

Site Grading and Drainage to Achieve High-Performance Basements

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Proper site grading and foundation drainage strategies are required in order to prevent water damage to basements and their contents. This Update reviews current construction practices used for basements, discusses some of the key issues and deficiencies that lead to problems, and provides practical suggestions for improving drainage and construction.

The causes of basement moisture problems are mainly external, but they can be addressed by providing diversion of water away from the building, drainage along the basement perimeter, protection of the founda-

tion walls against moisture, as well as by effective and durable grading near the basement and over the entire lot. (see Figure 1).

Well-considered design of foundations and their interface with surrounding soils, combined with effective site drainage, can eliminate most of the moisture problems found in basements.

Moisture in Basements

Basement moisture problems can be caused by water penetration (leakage), dampness in the form of water and water vapour migrating from the soil through the basement enclosure, and sump pump failures and sewer backups; they can also be caused by internal sources (humidity and plumbing leaks).

Leakage occurs when there is an accumulation of water outside a basement wall or floor that is adjacent to a crack or defect. Surface water that is not directed away from the building can enter the basement through unintentional openings (e.g., joint cracks) at or below grade. By providing adequate drainage around the perimeter of the basement, this situation can be avoided. Alternatively, the basement can be water-proofed (see sidebar, p. 2) to resist hydrostatic pressures and thus control leakage. A fluctuating water table that rises above the basement floor level may cause leakage unless the basement is waterproofed or the

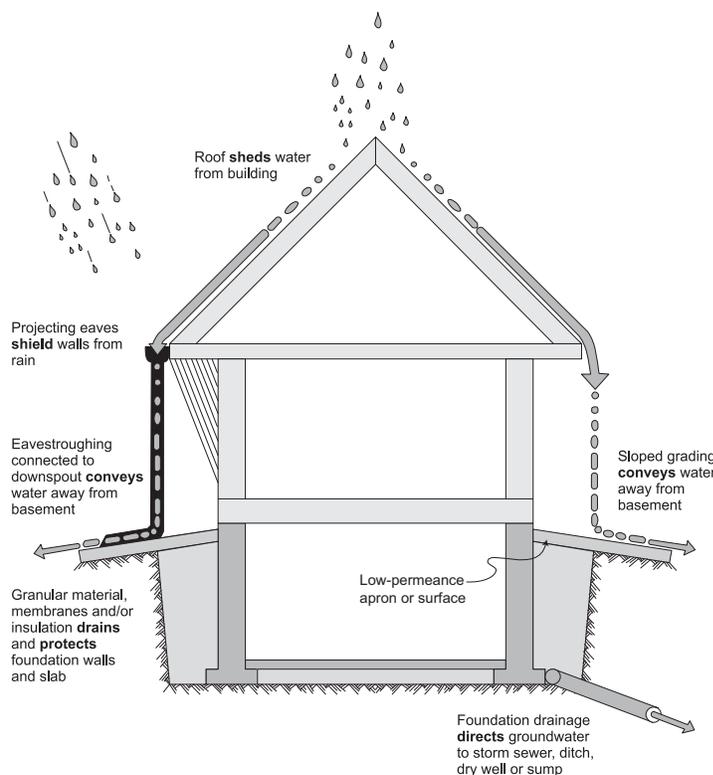


Figure 1. Key elements involved in providing moisture protection for basements

Waterproofing: Treatment of the surface or structure to prevent the passage of water through the basement envelope under hydrostatic pressures.

Dampproofing: Treatment of a surface or installation of a technology to resist the passage of moisture caused by differences in moisture content, vapour pressure and temperature across basement envelope components.

Note: Most foundations in new Canadian houses feature footing drainage systems with complementary dampproofing elements in the wall. This approach normally precludes the need for waterproofing. The basement systems discussed in this Update use drained approaches, without waterproofing.

groundwater level around the basement is lowered (to below floor level) by the operation of a sump pump.

