# Section 4.2. Foundations

## 4.2.1. General

### 4.2.1.1. Application

**1)** This Section applies to *excavations* and *foundation* systems for *buildings*.

## 4.2.2. Subsurface Investigations, Drawings and Reviews

### 4.2.2.1. Subsurface Investigation

**1)** A *subsurface investigation*, including *groundwater conditions*, shall be carried out by or under the direction of a professional engineer having knowledge and experience in planning and executing such investigations to a degree appropriate for the *building* and its use, the ground and the surrounding site conditions. (See Note A-4.2.2.1.(1).)

### 4.2.2.2. Drawings

**1)** Drawings associated with *foundations* and *excavations* shall conform to the appropriate requirements of Section 2.2. of Division C. (See Article 2.2.4.6. of Division C.)

### 4.2.2.3. Field Review

**1)** A field review shall be carried out by the *designer* or by another suitably qualified person to ascertain that the subsurface conditions are consistent with the design and that construction is carried out in accordance with the design and good engineering practice. (See Note A-4.2.2.3.(1).)

**2)** The review required by Sentence (1) shall be carried out

a) on a continuous basis

i) during the construction of all *deep foundation units* with all pertinent information recorded for each *foundation unit*,

ii) during the installation and removal of retaining structures and related backfilling operations, and

iii) during the placement of engineered *fills* that are to be used to support the *foundation units*, and

b) as required, unless otherwise directed by the *authority having jurisdiction*,

i) in the construction of all *shallow foundation units*, and

ii) in excavating, dewatering and other related works.

### 4.2.2.4. Altered Subsurface Condition

**1)** If, during construction, the *soil*, *rock* or *groundwater* is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the *designer*.

**2)** If, during construction, climatic or any other conditions change the properties of the *soil*, *rock* or *groundwater*, the design shall be reassessed by the *designer*.

## 4.2.3. Materials Used in Foundations

### 4.2.3.1. Wood

**1)** Wood used in *foundations* or in support of *soil* or *rock* shall conform with the appropriate requirements of Subsection 4.3.1.

### 4.2.3.2. Preservation Treatment of Wood

**1)** Wood exposed to *soil* or air above the lowest anticipated *groundwater* table shall be treated with preservative in conformance with CAN/CSA-O80 Series, "Wood Preservation," and the requirements of the appropriate commodity standard as follows:

a) CAN/CSA-O80.2, "Processing and Treatment,"

b) CAN/CSA-O80.3, "Preservative Formulations," or

c) CSA O80.15, "Preservative Treatment of Wood for Building Foundation Systems, Basements, and Crawl Spaces by Pressure Processes."

**2)** Where timber has been treated as required in Sentence (1), it shall be cared for as provided in AWPA M4, "Care of Preservative-Treated Wood Products," as revised by Clause 6 of CAN/CSA-O80 Series, "Wood Preservation."

### 4.2.3.3. Plain and Reinforced Masonry

**1)** Plain or reinforced masonry used in *foundations* or in support of *soil* or *rock* shall conform with the requirements of Subsection 4.3.2.

### 4.2.3.4. Prevention of Deterioration of Masonry

**1)** Where plain or reinforced masonry in *foundations* or in structures supporting *soil* or *rock* may be subject to conditions conducive to deterioration, protection shall be provided to prevent such deterioration.

### 4.2.3.5. Concrete

**1)** Plain, reinforced or pre-stressed concrete used in *foundations* or in support of *soil* or *rock* shall conform with the requirements of Subsection 4.3.3.

### 4.2.3.6. Protection Against Chemical Attack

**1)** Where concrete in *foundations* may be subject to chemical attack, it shall be treated in conformance with the requirements in CSA A23.1, "Concrete Materials and Methods of Concrete Construction."

### 4.2.3.7. Steel

**1)** Steel used in *foundations* or in support of *soil* or *rock* shall conform with the appropriate requirements of Subsection 4.3.3. or 4.3.4., unless otherwise specified in this Section.

