but none he could attribute to frost problems. On the other hand, he has seen frozen soil drag up and displace exterior foundation insulation. For that reason, he recommends placing foundation insulation on the interior, where Mother Nature will not push it around.

In 11,000-degree-day Saskatchewan, they don't seem to have any problems with basement insulation, according to building researcher Rob Dumont. The reason may be that Saskatchewan has only 15 inches of precipitation annually compared with Duluth's 28 inches, most of which drops in the summer and fall—saturating the clay soil. Other cold-climate soils engineers I contacted around the country concur that they had never seen frost action cause structural damage to residential foundations.

Frost heaves

There are two distinct problems associated with frozen ground: frost heaving and frozen soil.

Frost heaving is what makes roads buckle during the winter in many northern states. It is caused by small plates of ice called "ice lenses" that form a foot or more below the surface. Ice lenses draw water from the surrounding soil by capillary action, typically growing to ¼ inch to 2 inches in thickness and up to several feet across. Often several lenses form in layers, adding to the total soil movement. Ice lenses form in porous silts and clays, which can support capillary action. They need extreme cold combined with a subsurface water source. Roads and sidewalks are good candidates for frost heaves because melted snow provides a good water source, and frost can penetrate deep because they're usually cleared of their insulating snow cover.

Where the direction of heat loss is upward to grade, ice lenses form horizontally. In these cases, ice lenses push mostly upward, not laterally. Theoretically, a frost heave could lift a foundation wall or pier if the soil above the ice lens were frozen to the concrete. Heley has seen concrete piers for highway sign posts lifted as much as an inch per year by frost heaving. But he has never seen frost do structural damage to foundations. Where the direction of heat loss is horizontal, as through a retaining wall or the wall of a frozen basement, ice lenses could form in the vertical plane—and push laterally.

Frozen soil

Soil that expands due to freezing is a separate problem. The necessary ingredients are water-saturated clay soil and continuous freezing temperatures. Water-saturated clays can hold up to two-thirds water by volume, and water expands 8 percent when it freezes. So the total volume of soil can expand as much as 5 percent. Unlike ice lenses, this expansion exerts equal force in all directions. The force against a wall, according to Heley, could be enough to crack the unreinforced block walls in Duluth.

Even if it doesn't cave in the wall, the expanding mass of freezing soil may make a mess of exterior insulation or waterproofing coatings, as was reported in Fargo. As the soil expands, it may