Grounding electrodes

Rule 10-700 Grounding electrodes

All parts of the grounding and bonding system can be controlled by careful design and material selection, except for the system's actual connection to the earth. The quality and reliability of this connection depends on the resistance of the earth on which the building stands, on the moisture content of that earth, and on the grounding electrode or electrodes that are placed in the earth, which are all variable factors. For this reason, installers must determine the best possible electrode system that is consistent with the requirements of a given electrical installation.

A high-voltage system can deliver considerable current through the ground path, and in so doing raise the voltage of the earth to a level dangerous to people standing on the ground in the vicinity of the fault. For such systems, a much more complicated grounding electrode system is required in order to limit the ground potential rise (see Rules 36-300 to 36-312).

A grounding electrode is a buried metal water piping system or a metal object or device buried in, or driven into, the ground that makes intimate contact with the earth; a grounding conductor is electrically and mechanically connected to it.

Rule 10-700(1) recognizes three kinds of grounding electrodes:

(1) Manufactured grounding electrodes — types of electrodes that are manufactured in a factory setting and approved in accordance with CSA C22.2 No. 41, such as rod and plate electrodes.

(2) Field-assembled grounding electrodes — electrodes manufactured on site using readily available materials, such as bare copper conductors directly buried or encased in concrete foundation footings.

(3) In-situ grounding electrodes — parts of the building's infrastructure that are in contact with the earth, such as a water piping system, metallic reinforcement of a concrete slab, concrete piling, concrete foundation, or iron piling, etc., that have the same surface area in contact with the earth at 600 mm below finished grade as a manufactured grounding electrode.

Subrule (2) sets out requirements for the installation of manufactured grounding electrodes (see Figure 10-23).

Rod electrodes must consist of at least two manufactured rod electrodes. Rods must

- be at least 3 m long (as required by CSA C22.2 No. 41);
- be driven into the earth to their full length and spaced no less than 3 m apart; and
- be bonded together by a grounding conductor sized in accordance with Rule 10-812.

Plate electrodes must

- have an exterior surface area of at least 0.2 m2 (as required by CSA C22.2 No. 41) in contact with the soil and be buried at a depth not less than 600 mm below finished grade level; or
- be encased within the bottom 50 mm of a concrete foundation footing that is in direct contact with the earth, having an exterior surface area to the concrete of at least 0.4 m2 (as required by CSA C22.2 No. 41), and buried at a depth not less than 600 mm below finished grade.

