Cracked Foundations

Prevention is easier than repair

by Kip Park

Throughout much of North America, home owners face a similar problem—the cracking concrete foundations supporting their houses. The results are rarely life-threatening, but can be plenty uncomfortable. Water seeps into basements, plaster in the house cracks and doors jam.

There's no doubt that the problem is widespread. A 1981 survey by Owens-Corning Fiberglas Corporation of over 31,000 families throughout the U. S. found 59% of the households reporting leaky basements. A similar survey here in Canada in 1983 (by the University of Manitoba civil engineering department) found that over 70% of the houses surveyed had cracks in their basement floors, interior walls and ceilings, with major cracks in 9% of the houses (see photo below). Cracks in foundations are a particular problem in areas where there are expansive soils. Poor construction practices can also cause major problems with cracking.

Unruly substrates—Expansive soils are found throughout North America, but are particularly common here in Winnipeg, which is located on a former glacial lake bottom. Lake Agassiz was formed during the last Ice Age and covered about 180,000 sq. mi. of what is now Manitoba, Saskatchewan, North Dakota and Minnesota. When the lake vanished about 7,000 years ago, a layer of silt and clay which varies in thickness between 15 and 40 ft. was left behind.

Lake Agassiz clay, like most clays, changes in volume as soil moisture levels change. According to Prof. Len Domaschuk of the University of Manitoba civil engineering department (who conducted the Winnipeg foundation survey), a layer of clay one foot thick will change about an inch in thickness as it alternates between dehydration and saturation. As it swells, clay can exert over 10,000 lb. of pressure per sq. ft. against a foundation.

A National Research Council of Canada study in Winnipeg between 1962 and 1966 found that the elevation of the ground surface fluctuated by 5 in. during that period, with vertical movements of 3 in. at 5 ft. below grade. A house built on this unruly substrate with its foundation footings 5 ft. below grade will therefore heave or settle up to 3 in. as moisture levels change. The house will sit still only if the moisture level is stabilized.

Foundation cracks allow water to seep into basements and can cause doors to stick, plaster to crack and mildew to grow.

Controlling soil moisture—There are some basic and inexpensive measures that can be taken to minimize changes in the moisture content of the soil.

Lots shouldn't be completely cleared of shrubs and trees, as they often are in subdivisions. Roots take moisture from the soil, and when they're removed, soil moisture levels increase and the soil swells. A new concrete foundation placed in this swelling soil will almost always crack, especially if the concrete hasn't reached its full design strength—and often it hasn't.

Conversely, trees shouldn't be planted too near a foundation. They should be kept at least 15 ft. away, otherwise they'll cause the clays against the house to shrink excessively and cause the house to settle. If there's a tree right next to the foundation, remove it.

In Winnipeg, new houses are now required to be "perched" by building up the soil around the house so surface water drains away from the foundation. The. house must be perched a minimum of 3 in. above grade, with slopes extending from the house a minimum of 7 ft. at the front and rear and a minimum of 3 ft. in side yards. Also, the entire lot must be sloped—typically about 6 in. from front to rear on a 100-ft. deep lot—to direct surface water off the lot. Skew the house at an angle to the slope so it won't dam up the runoff, or slope the grade from the center out to the corners of the house to keep water from puddling against the foundation. Around existing homes, the soil will settle over time, creating a natural ditch which directs runoff water toward the foundation. Inspect the level of the soil regularly and add fill as needed to maintain a slope away from the house.

Downspouts direct rainwater away from the building. Splashpads are a must. The most durable and maintenance-free of these are made of precast concrete. They should be at least 3 ft. in length to prevent rainwater from seeping down the side of the foundation and into the expansive soil. Flexible plastic tubes attached to downspout ends help to carry rainwater away from the house.

Sidewalks, where they abut a foundation, should be sloped to direct water away from the house. When replacing a sidewalk, remove the deteriorated concrete. Don't place the new sidewalk over the old one, because the additional weight puts more pressure on the foundation and can produce horizontal cracks in the foundation wall. Concrete driveways should be at least 5 ft. away from foundation walls for the same reason.