### 4.2.3.8. Steel Piles

**1)** Where steel *piles* are used in *deep foundations* and act as permanent load-carrying members, the steel shall conform with one of the following standards:

a) ASTM A 252, "Welded and Seamless Steel Pipe Piles,"

b) ASTM A 283/A 283M, "Low and Intermediate Tensile Strength Carbon Steel Plates,"

c) ASTM A 1008/A 1008M, "Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable,"

d) ASTM A 1011/A 1011M, "Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength," or

e) CSA G40.21, "Structural Quality Steel."

### 4.2.3.9. High Strength Steel Tendons

**1)** Where high strength steel is used for tendons in anchor systems used for the permanent support of a *foundation* or in the erection of temporary support of *soil* or *rock* adjacent to an *excavation*, it shall conform with the requirements of CSA A23.1, "Concrete Materials and Methods of Concrete Construction."

### 4.2.3.10. Corrosion of Steel

**1)** Where conditions are corrosive to steel, adequate protection of exposed steel shall be provided. (See Article 1.2.1.1. of Division A for use of other materials.)

## 4.2.4. Design Requirements

### 4.2.4.1. Design Basis

**1)** The design of *foundations*, *excavations* and *soil-* and *rock*-retaining structures shall be based on a *subsurface investigation* carried out in conformance with the requirements of this Section, and on any of the following, as appropriate:

a) application of generally accepted geotechnical and civil engineering principles by a professional engineer especially qualified in this field of work, as provided in this Section and other Sections of Part 4,

b) established local practice, where such practice includes successful experience both with *soils* and *rocks* of similar type and condition and with a *foundation* or *excavation* of similar type, construction method, size and depth, or

c) in situ testing of *foundation units*, such as the load testing of *piles*, anchors or footings, carried out by a person competent in this field of work.

(See Note A-4.2.4.1.(1).)

**2)** The *foundations* of a *building* shall be capable of resisting all the loads stipulated in Section 4.1., in accordance with limit states design in Subsection 4.1.3.

**3)** For the purpose of the application of the load combinations given in Table 4.1.3.2.-A, the geotechnical components of loads and the factored geotechnical resistances at ULS shall be determined by a suitably qualified and experienced professional engineer. (See Note A-4.2.4.1.(3).)

**4)** Geotechnical components of service loads and geotechnical reactions for SLS shall be determined by a suitably qualified and experienced professional engineer.

**5)** The *foundation* of a *building* shall be designed to satisfy SLS requirements within the limits that the *building* is designed to accommodate, including total settlement and differential settlement, heave, lateral movement, tilt or rotation. (See Note A-4.2.4.1.(5).)

**6)** Communication, interaction and coordination between the *designer* and the professional engineer responsible for the geotechnical aspects of the project shall take place to a degree commensurate with the complexity and requirements of the project.

### 4.2.4.2. Subsurface Investigation

**1)** A *subsurface investigation* shall be carried out to the depth and extent to which the *building* or *excavation* will significantly change the stress in the *soil* or *rock*, or to such a depth and extent as to provide all the necessary information for the design and construction of the *excavation* or the *foundations*.

### 4.2.4.3. Identification

**1)** The identification and classification of *soil*, *rock* and *groundwater* and descriptions of their engineering and physical properties shall be in accordance with a widely accepted system.

### 4.2.4.4. Depth of Foundations

**1)** Except as permitted in Sentence (2), the *bearing surface* of a *foundation* shall be below the level of potential damage, including damage resulting from *frost action*, and the *foundation* shall be designed to prevent damage resulting from *adfreezing* and frost jacking. (See Note A-4.2.4.4.(1).)

**2)** The *bearing surface* of a *foundation* need not be below the level of potential damage from frost where the *foundation*

a) is designed against *frost action*, or

b) overlies material not susceptible to *frost action*.

### 4.2.4.5. Sloping Ground

**1)** Where a *foundation* is to rest on, in or near sloping ground, this particular condition shall be provided for in the design.

### 4.2.4.6. Eccentric and Inclined Loads

**1)** Where there is eccentricity or inclination of loading in *foundation units*, this effect shall be fully investigated and provided for in the design.

### 4.2.4.7. Dynamic Loading

**1)** Where dynamic loading conditions apply, the effects shall be assessed by a special investigation of these conditions and provided for in the design.