Achieving complete basement protection requires that appropriate control measures be provided for each form of moisture. There are five major considerations:

1. Site grading and drainage provide the first line of defence against exterior water entering the basement.
2. Foundation drainage (weeping tile and/or a granular drainage layer), combined with effective drainage around the basement walls and appropriate moisture protection of the below-grade basement envelope surfaces, provide the second line of defence.
3. Incorporating special design details and building in redundancy or factors of safety are ways of addressing weak links in these two lines of defence. Preventing leaks at window wells and sump pump failures are two examples of this approach.
4. Selecting the proper materials is an integral part of achieving complete basement protection (see Construction Technology Update No. 70 *Options in the Selection of Materials for Basement Construction* for additional information).
5. Eliminating and/or controlling indoor sources of moisture is the final step in providing adequate moisture protection in basements.

The first three of these considerations are discussed in the following sections.

Site Grading and Drainage

Improper grading of the lot can result in poor surface drainage, ponding or flooding around the basement wall, foundation settlement or other damage, and basement

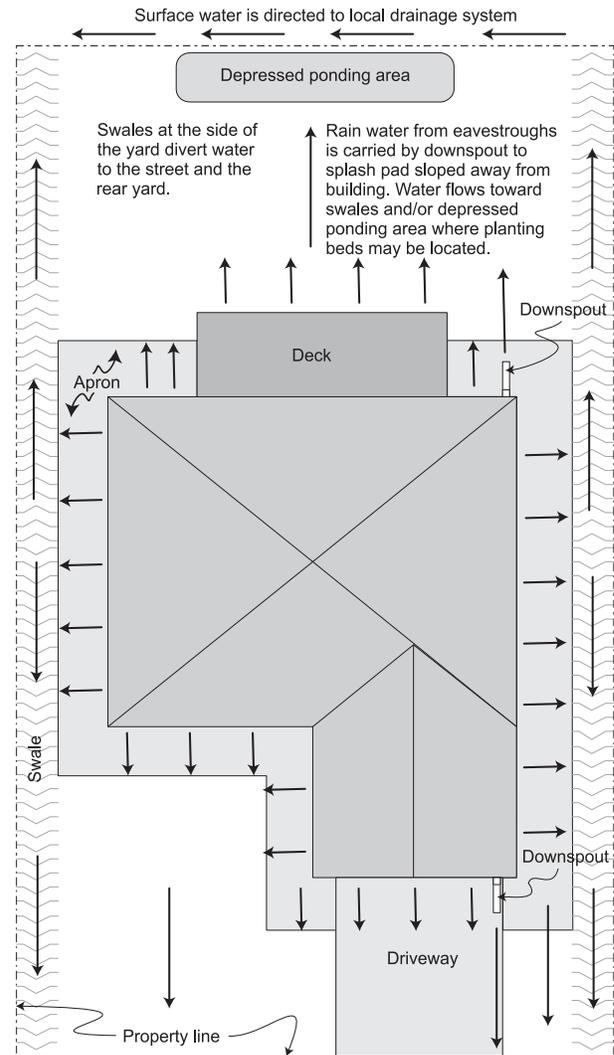


Figure 2. Split site-grading and drainage plan

dampness and other undesirable effects.

It is one of the main generators of customer complaints, call-backs, warranty repairs and legal proceedings following the completion and occupancy of a dwelling.

The two most common types of lot grading are:

Back to front. With this type of grading, the rear lot line is the high point. First of all an elevated apron must be created around the house. This allows the surface drainage to flow towards the back and then forward to the street at the edges of the property. Back-to-front grading is typical of properties on a hillside or mountainside.

Split. With this type, the house is the high point and the lot is graded so that surface drainage flows forward to the street and

backward toward the rear lot line, which is then generally drained by a swale and catch basin system (see Figure 2). This is the more common type and is typical of housing developments on relatively flat land.

Most surface drainage problems occur along the side lot lines between two houses, especially where the houses are close together. In these areas, a well-defined swale between the houses should be formed, which allows surface water to be diverted from the house and directed to the swale and then forward or backward, depending on the type of lot-grading approach used.