Design and placement of concrete—It's not just expansive soil that causes foundation cracking. Concrete that is poorly designed or improperly placed or cured will add to the problem. In Manitoba, poured concrete, ideally reinforced with rebar, is nearly always used for residential foundations. It provides a stronger barrier than concrete block against expansive soil and is the cheaper alternative in our area. Concrete is subject to a lot of abuse when it's being placed—and note the distinction between *placing* concrete and *pouring* concrete. Pouring concrete suggests that it has the consistency of soup. This occurs when water is added to the mix on site, as workers often do in order to make the concrete easier to move around in the forms. But adding even one gallon of water to a cubic yard of concrete lowers its compressive strength by more than 150 lb. per sq. in. (psi). The watered concrete is prone to greater shrinkage and cracking during setting, and its durability and watertightness is reduced.

Canada's National Building Code allows a maximum slump of 4 in. in concrete used for house foundations. That's pretty stiff, and the concrete isn't easy to move around. To make the job easier, place the concrete in several different locations around the perimeter of the form. Or use chutes, buckets, or a pump truck to get the concrete as close as possible to its final destination. You might want to ask the concrete plant to add a superplasticizer, which helps prevent segregation of the concrete while improving its workability. Don't drop the concrete more than about 6 ft., as this will cause the segregation of aggregates, fines and cement, which decreases the strength and watertightness of the wall. Don't vibrate the concrete more than necessary, and don't move it with a rake either, as both techniques will cause segregation.

Mixed with the concrete at the batch plant, additives called air-entraining agents create a system of tiny bubbles throughout the mix. In addition to improving the workability of the concrete, the bubbles create a void into which moisture within the concrete can expand during freezing, thus preventing damage to the concrete itself. The Canadian Standards Association (CSA) requires 3% to 6% air entrainment for footings and 5% to 8% for walls, garage slabs and other exterior concrete. Ready-mix plants in Canada sometimes include an air-entrainment admixture at no extra charge.

There's another additive that has only recently hit the market. Fibermesh (Fibermesh, Inc., 4019 Industry Dr., Chattanooga, Tenn. 37416) is claimed to help prevent shrinkage cracks in the concrete, which typically develop within 40 days of the concrete placement.

Fibermesh consists of millions of individual ¾-in. to 2 in.-long interconnected polypropylene fibers, which are uniformly distributed throughout the concrete. They are dumped in the mixing drum on site at the rate of 1 to 1½ lb. per cu. yd. of concrete.

As concrete hardens, microscopic cracks develop as the result of plastic and drying shrinkage. When these cracks intersect the nearest Fibermesh strand, they are blocked and prevented from developing into larger cracks. Fibermesh retards concrete setting by about half an hour because the fibers tend to hold moisture in the mix, but this can be an advantage. In the Winnipeg area, it costs $20 per cu. m. ($13 per cu. yd. U. S.) to add Fibermesh to concrete.

Curing—Concrete will reach its full design strength only if it is allowed to cure in conditions that prevent the rapid loss of moisture. Concrete forms should be moistened with water or oiled, and the subgrade should be dampened to prevent water from being sucked out of the concrete. If you oil the forms, apply the oil before assembly so it doesn't end up on the subgrade, footings or reinforcing steel. The CSA requires forms to be left on the concrete for a minimum of 24 hrs. after placement, but recommends leaving the forms for the walls in place for at least two days to prevent the concrete from drying out too fast.

Erecting a concrete foundation in extreme temperatures can also affect its durability. When temperatures are above 85° F, concrete should be placed in the early morning or in the evening to reduce the loss of water through evaporation, which reduces the strength of the concrete. When ordering the concrete, ask the dispatcher to reduce the temperature of the concrete, or to add a set-retarder to the mix. This will buy some time to get the concrete in place before it loses too much moisture. Protect fresh concrete from rapid drying and direct sun by covering it with clear polyethylene sheeting between finishing operations. Keep the concrete covered after placement for at least as long as its surface is damp.