### 4.2.4.8. Hydrostatic Uplift

**1)** Where a *foundation* or any part of a *building* is subject to hydrostatic uplift, the effects shall be provided for in the design.

### 4.2.4.9. Groundwater Level Change

**1)** Where proposed construction will result in a temporary or permanent change in the *groundwater level*, the effects of this change on adjacent *buildings* shall be fully investigated and provided for in the design.

### 4.2.4.10. Permafrost

**1)** Where conditions of permafrost are encountered or proven to exist, the design of the *foundation* shall be based upon analysis of these conditions by a person especially qualified in that field of work.

### 4.2.4.11. Swelling and Shrinking Soils

**1)** Where swelling or shrinking *soils*, in which movements resulting from moisture content changes may be sufficient to cause damage to a structure, are encountered or known to exist, such a condition shall be fully investigated and provided for in the design.

### 4.2.4.12. Expanding and Deteriorating Rock

**1)** Where *rock* that expands or deteriorates when subjected to unfavourable environmental conditions or to stress release is known to exist, this condition shall be fully investigated and provided for in the design.

### 4.2.4.13. Construction on Fill

**1)** *Buildings* may be placed on *fill* if it can be shown by subsurface investigation that

a) the *fill* is or can be made capable of safely supporting the *building*,

b) detrimental movement of the *building* or of services leading to the *building* will not occur, and

c) explosive gases can be controlled or do not exist.

### 4.2.4.14. Structural Design

**1)** The structural design of the *foundation* of a *building*, the procedures and construction practices shall conform with the appropriate Sections of this Code unless otherwise specified in this Section.

## 4.2.5. Excavations

### 4.2.5.1. Design of Excavations

**1)** The design of *excavations* and of supports for the sides of excavations shall conform with Subsection 4.2.4. and with this Subsection. (See Note A-4.2.5.1.(1).)

### 4.2.5.2. Excavation Construction

**1)** Every *excavation* shall be undertaken in such a manner as to

a) prevent movement that would cause damage to adjacent *buildings* at all phases of construction, and

b) comply with the appropriate requirements of Part 8.

**2)** Material shall not be placed nor shall equipment be operated or placed in or adjacent to an *excavation* in a manner that may endanger the integrity of the *excavation* or its supports.

#### 4.2.5.3. Supported Excavations

**1)** The sides of an *excavation* in *soil* or *rock* shall be supported by a retaining structure conforming with the requirements of Articles 4.2.5.1. and 4.2.5.2., except as permitted in Article 4.2.5.4.

#### 4.2.5.4. Unsupported Excavations

**1)** The sides of an *excavation* in *soil* or *rock* may be unsupported where a design is prepared in conformance with the requirements of Articles 4.2.5.1. and 4.2.5.2.

#### 4.2.5.5. Control of Water around Excavations

**1)** Surface water, all *groundwater*, *perched groundwater* and in particular *artesian groundwater* shall be kept under control at all phases of *excavation* and construction.

#### 4.2.5.6. Loss of Ground

**1)** At all phases of *excavation* and construction, loss of ground due to water or any other cause shall be prevented.

#### 4.2.5.7. Protection and Maintenance at Excavations

**1)** All sides of an *excavation*, supported and unsupported, shall be continuously maintained and protected from possible deterioration by construction activity or by the action of frost, rain and wind.

#### 4.2.5.8. Backfilling

**1)** Where an *excavation* is backfilled, the backfill shall be placed so as to

a) provide lateral support to the *soil* adjacent to the *excavation*, and

b) prevent detrimental movements.

**2)** The material used as backfill or *fill* supporting a footing, *foundation* or a floor on grade shall be of a type that is not subject to detrimental volume change with changes in moisture content and temperature.

### 4.2.6. Shallow Foundations

#### 4.2.6.1. Design of Shallow Foundations

**1)** The design of *shallow foundations* shall be in conformance with Subsection 4.2.4. and the requirements of this Subsection. (See Note A-4.2.6.1.(1).)

