50 mm) in diameter and covered with geotextile to prevent loss of bedding sand into them.

Layout of the Heating System

After receiving consultation and design recommendations from the manufacturer, the installation of wiring or pipe should be done by an electrical and/or plumbing contractor experienced with installing these systems (Figure 6). The installed system should be tested for leaks before placing sand or pavers over it. Liquid systems should have their pipes filled and placed under pressure prior to placing asphalt or concrete over them.

The wires are generally no thicker than 3/4 in. (19 mm). Pipes can vary in diameter from 1/2 in. (13 mm) to 1 in. (25 mm) depending on the area to be heated and system flow requirements. Reference 7 provides design and installation guidelines for hydronic pipe and electric wire systems.

Bedding sand—Normally, a consistently thick layer between 1 to 1 1/2 in. (25 to 40 mm) is recommended under concrete pavers. With snow melt systems, up to 2 in. (50 mm) (before compaction) of bedding sand may be required to cover and protect the wires or pipes. The gradation of the bedding sand should conform to ASTM C 33 (3) or CSA A23.1 (5) as shown in Table 2. Limestone screenings or stone dust should not be used as they often have material passing smaller than the No. 200 (0.075 mm) sieve. This fine material slows the drainage of the bedding sand layer. The bedding should be moist when screeded but not saturated. Screed bars (for screeding bedding sand) will need to be carefully placed so as to

Table 2. Grading Requirements for Bedding Sand

ASTM C 33		or CSA A23.1	
Sieve Size	**Percent Passing**	**Sieve Size**	**Percent Passing**
9.5 mm	100	10 mm	100
4.75 mm	95 to 100	5 mm	95 to 100
2.36 mm	85 to 100	2.5 mm	80 to 100
1.18 mm	50 to 85	1.25 mm	50 to 90
0.600 mm	25 to 60	0.630 mm	25 to 65
0.300 mm	0 to 30	0.315 mm	10 to 35
0.150 mm	2 to 10	0.160 mm	2 to 10
0.75 mm	0 to 1	0.075 mm	0 to 1

Figure 8. Spreading joint sand over the installed concrete pavers.

Figure 9. Final compaction of the pavers and settling of the sand into the joints.

not disturb or damage the pipe or wires during screeding of the bedding sand. (See Figure 7.)

All pavers should be compacted, their joints filled with sand and compacted again at the end of each day. If the paver installation takes more than one day, the screeded bedding sand should not extend more than a few feet (1 m) beyond the edge of the open pattern at the end of each day. If there is a chance of rain, this area should be covered with a waterproof covering to prevent the bedding sand from becoming saturated. If the bedding sand is exposed to rain, it will become saturated and will have to be replaced or left to dry for many days. Saturated bedding sand is impossible to compact effectively and often requires removal. This will be very difficult and time-consuming since
the pipes or wires will slow bedding sand removal considerably.

Concrete pavers—Concrete pavers should meet the requirements for strength and durability in ASTM C 936 (6) or CSA A231.2 (8). For pedestrian and residential driveway applications, 2³/₈ in. (60 mm) thick pavers are recommended, and 3¹/₈ in. (80 mm) thick for vehicular uses. Once the bedding sand is screeded smooth, place the pavers in the prescribed laying pattern. All pavers should be constrained by edge restraints. *ICPI Tech Spec 3–Edge Restraints for Interlocking Concrete Pavements* offers guidance on the selection and application of edge restraints for all applications.

The concrete pavers should be compacted into the bedding sand with a 75–100 Hz plate compactor having a minimum centrifugal compactive force of 5,000 lbf (22 kN). Bedding sand is then spread across the surface of the pavers. A finer sand may be used to fill the joints that conforms to the grading requirements of ASTM C 144 (9) or CSA A179 (10). In either case, the joint sand should be dry so that it easily enters the joints between the pavers.

The concrete pavers are then compacted again and sand swept into the joints between them until they are completely full. Figures 8 and 9 show spreading the joint sand and the final compaction of the pavers. Excess sand is removed. Check with the manufacturers of snow melting systems to see if cleaners and sealers can be applied with no adverse effects to the pipes or wires. For additional guidance on the selection of cleaners and sealers, see ICPI *Tech Spec 5–Cleaning and Sealing Interlocking Concrete Pavements—A Maintenance Guide*. The minimum recommended slope of the finished pavement surface should be 2%. Water should not drain onto other pavements where it might collect and freeze.

Snowmelt Systems with Permeable Interlocking Concrete Pavements

Hydronic snowmelt systems have been installed within the permeable aggregate bedding layer within permeable interlocking concrete pavements (PICP) for pedestrian applications. Compared to pipes in sand bedding,

Figure 10. Electric heat tape snow melt system is installed in the bedding layer of permeable interlocking concrete pavement.

Figure 11. Concrete pavers installed to accommodate permeable bedding and jointing materials, all supported by a permeable stone base.

the pipe spacing will be reduced to account for heat loss to the air voids within the permeable aggregate bedding. For residential driveway applications, the pipe manufacturer should be consulted on durability of pipe material against the bedding aggregate while subject to vehicular tire loads. Figures 10 and 11 illustrate an electric snow melt system installed in the open-graded stone bedding layer of a PICP driveway.

References

1. *Snow Melting Calculation and Installation Guide*, Hyrdronic Institute of the Gas Appliance Manufacturers Association, Publication S-40, Radiant Panel Association, Hyrum, Utah.

2. *Annual Book of ASTM Standards*, ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)), Vol. 04.08, American Society for Testing and Materials, Conshohocken, Pennsylvania, 2013.

3. *Annual Book of ASTM Standards*, ASTM 2940 - Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways and Airports, Vol. 04.03, American Society for Testing and Materials, Conshohocken, Pennsylvania, 1995.

4. *Annual Book of ASTM Standards*, ASTM C 33 - Standard Specification for Concrete Aggregates, Vol. 04.02, American Society for Testing and Materials, Conshohocken, Pennsylvania, 1996.

5. CSA-A23.1, *Concrete Materials and Methods of Concrete Construction*, Canadian Standards Association, Rexdale, Ontario, 1994, Clause 5.3.2.1.

6. *Annual Book of ASTM Standards*, ASTM C 936 - Standard Specification for Solid Concrete Interlocking Paving Units, Vol. 04.05, American Society for Testing and Materials, Conshohocken, Pennsylvania, 2013.

7. *Guidelines for the Design and Installation of Radiant Panel Heating and Snow/Ice Melting Systems*, Radiant Panel Association, Loveland, Colorado, 2007 edition.

8. CSA-A231.2, *Precast Concrete Pavers*, Canadian Standards Association, Rexdale, Ontario, 2013.

9. *Annual Book of ASTM Standards*, ASTM C 144 - Standard Specification for Aggregate for Masonry Mortar, Vol. 04.05, American Society for Testing and Materials, Conshohocken, Pennsylvania, 2013.

10. CSA A179, *Mortar and Grout for Unit Masonry*, Canadian Standards Association, Rexdale, Ontario, 2009.

icpi
Interlocking Concrete Pavement Institute

14801 Murdock Street
Suite 230
Chantilly, VA 20151

In Canada:
P.O. Box 1150
Uxbridge, ON L9P 1N4
Canada

Tel: 703.657.6900
Fax: 703.657.6901
E-mail: icpi@icpi.org
www.icpi.org