While hot weather calls for slowing down the curing of concrete, cold weather calls for the reverse. If concrete freezes before it cures, it suffers a permanent loss of strength and watertightness. Concrete temperatures must be maintained above 50° F during its placement and for three days afterwards. Calcium chloride is sometimes added to accelerate the curing, but no more than 2% of the weight of the cement should be added. It's available in pellet, flake and granular forms. Keep in mind that too much calcium chloride may increase shrinkage cracks and scaling, corrode reinforcing steel and darken the concrete. For walls, leave the forms in place for at least three days to take advantage of the heat of hydration. For flatwork, cover the slab with insulation blankets. In Winnipeg, propane heaters are usually used in conjunction with the blankets during the cold season.

Control joints—Some jobs are likely to crack despite careful placing and curing, and shrinkage is usually the culprit. Some builders use control joints to predetermine the location of shrinkage cracks. The idea is that if you can't beat the crack, you might as well plan for it. The Canadian Home Builders Association says that this could reduce foundation callbacks by 90%. In walls, the CSA recommends vertical control joints every 17 ft., starting 10 ft. from the corners. They also suggest control joints at window openings.

To be effective, the depth of the control joints must be one-quarter of the wall thickness. In either case, the joints must be filled

with a bond breaker, which will stretch when the concrete cracks, then sealed with a gun-grade, oil-based caulking. A polysulphide caulking such as Ake Vulkem 116 (Mameco International, 4475 East 175th St., Cleveland, Oh. 44128-3599) can also be used. The caulking must be protected from backfill by asphalt paper or exterior insulation.

Cracks in slabs can also be controlled by using control joints, sawcut 6 to 16 hours after placement or created with boards that remain in the slab after the pour. Joints in slabs can also be created with T-shaped plastic crack initiators (J. A. Crawford Company, P. 0. Box 1473, Whittier, Calif. 90609). The top of the T is removed after the slab is troweled. Control joints should be spaced 15 ft. to 20 ft. apart in a rectangular grid in basement slabs. Joint depth should be one-quarter of the slab's thickness.

Drainage and backfill—Exterior foundation insulation is a very effective means of reducing heat loss through the basement. During backfilling, the insulation protects any dampproofing membrane that is applied to the outside of the foundation. It also creates a resilient spacer between foundation walls and expansive subsoils, thereby reducing pressure on the concrete.

In Canada, Fiberglas Canada Inc. (4100 Yonge St., Willowdale, Ontario M2P 2B6) markets Baseclad as an exterior insulation/drainage product for basements of either new or existing houses. Because Baseclad is made up of fibers oriented vertically, moisture penetrates only the surface layer; moisture droplets are then passed from one fiber to another down its surface to the footings below, keeping moisture away from the foundation wall.

Of course, once the water gets to the footings, it needs someplace to go. Drain tiles collect this water and deliver it via leader lines to a sump pit inside the basement (where it is pumped out to a septic tank or sewer) or to a sewer or drain located away from the house.

Foundations can be weakened or cracked by improper backfilling techniques. One of the major causes of cracks is backfilling against "green" concrete, so it's suggested that backfilling be delayed for at least seven days. Walls should be supported laterally by diagonal bracing from the sill to stakes driven in the ground or by floor joists. Start the backfilling at the corners and work your way toward the middle of each wall.

In new construction, it's a good idea to use crushed limestone or a similar material as a backfill around the foundation instead of the usual excavated soil. The stone promotes good drainage, preventing moisture from collecting around the foundation wall and its footings. ❑

