B3 THE NATIONAL BUILDING CODE OF FINLAND

Foundations
Regulations and Guidelines 2004

Decree of Ministry of the Environment on foundations

Issued in Helsinki, on 25 September 2003

In accordance with the Decision of the Ministry of the Environment, the following regulations and guidelines on foundations in building works are enacted by virtue of section 13 of the Land Use and Building Act (132/1999) of 5 February 1999.

In addition to these guidelines, also the decision of the Ministry of the Environment dated 9 May 1996, on alternative method used in geotechnical engineering, Eurocode 7 part 1 together with the national application document, shall be valid.

The regulations and guidelines have been notified in accordance with Directive 98/34/EC of the European Parliament and of the Council, as amended by Directive 98/48/EC, laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services.

This Decree enters into force on 1 March 2004 and it repeals the Decision of the Ministry of the Interior issued on 20 November 1975 on foundations (B3). Previous regulations may be applied to permit applications initiated before the Decree entered into force.

Helsinki, on 25 September 2003

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B3 The National Building Code of Finland
Ministry of the Environment, Housing and Building Department
Foundations
Regulations and Guidelines 2004

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Annex 1 Information for guidance

KEY TO SYMBOLS

Regulations printed in the wide column using this large font size are mandatory.

Guidelines in the narrow column with small font size provide acceptable solutions in conformity with the regulations.

***Explanations** in italics in the narrow column provide further information and contain references to provisions, regulations and guidelines.*

DEFINITIONS

Geotechnical engineering deals with the technical properties of soil and bedrock and their application to earthworks and foundation engineering, as well as design methods for dimensioning of structures and foundations.

Geotechnical soil layer refers to a layer defined by its thickness and area, in which the geotechnical design value required by the design situation under consideration can be presented as a numerical value representing the whole layer.

Geotechnical design refers to adapting the technical properties of soil and bedrock and foundations or other load-bearing structures and structures subjected to earth pressure based on the utilization of geotechnical design values, in order to determine the dimensions of the foundations in such way that deformations of the structures remain within the limits they tolerate, and stability against breaking of the ground is sufficient.

Geotechnical design value refers to a certain technical property of a geotechnical soil layer or rock used in the design work, expressed in numerical values. In the total safety factor method a design value is a characteristic value and in the partial safety factor method the design value is a characteristic value divided by the partial safety factor.

Design value of load refers to a load, on the basis of which the force quantities in the design situation under consideration are calculated. In the total safety factor method a design value is a characteristic value and in the partial safety factor method a design load is obtained by multiplying the characteristic value of load by the relevant partial safety factor.

Earth structures refer to compacted soil or soil structure layers, replaced and compacted soil structure layers (replacement of quantities) or reinforced soil or soil structure layers (subgrade reinforcement).

Subgrade reinforcement refers to various methods working on different principles used with the aim of improving the geotechnical properties of soil, e.g. by increasing strength and reducing compressibility and reducing or increasing permeability to water. In geotechnical design, a reinforced subgrade is treated as soil. By mixing of different binding agents into the soil no foundations (such as piles) are generated, only reinforced soil.

Foundation construction plan contains a building specification and/or quality requirements and related soil exploration and foundation construction drawings, as well as geotechnical and structural design calculations.

Foundation design refers to dimensioned coordination of the behaviour of soil and rock with foundations in such a way that also superstructures function as planned and no damage is caused to a building or a structure or a building or a structure does not become unserviceable due to e.g. ground frost, moisture or harmful substances.

Foundation construction work refers to excavation, rock excavation, supporting, drainage, compaction and reinforcement work necessary to construct fit-for-purpose and safe foundations for buildings and structures and underground spaces, as well as other construction work and construction of permanent foundations.

Foundations refer to either permanent, such as foundations of buildings and structures, wall and floor structures resting against the ground, drainage structures, as well as frost protection structures and other protective structures, or temporary, such as retaining structures of excavations, groundwater lowering structures and temporary protective structures.

Inspection document refers to a protocol kept at the site, in which surveys, inspections executed by authorities, and inspections which are the engineers’ or other work supervisors’ responsibility, are recorded. As-built drawings, performance protocols and inspection reports shall all be collected into the inspection document in the extent required by the building owner and the building inspection authorities (the National Building Code of Finland, part A1).

As-built drawing refers to a soil exploration drawing, in which the soil layers detected during the construction time are presented, or a foundation construction drawing, in which the constructed foundations with location and dimension variances are presented.

Working and quality plan is a plan, in the working plan section of which the builder presents the construction of the foundations in detail and, in the quality plan section, the control reports and performance protocols to be prepared and the measurements to be made, including measuring methods, measuring accuracy and the quantities of measurements, to verify quality.

Requirement classification is in part B3 of the National Building Code of Finland, presented in such a way that a design work concerning foundation construction on which special requirements are imposed, corresponds to category AA as stated in part A2 of the National Building Code of Finland, a design work concerning foundation construction on which basic requirements are imposed to category A, and a design work concerning foundation construction in which standard requirements are imposed to category B.