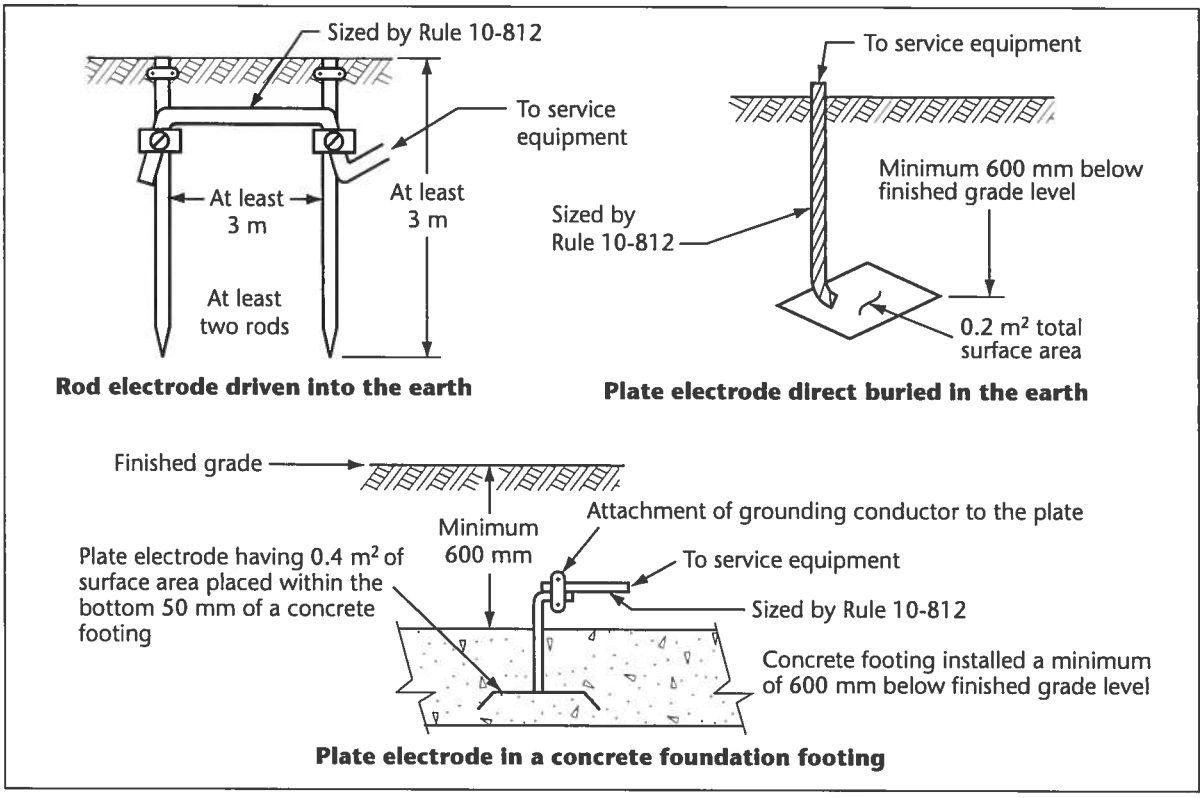

Figure 10-23
Manufactured grounding electrodes

Subrule (3) provides requirements for the installation of field-assembled grounding electrodes. Where a bare copper conductor is encased in concrete footing in direct contact with the earth

- the bare copper conductor must be sized in accordance with Table 43;
- the length of conductor must be no less than 6 m; and
- the conductor must be encased within the bottom 50 mm of a concrete foundation footing, with the footing in direct contact with the earth, at not less than 600 mm below finished grade.

Where bare copper conductor is directly buried in the earth (see Figure 10-24)

- the bare copper conductor must be sized in accordance with Table 43;
- the length of conductor must be no less than 6 m; and
- the conductor must be in direct contact with the earth and buried at a depth of not less than 600 mm below finished grade.