Downspouts from the roof should discharge at grade onto a splash pad at least 1 m (3 ft.) away from the building; they should not be directed toward adjacent property but rather toward swales established between the properties and within the property boundary.

In addition, the following guidelines should be followed:

- Minimum height of top of foundation wall above grade: 200 mm (8 in.)
- Minimum slope away from house for at least 1.5 m (5 ft.): 5%, i.e., approximately 19 mm per 300 mm (3/4 in. per ft.).
- Minimum slope on rest of lot: 1.5%, i.e., approximately 6 mm per 300 mm (1/4 in. per ft.)
- Minimum elevation of lot, at house, above street level: 450 mm (1.5 ft.)
- Minimum depth of swales: 150 mm (6 in.)
- Surface drainage should be directed away from window wells, exterior stairwells and decks

- Planned elevations at the perimeter of the lot should not be altered as a consequence of gardening, landscaping or fencing projects.

Site grading and drainage require careful planning, as this work will not be executed until the building is nearly completed. However, moisture-protection measures must be considered and addressed during the construction process.

Foundation Drainage and Moisture Protection

To deal with groundwater and surface water that have not been directed away from the building by site grading, certain measures must be taken to provide adequate foundation drainage and moisture protection.

Foundation Drainage

The most common approach to foundation drainage is illustrated in Figure 3(a). It uses weeping tile (pipe that is continuous and perforated, which can be either rigid or

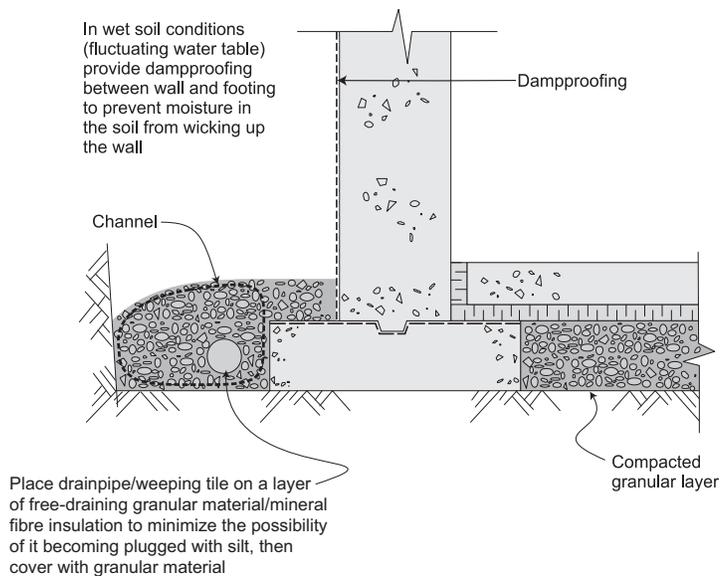


Figure 3(a). Best practice associated with foundation drainage design

Patios next to the house basement. This is a common landscape feature and one that invites problems. In time, patios almost always end up sloping toward the house. The 5% recommended slope could pose problems for interlock patios and related walkways next to the house. These require additional planning consideration. A lesser slope may have to be used as a compromise, for reasons of practicality and safety. Gradual and consistent sloping away from the house (with a slope of 1%), using laser technology, in combination with thorough tamping, should allow acceptable outward water flow to be achieved during heavy rain events. Such patios can provide a more consistent surface for water runoff than other landscaping, hence the exception to the 5% rule.