Responsible foundation engineer refers to an engineer who prepares a foundation construction plan, In general, the tasks concerning the preparation of a foundation construction plan are divided between a geotechnical engineer and an engineer familiarized with load-bearing structures, in order to ensure sufficient know-how of both geotechnical and foundation engineering. One of them is appointed the responsible foundation engineer, depending on his or her competence and the requirements imposed on the work.

1. GENERAL

1.1 Scope of application

1.1.1
These regulations and guidelines concern a construction work subject to permission and which, possibly, otherwise requires an official approval as well as preparatory actions prior to construction.

These regulations shall be observed in the design and construction of foundations for buildings, structures and spaces, as well as earth structures connected with them and in the supervision of the construction work.

1.1.2
In the design and construction of load-bearing foundations, the same principles shall be followed as in the design and construction of other load-bearing structures, however taking into account the interaction between the soil and the structure.

Foundations shall be designed and constructed in such a way that a long-term durability and health corresponding to the service life of the foundations are secured and damage caused by moisture is prevented.

Guideline
In the structural design and construction of foundations, the regulations and guidelines laid down in sections B of the National Building Code of Finland on the materials used in load-bearing structures shall be observed.

Explanation
In the design and construction of foundations shall, in addition to the Land Use and Building Act, also other legislation be taken into account. Most important of such provisions are, among other things, those concerning extraction of soils, air raid shelters, environmental protection and safety at work.

Local building ordinances may contain rules, e.g. on the lowest building heights and areas containing risk of flood, collapse or landslide, on important groundwater areas and contaminated soils, radon risk areas and areas subjected to traffic vibration.

The following list contains some of the most important aspects of foundation engineering contained in the Land Use and Building Act (MRL) and Decree (MRA):
- *objectives of building guidance [MRL 12 §]*
- *the National Building Code of Finland [MRL 13 §]*
- *building ordinance [MRL 14§]*
- *building design (investigations related to foundations) [MRA, Section 49, paragraph 2]*
- *requirements concerning construction site (risk of flood, collapse and landslide) [MRL, Section 116, paragraph 2]*
- *essential technical requirements of buildings [MRA, Section 50)*
- *requirements concerning construction work (repair works and alterations) {MRL, Section 117, paragraph 4]*
- *avoiding harmful effects in building [MRA, Section 83, paragraph 1]*
- *ecological consideration in building [MRA, Section 55]*
- *duty to take care in building activities MRL, Section 119]*
- *start-up meeting [MRL, Section 121]*
- *inspection by authorities [MRL, Section 150]*

- *expert inspection [MRL, Section 151]*
- *construction inspection document [MRA, Section 77]*

1.2 Recognition of mutual acceptance

1.2.1
When these guidelines or explanations contain references to applicable Finnish SFS standards, instead of them an EN or other standard in force in an other European Economic Area member state, meeting the corresponding safety requirements, can be used in accordance with the recognition of mutual acceptance principle.

The construction materials and products, as well as the working methods employed in foundation engineering, shall be suitable for Finland's geological and climatic conditions.

2. SURVEYS OF BUILDING GROUND AND SURROUNDINGS

2.1 SOIL EXPLORATION

2.1.1
The soil conditions at the construction site shall be analysed in advance in connection with each building project. In general, and always in the case of category AA foundation construction objects, this shall be done by means of a soil exploration conducted at the construction site in connection with the building project.

The contours of surface, the layer structure of subgrade, the location of rock surface, the properties of soil layers and rock, and groundwater relations concerning the construction object and its affected zone, shall be determined by means of a soil exploration in such a way that sufficient data is obtained to make it possible to design the foundations and to construct them technically in an appropriate and safe way. In addition, a soil exploration shall include an investigation of the location, quality and condition of the foundations of buildings and structures, as well as the substructures located at the construction site and in its vicinity in an extent deemed necessary.

Guideline
If results of soil explorations conducted in connection with land use planning or on other occasion, or other information, the scope and quality of which is sufficient, are available at the construction site so that on the basis of such data the design and construction of foundations can be reliably and safely executed, a soil exploration is not necessary in connection with the building project in the case of category B and A foundation construction objects.

In the case of category B foundation construction objects, a terrain survey performed in advance by an expert may be sufficient. The conclusions concerning the soil conditions at the construction site drawn on the basis of such survey shall always be presented in written form and attached to the other design documents of the building project.

2.1.2
The responsible foundation engineer of the building project is responsible for the programming of the soil explorations, which include selection of the exploration methods to be employed and determination of the number and location of the exploration points. The foundation construction engineer shall follow the progress of soil explorations and their results and, if necessary, complement the exploration program.

Guideline
The quality and scope of a soil exploration are determined on the basis of the grade of soil, loads and the existing buildings and structures at the construction site, as well as the surroundings of the construction site and its anticipated development.