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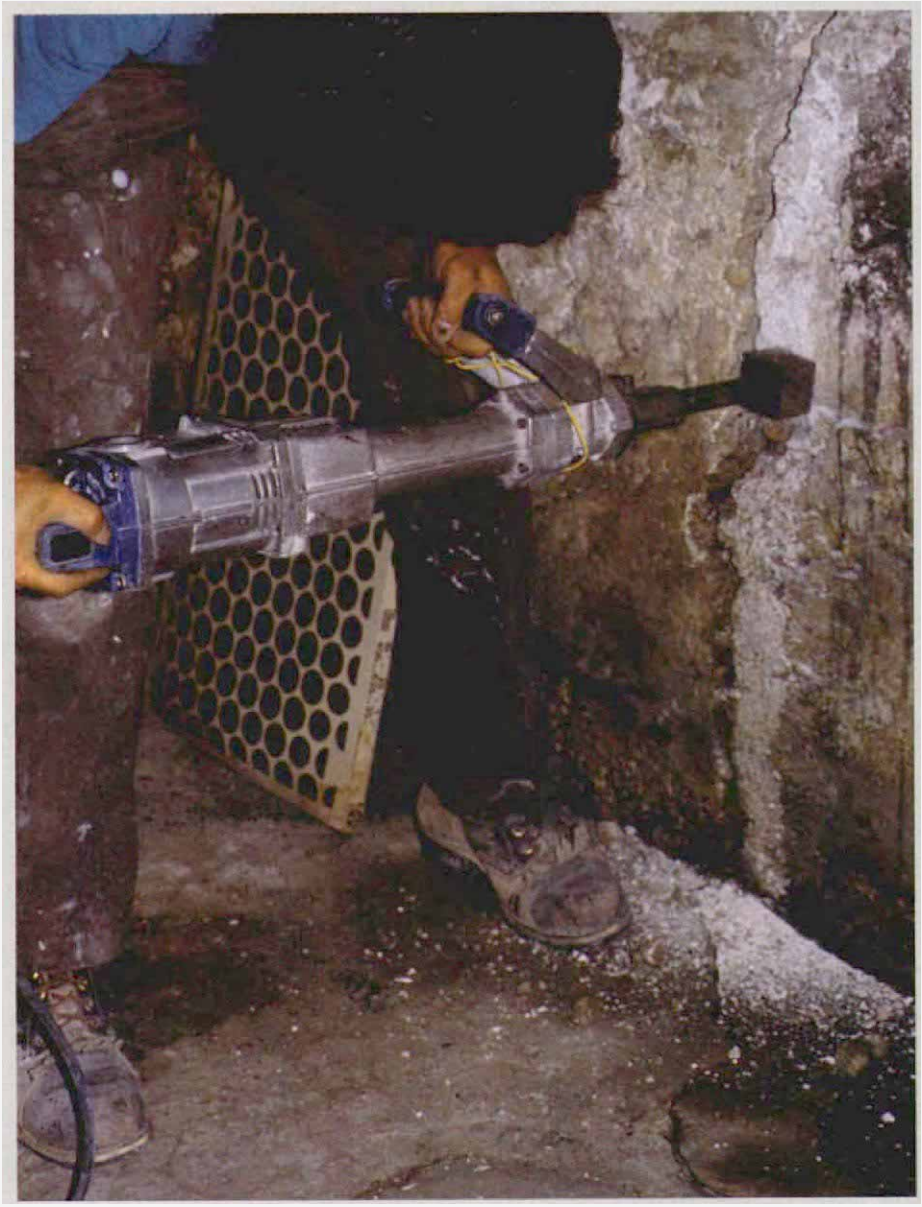
Repairing cracks in concrete

Permanently repairing a cracked concrete foundation requires skill and special materials, but it can be done. The best method is epoxy injection, according to Wally Sokoliuk, a foundation repair expert in Winnipeg, Canada, where extensive pockets of expansive soil make foundation cracks a major problem. It's the only method that seals cracks permanently, other than repairing and sealing the foundation from the exterior, a method which often can't be used.

***Epoxy injection*—Sokoliuk's company, Concrete Restoration Services (77 Paquin Road, Winnipeg, Manitoba, R2J 3V9) has been repairing cracked foundations with epoxy injection for the past 17 years, and reports excellent success. The epoxy he uses is manufactured by Dural International Corp. (95 Brook Avenue, Deer Park, N. Y. 11729) and costs about $100C a gallon ($60 per gal. U. S.). There are three different types, and the use of each is dictated by the width of the crack.**

Epoxy isn't the easiest substance to work with, and epoxy injection isn't recommended for the novice. The epoxy has a mere 15 to 20 minute pot life (shorter in warm conditions). Anyone who is unfamiliar with the process will find himself with *A* pot of expensive hardened epoxy and a crack which has not been completely sealed.