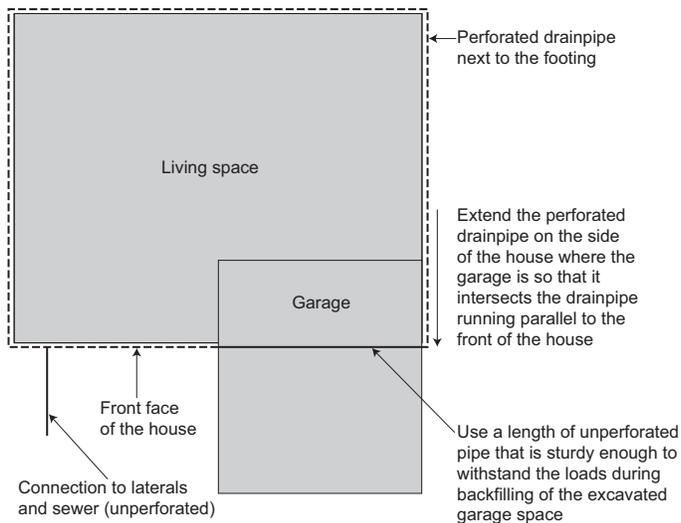


Figure 3(b). Drainpipe type and configuration needed to achieve optimal flow

flexible) installed around the perimeter of the foundation wall footing and covered with a granular material (gravel) prior to backfilling.

It is important to keep in mind that although Figure 3(a) depicts the most common best practice, this approach is nevertheless not intended to drain large quantities of water away from the footings. The following situations require some additional planning to promote effective footing drainage:

- *The travel distances for water through the drainpipe and gravel (from the back of the house to the storm sewer or sump) can sometimes be relatively long, resulting in large flow resistances and low water flow rates.*

Consider an additional line connection to the storm sewer or sump so that both sides of the house can be drained directly.

- *The corrugated design of the drainpipe, needed to provide strength and flexibility, introduces friction into the pipe, slowing the water flow. As well, the many corners associated with complex floor plans and attached garages introduce bends in the drainpipe resulting in even more flow resistance.*

Use a straight run of unperforated pipe in areas where water is not expected to drain from above, such as under attached garages, as shown Figure 3(b); extend the perforated drainpipe on the side of the house with the garage so that it intersects with the drainpipe running parallel to

the front of the house. This configuration eliminates two corners when the garage is inset into the house.

- *House footings are generally level, so the “channel” next to the footing is also basically level. This channel is formed by the edge of the footing, the ground and the face of the excavation, and provides a space in which the water can accumulate and then flow toward the pipes connecting to the storm sewer or sump (see Figure 3(a)). However, in low-permeability soils such as clays, the water tends to sit there, even when there are drainpipes and sufficient gravel. Sitting water tends to deposit silt, decreasing the available flow area in the pipe and gravel, and under some conditions, totally blocking both.*

As indicated in Figure 3(a), place the weeping tile or drainpipe on a layer of free-draining material. This can extend the life of the drainpipe, as the silt gets deposited in the granular material underneath (not inside) the pipe.

- *When the water has to travel a relatively long distance, sloping (standard) drainpipe with random perforations will not provide the desired result. The corrugations create additional friction and the random perforations prevent the build-up of water pressure, or head, inside the pipe. This head is necessary to drive the water down the pipe and gravel toward the storm sewer or sump.*

There are now some proprietary drainage systems available on the market that feature side slots and smooth rectangular channels, with no perforations at the bottom. Sloping such channels toward the storm sewer or sump connections can improve water evacuation rates.

Even when all of these best practices are followed, great emphasis still needs to be put on keeping the water out of the foundation drainage system. Footing drainage is the weakest link in the system, and this needs to be recognized in the overall drainage plan.