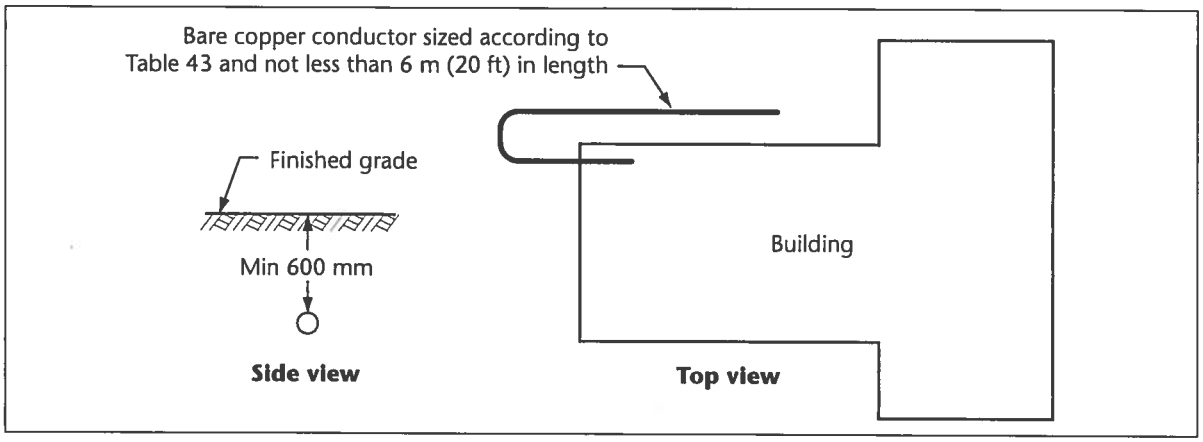

Figure 10-24
Field-assembled grounding electrode direct buried in the earth

Subrule (4) addresses in-situ grounding electrodes provided by a building's infrastructure, such as a water piping system, iron piling, or metallic reinforcement of a concrete slab, concrete piling, or concrete foundation. Such electrodes must be 600 mm or more below finished grade and have a minimum surface area of metal equal to that of a manufactured grounding electrode [0.2 m2 when the metal is in direct contact with the earth (see Figure 10-27) and 0.4 m2 when buried in concrete]. See Figure 10-26.

For example, an underground metal water piping system located at least 600 mm below finished grade and extending at least 3 m (see Figure 10-25) has traditionally been recognized as a suitable grounding electrode. The metal reinforcement of concrete slabs, concrete pilings, and concrete foundations, as well as iron pilings, when they are in significant contact with earth 600 mm or more below finished grade have also been found to be suitable in-situ grounding electrodes. Any metallic material protected from corrosion by a non-conductive compound, however, is not acceptable for use as an in-situ grounding electrode. The Note to Rule 10-700(4) in Appendix B advises that the potential effects of corrosion on the durability and life expectancy of an in-situ grounding electrode should be considered.