#### 4.2.6.2. Support of Shallow Foundations

**1)** Where a *shallow foundation* is to be placed on *soil* or *rock*, the *soil* or *rock* shall be cleaned of loose and unsound material and shall be adequate to support the design load taking into account temperature, precipitation, construction activities and other factors that may lead to changes in the properties of *soil* or *rock*.

#### 4.2.6.3. Incorrect Placement of Shallow Foundations

**1)** Where a *shallow foundation unit* has not been placed or located as indicated on the drawings,

a) the error shall be corrected, or

b) the design of the *foundation unit* shall be recalculated for the altered conditions by the *designer* and action taken as required in Article 2.2.4.7. of Division C.

#### 4.2.6.4. Damaged Shallow Foundations

**1)** If a *shallow foundation unit* is damaged,

a) it shall be repaired, or

b) the design of the *foundation unit* shall be recalculated for the damaged condition by the *designer* and action taken as required in Article 2.2.4.7. of Division C.

# 4.2.7. Deep Foundations

## 4.2.7.1. General

**1)** A *deep foundation* shall provide support for a *building* by transferring loads by end-bearing to a competent stratum at considerable depth below the structure, or by mobilizing resistance by adhesion or friction, or both, in the *soil* or *rock* in which it is placed. (See Note A-4.2.7.1.(1).)

## 4.2.7.2. Design of Deep Foundations

**1)** *Deep foundations* shall be designed in conformance with Subsection 4.2.4. and this Subsection. (See Note A-4.2.7.2.(1).)

**2)** Where *deep foundation units* are load tested, as required in Clause 4.2.4.1.(1)(c), the determination of the number and type of load test and the interpretation of the results shall be carried out by a professional engineer especially qualified in this field of work. (See Note A-4.2.7.2.(2).)

**3)** The design of *deep foundations* shall be determined on the basis of geotechnical considerations taking into account

a) the method of installation,

b) the degree of inspection,

c) the spacing of *foundation units* and group effects,

d) other requirements in this Subsection, and

e) the appropriate structural requirements in Section 4.1. and Subsections 4.3.1., 4.3.3. and 4.3.4.

**4)** The portion of a *deep foundation unit* permanently in contact with *soil* or *rock* shall be structurally designed as a laterally supported compression member.

**5)** The portion of a *deep foundation unit* that is not permanently in contact with *soil* or *rock* shall be structurally designed as a laterally unsupported compression member.

**6)** The structural design of prefabricated *deep foundation units* shall allow for all stresses resulting from driving, handling and testing.

## 4.2.7.3. Tolerance in Alignment and Location

**1)** Permissible deviations from the design alignment and the location of the top of *deep foundation units* shall be determined by design analysis and shall be indicated on the drawings.

## 4.2.7.4. Incorrect Alignment and Location

**1)** Where a *deep foundation unit* has not been placed within the permissible deviations referred to in Article 4.2.7.3., the condition of the *foundation* shall be assessed by the *designer*, any necessary changes made and action taken as required in Article 2.2.4.7. of Division C.

## 4.2.7.5. Installation of Deep Foundations

**1)** *Deep foundation units* shall be installed in such a manner as not to impair

a) the strength of the *deep foundation units* and the properties of the *soil* or *rock* on or in which they are placed beyond the calculated or anticipated limits,

b) the integrity of previously installed *deep foundation units*, or

c) the integrity of neighbouring *buildings*.

## 4.2.7.6. Damaged Deep Foundation Units

**1)** Where inspection shows that a *deep foundation unit* is damaged or not consistent with design or good engineering practice,

a) such a unit shall be reassessed by the *designer*,

b) any necessary changes shall be made, and

c) action shall be taken as required in Article 2.2.4.7. of Division C.

## 4.2.8. Special Foundations

### 4.2.8.1. General

**1)** Where special *foundation* systems are used, such systems shall conform to Subsection 4.2.4., Sentence 4.1.1.5.(2) and Article 1.2.1.1. of Division A.

### 4.2.8.2. Use of Existing Foundations

**1)** Existing *foundations* may be used to support new or altered *buildings* provided they comply with all pertinent requirements of this Section.