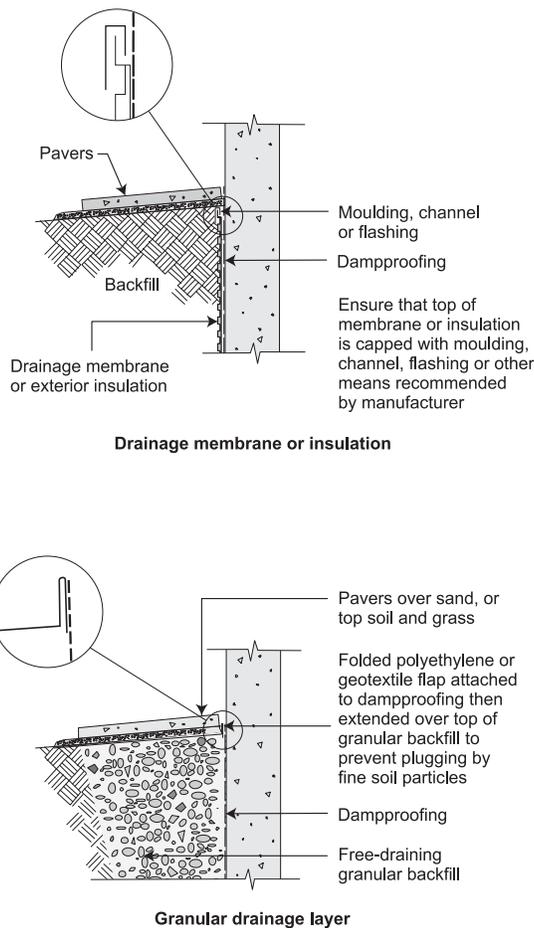


Figure 4. Two options for effective drainage of below-grade basement walls

Moisture Protection

The basement walls below grade are surrounded by soil containing moisture. By providing an adequate slope away from the building, as well as an impermeable cap, one can minimize the amount of water directed toward the below-grade basement walls though not eliminate it altogether. Two approaches are commonly used for moisture protection of the below-grade basement walls, as depicted in Figure 4.

The first approach involves using a drainage membrane or exterior insulation to control water migration through cracks and pores of basement structures. The second approach uses free-draining granular backfill to drain bulk water and dampproofing to control migration through the pores of the concrete.

Both approaches provide a vertical path (air space) that allows the water along the soil/wall interface to drain, and both are backed up by a second water-resistant surface (i.e., dampproofing membrane or coating) that drains any water down to the footing.

Each of these approaches has advantages. For example, in many parts of Canada, granular backfill materials are readily available and inexpensive. However, drainage membranes can also be used in unfavourable ground and weather conditions, without incurring the cost of removing excavated soil from the site. Both approaches provide effective perimeter basement wall drainage.

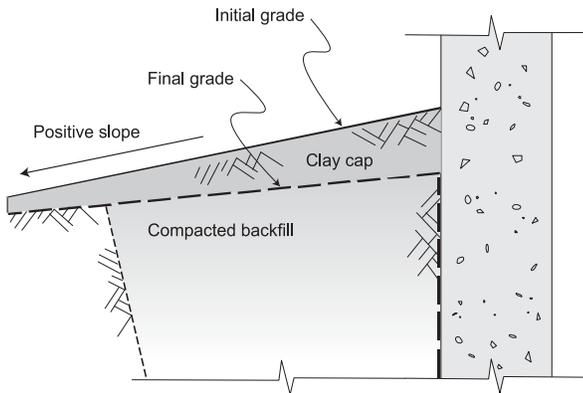
Regardless of the approach taken, once the basement moisture-protection system has been installed, attention must be paid to the grading and capping of the apron (see Figure 2 in “Site Grading” section) surrounding the building to ensure that water is directed away from the grade/basement wall interface. Grading and capping of the perimeter drainage system ensures that this system does not become overloaded such that its carrying capacity is exceeded (see Figure 5).

There are different ways of capping: one option involves using a low-permeability, fine-grained cohesive soil such as clay. Another more effective capping technique uses a membrane or low-permeability insulation board placed just below ground and sloped away from the wall. In all cases, the slope must be maintained after soil settlement and the capping must extend beyond the line of excavation and backfill.

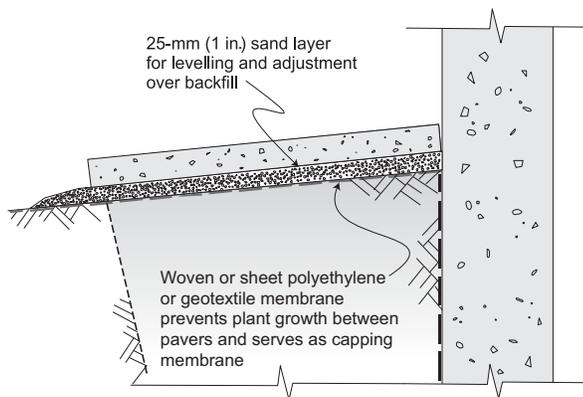
Grading and capping are the final steps in completing the foundation drainage system, tying it into the site grading and drainage system to control surface water.