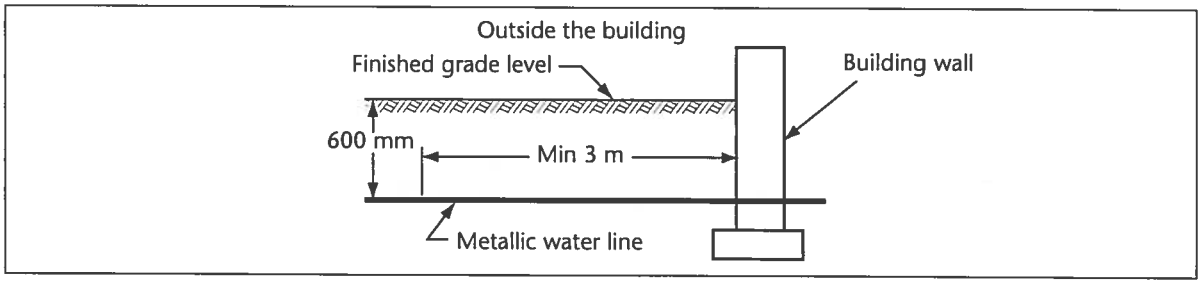

Figure 10-25
In-situ grounding electrode — Water piping

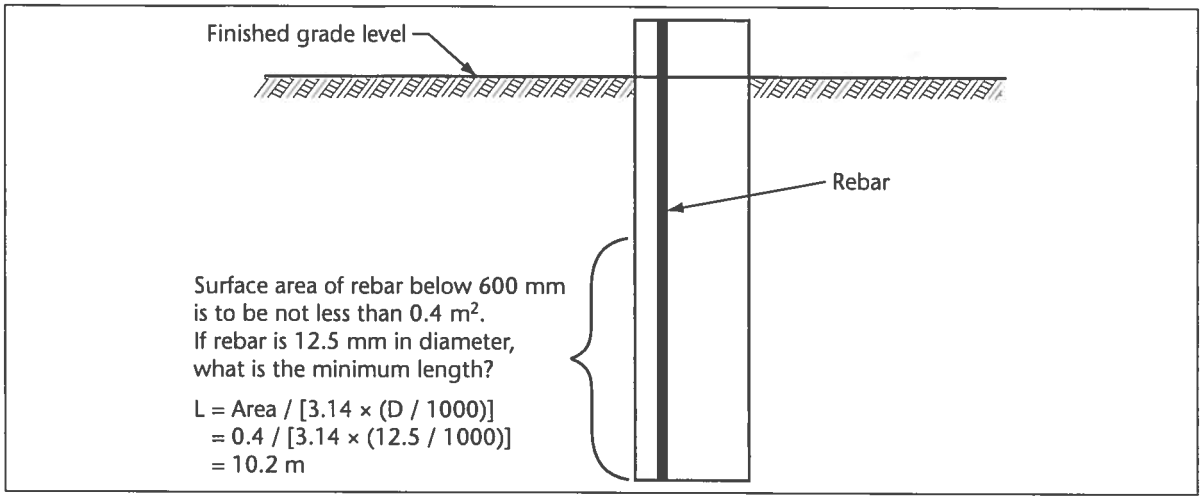

Figure 10-26
In-situ grounding electrode

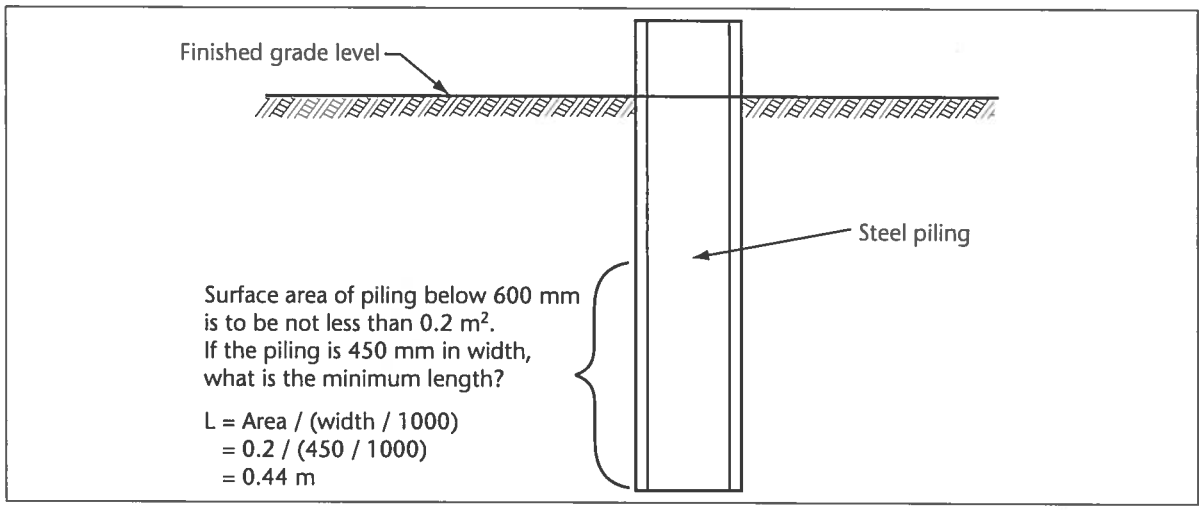

Figure 10-27
In-situ grounding electrode — Steel piling

Subrule (5) takes into account local conditions (e.g., rock or permafrost) that might prevent the installation of a rod or a plate grounding electrode to its required depth. In such cases, the electrode may be buried at a lesser acceptable depth (see Figures 10-28 and 10-29). The defined term "acceptable" is used, instead of specifying an alternative depth, because a variety of means are available to address the situation, and the inspection authority will make the final determination as to the most appropriate one.