Repairing cracked concrete foundations by epoxy Injection is a three-step process, and the work stretches out over several days. First, the crack is prepared by cleaning out the debris (photos below) and drilling *1½-in.* deep holes, 8 in. to 9 in. apart, into the crack. Then polyethylene "ports" are inserted into the holes (copper pipe can be substituted). The ports allow the epoxy to penetrate deep into the crack. Next, an epoxy mortar is troweled over the crack. After it has set, another epoxy product such as Duralpatch, is troweled over it to prevent the epoxy from leaking



out later. If water is running out the crack, Sokoliuk uses Duralcrete instead.

The second step is the actual injection of the epoxy. The epoxy is forced Into the lowest port with a special injection gun. When the epoxy begins to leak out of the next highest port, the lower port is plugged and the nozzle moved to the flowing port. This process is continued on up the wall until all the ports have been filled.

The final step is to grind off the ports. This is usually done on the third day, when the epoxy has had a chance to reach full-strength (about 4,000 to 9,000 lb. per sq. in., which is stronger than the concrete of most foundations). Sokoliuk says grinding is preferred to using a cold chisel because a chisel might split the epoxy.

Although the process takes three consecutive days, sealing the crack might take only four hours in actual working time. Sokoliuk charges a flat fee of $400C ($350 U. S.) to repair a moderate crack by epoxy injection. On foundations with more extensive cracking, the charge is $40 a lineal ft. ($35 U. S.) He gives a five-year warranty with each injection job. (You can locate a foundation repair expert in your area by contacting the Poured Concrete Wall Contractors Association of America, 825 E. 64th St., Indianapolis, Ind. 46220, or by looking in the Yellow Pages under Foundation Contractors.)

The excavation method—Sometimes foundation cracks can't be repaired by epoxy injection. This is particularly true for houses built before 1940, when concrete quality was usually poor. According to Sokoliuk, there doesn't have to be a crack-the water sometimes just seeps through the wall. Older basements often require sealing from the exterior, a much more labor-intensive, expensive process.

First, Sokoliuk excavates the entire foundation perimeter down to the footing. If necessary, he replaces the drain tiles and covers them with **¾-in.** down limestone or a geotextile cloth. Then he trowels a coating of an asphaltic sealant material onto the concrete and embeds a layer of fiberglass material into it. Another coating of the asphaltic sealant follows, with another layer of fiberglass embedded into it, to be covered with a third and final coating of sealant.

A sheet of 6 mil polyethylene sheeting covers the entire foundation. This is protected by an asphalt-impregnated fiberboard (manufactured by C. P. D. Services, 219 Connie Crescent, Unit 14, Concord, Ont. L4K 1L4). Backfilling follows. Ideally, the material used for backfilling should be crushed limestone to provide better drainage around the foundation.

This method of sealing foundations is expensive, running about $100C ($80 U. S.) a lineal foot, so that the average basement will cost between $8,000C and $15,000C ($6,500 to $12,000 U. S.) to seal, says Sokoliuk. The excavation method is limited by existing conditions around the house, such as sidewalks, driveways and shrubs, or the proximity of a neighboring house, which may hamper equipment movement or prevent excavation entirely. *-K.P.*

Repairing cracks with epoxy injection. **One** way to repair cracks in basement walls is to fill them with epoxy, a process that takes three days. On the first day, surface debris is removed from the crack with a cold chisel or rotary hammer (photo, facing page). Holes are then drilled in the crack, **1½ in.** deep and 8 in. to 9 in. apart, and polyethylene or copper "ports" are inserted into the concrete. Next, a batch of epoxy mortar is troweled over the crack. When it sets, a commercially available epoxy grout is troweled on top (photo, above left). This process prevents epoxy from leaking out in later steps. On the second day, the crack is filled with epoxy. Starting with the lowest port, the epoxy is injected with a special hand pump until it starts flowing out of the next highest port (photos, top right and below right). The lower port is then plugged, and the pump nozzle is moved to a new port. The process is repeated up the wall until the entire crack has been filled. The final step is to grind the ports flush with the surface of the wall. This is done on the third day, after the epoxy has reached full strength.