Special Design and Construction Measures

There are numerous situations encountered in the construction of basements where special methods, materials or equipment may be required. Such measures include window wells and sump pumps.



- To maintain a positive slope around the house foundation:
- Initially provide an exaggerated grade to compensate for long-term settlement; or
 - Compact backfill in several lifts to reduce settlement.



- Install paved surfaces with a positive slope over a sand layer.
 Use discrete units to facilitate future adjustments of grade.
 Avoid long lengths of pavers or aprons that cannot be easily adjusted.
 Consider the impact of future landscaping on the grading.

Figure 5. Two ways of providing effective grading and capping of the basement perimeter walls

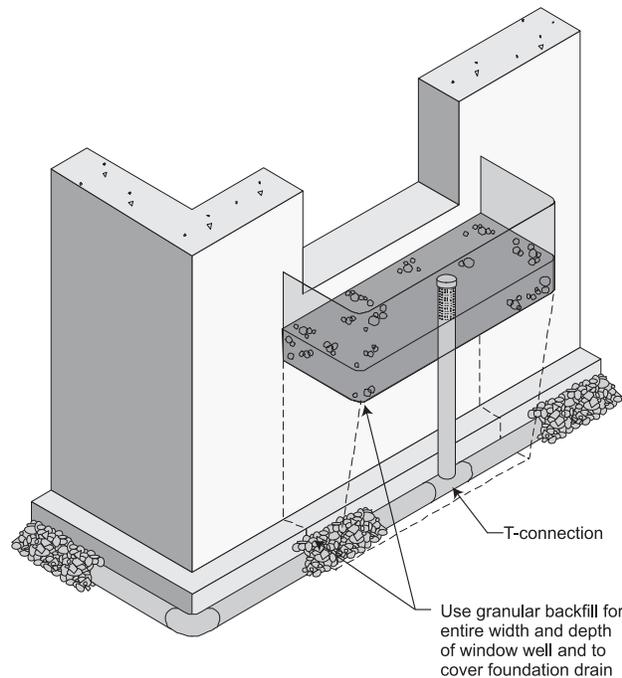
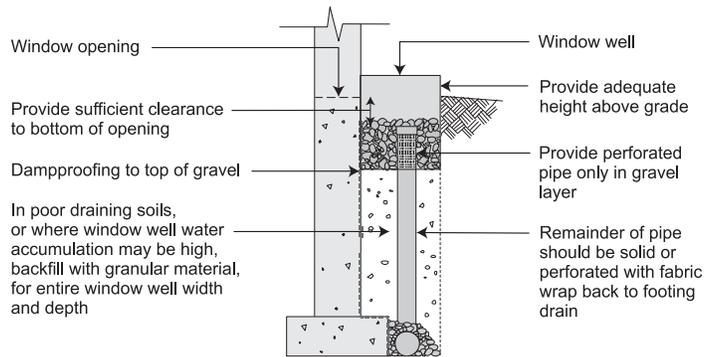


Figure 6. Critical considerations in the design and construction of window wells

Window Wells

Window wells are not a preferred basement construction practice, as they are lower than grade, attract snow and surface water, and can quickly overload the drainpipe system below. They rely on positive drainage from the granular layer below the window through a drainpipe to the footings. This helps avoid moisture problems at the foundation wall in the vicinity of the well and the wetting of the window itself. Figure 6 provides details for achieving proper window well performance.

The performance of the window well can be improved by providing sufficient distance from the top of the granular layer to the bottom of the window opening to avoid accumulation of water and melting snow that could rise above the bottom of the window opening. Because the window is not designed to resist the build-up of water, this additional vertical space provides a measure of added protection.