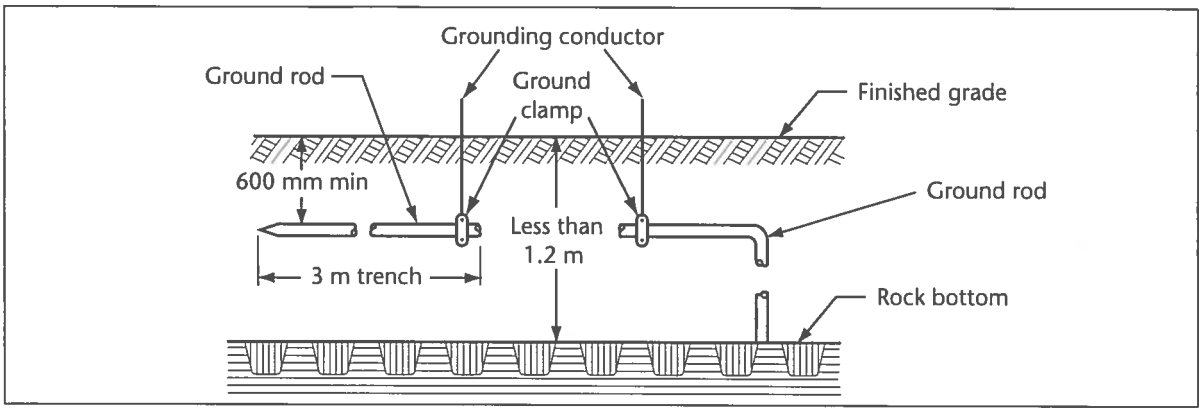

Figure 10-28
Alternative when a rod electrode encounters rock at a lesser depth

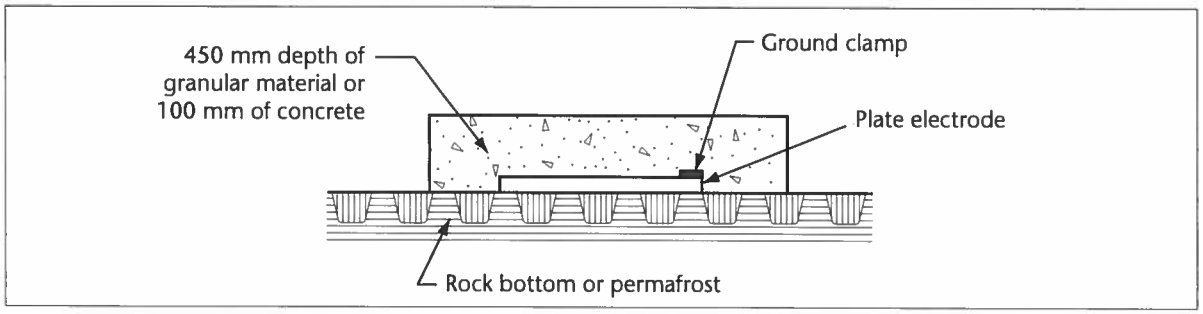

Figure 10-29
Alternative to 600 mm burial depth for manufactured grounding electrode

Rule 10-702 Spacing and interconnection of grounding electrodes

Rule 10-702(a) requires that a separation of at least 2 m be maintained between the grounding electrodes of building electrical wiring systems and the grounding electrodes of other wiring systems, such as lightning rod, communication, and community antenna distribution systems, so that the area of influence of one electrode does not intrude upon that of another. The advantage of having more than one electrode is fully realized only when they are spaced at least 2 m apart. A grounding electrode requires a minimum of 1 m radial space around it for dissipation of any electrical potential into the earth. If the electrodes are closer than 2 m, there is not enough earth between the electrodes to provide a low-resistance connection to earth for each rod and the electrical potential would not be fully discharged into the earth. Since a fault can occur between one of these grounding systems and the building electrical wiring systems, the grounding electrodes of the two systems must be interconnected to prevent ground loops and circulating currents from occurring between these different grounding and bonding systems. This interconnection offers a low-impedance path for any fault current and enables the quick operation of the overcurrent protection.

Interconnecting all electrodes is intended only to extend the equipotential plane, so Item (b) requires that a conductor used to interconnect the electrodes be made of material permitted by Rule 10-802 for grounding conductors and sized not smaller than No. 6 AWG if of copper or No. 4 AWG if of aluminum. The conductor is to be protected by location from mechanical damage. When connection is made between lightning protection system grounding electrodes and other electrical system grounding electrodes, the bonding conductor used for