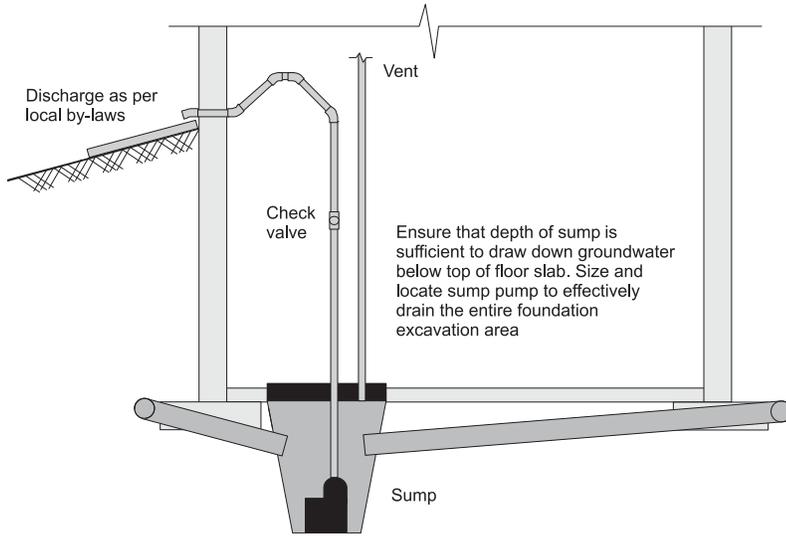


Figure 7. Important factors for sizing and locating sumps and sump pumps

Sump Pumps

Under some conditions sump pumps must be installed; for example, when there is a fluctuating water table or when the foundation drainage system is lower than a drainage receptor, making gravity drainage of the foundation impossible.

Sumps and sump pumps should conform to building code requirements; however, several issues not explicitly addressed by code requirements should be carefully considered (see Figure 7):

Area and configuration of the basement.

For very large basements, or basements with unusual shapes (e.g., L-shaped, J-shaped or U-shaped), more than one sump may be required to achieve effective drainage.

Low-permeability soils. The minimum required depth of the sump (750 mm or 30 in.) may not result in a sufficient water flow rate to the sump to maintain water levels at the extremities of the basement below the basement slab or floor assembly; this minimum may need to be exceeded to achieve an adequate flow rate.

Basements used as living spaces. It is advisable to provide an emergency back-up power supply to the sump pump in case extreme weather causes a power failure. A pump alarm is also recommended to indicate pump failure and/or the need for maintenance.

Review local practices for sump pumps for guidance on these issues.

Summary

The site grading and foundation drainage practices highlighted in this Update and summarized below can eliminate most basement performance problems in Canadian housing:

- Plan and design site grading and foundation drainage to anticipate all sources of moisture;
- Divert water away from the basement wall and provide an effective drainage layer around the perimeter of the basement. This will prevent the accumulation of ground water that can cause hydrostatic pressure on the basement walls and at the footings;
- Design and construct window wells properly to ensure acceptable performance under adverse weather conditions.
- Size and locate sumps and sump pumps to effectively control the groundwater level over the entire basement area.

Performance expectations for basements in Canadian housing have become higher because of the increased use of basements as living spaces. This Update presents key measures that need to be considered to help meet these expectations.

Performance Guidelines for Basement Envelope Systems and Materials

The Guidelines were developed under the guidance of the project steering committee, which was comprised of industry association and government agency representatives. This committee ensured that the Guidelines reflect the best collective knowledge of Canadian industry and related public and private agencies.

The complete report is now available at http://irc.nrc-cnrc.gc.ca/pubs/rr/rr199/index_e.html

Further Reading

Source and On-Site Controls for Municipal Drainage Systems. InfraGuide, Innovations and Best Practices: Storm and Wastewater (No. 3). National Guide to Sustainable Municipal Infrastructure. Ottawa, 2003. <http://sustainablecommunities.fcm.ca/InfraGuide/>

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