Explanation
The Requirement categories AA, A and B concerning a foundation design work and related engineer's qualifications are presented in part A2 of the National Building Code of Finland.

2.2 Groundwater

2.2.1
The average level and the variation limits of groundwater shall be determined by means of groundwater observations made in connection with the soil exploration, unless the responsible foundation engineer finds such investigation unnecessary because of the nature of the construction object and the soil conditions at the construction site.

The extent of the groundwater basin and the rate of replacement of groundwater shall be investigated, if variations in the groundwater level may be harmful to buildings or structures located at the construction site or in its surroundings or to nature.

Guideline
It is particularly important to determine the variations in the groundwater level, when designing spaces, which may extend below the highest groundwater level.

The assessment of long-term variation limits of the groundwater level shall be based on data obtained from long-term observations of the groundwater level made in corresponding conditions, from natural variations in the groundwater level and the altitudes of the water systems.

Groundwater observations shall be made sufficiently so that the variation limits of the groundwater level and, if necessary, the perched water table can reliably be assessed. In the case of soil layers poorly permeable to water, changes in the pore pressure in the fine-grained stratum shall be taken into account, if necessary. If necessary, groundwater observations shall be carried on during the construction time and also afterwards, especially if the building pit extends below the groundwater or perched water table.

2.3 Soil exploration documents

2.3.1
The results of soil explorations shall be presented in soil exploration documents, which include drawings of the explorations and description of the soil conditions and other material to be attached to the report. These shall also include data on the groundwater conditions, the buildings and structures at the construction site and, to the necessary extent, data on the buildings and structures in its surroundings as well as other necessary information and annexes.

The results of the soil explorations shall be presented in a manner commonly used, sufficiently accurately, in such a way that the reliability and comprehensiveness of the explorations and the generalizations of the relevant soil conditions can be unambiguously evaluated and understood. The drawings of the explorations shall clearly show the soil conditions at the construction site and other terrain and environmental factors, which have an impact on the construction of the foundations.

Guideline
In the description of the subgrade at the construction site the geotechnical soil classification is used and, in the description of rock, the geological rock classification, where rock is described on the basis of rock type and cleavage, is used. In the soil and rock descriptions also international classifications, e.g. EN standards, approved for use in Finland, can be used.

2.3.2
The responsible foundation engineer shall take care of the results of the soil explorations as well the interpretations presented in the soil exploration documents.

2.4 Humidity of soil

2.4.1
The capillarity and other properties in respect of moisture of the soil materials in contact with structures resting against the ground shall be investigated in such a way that harmful effects of moisture transferred from the ground into the structures can be prevented.

The capillarity of material used in the drainage layers to be built underneath a floor resting against the ground, and outside walls resting against the ground, shall be sufficiently low so that the drainage layer reliably cuts off harmful horizontal and vertical capillary transfer of water into the structures.

Guideline
In soil layers above capillary rise, the water content of which is very low, there are generally always moisture. For this reason the relative humidity of air in the interstitial space is always very high, almost 100%.

2.5 Groundfrost

2.5.1
By means of observations and investigations made in connection with a soil exploration, such initial data on freezing of the building ground shall be obtained, on the basis of which preventive measures to protect against possible damage caused by freezing can be planned and implemented.

Guideline
Freezing of soils can be approximately assessed by means of a grading curve. Freezing of a soil layer can most reliably be evaluated by means of capillarity and frost boil tests in the laboratory and field observations of the frost heave.

The depth of frost can be assessed on the basis of reliable observations made in similar conditions and, numerically, based on climatic and soil conditions influencing the depth of frost.

In the case of permanent warm buildings and cold structures highly vulnerable to damage, it is to be recommended that the maximum cold content repeated once every 50 years should be used as the design criteria for assessing the depth of frost. Correspondingly, the maximum cold content repeated once every 20 years can be used in the design of yard structures and cold timber structures or other light structures, which are not especially sensitive to movements caused by frost.

Correspondingly, in the design of temporary frost protection, the maximum cold content repeated once every two years can be used. However, in winters colder than the average, preparations to reinforce temporary frost protection should be made.

2.6 Risk of flood and collapse

2.6.1
When constructing in areas where there is a risk of flood, the potential damage caused by water and ice shall be prevented in advance by correct selection of the construction site and/or structurally. When designing drainage of the building ground, the requirements in section 4.6 shall be taken into consideration.

Guideline
The lowest acceptable building height in respect of floods refers to the highest level to which water at the construction site can rise without causing damage to residential buildings or buildings intended for working. Such buildings shall be, as far as possible, located at the highest spots in the terrain and/or protected from floodwater and breaking-up of ice by means of flood dams or levees.

The risk of flood shall be taken into account in the geophysical design of the structures. Base floors shall be designed and constructed at so high a level that the water level at the construction site can rise no higher than to the bottom surface of the cut-off layer of capillary rise built under the base floor, unless the base floor is provided with tanking. Below the lowest building height such building elements can be installed, through which moisture cannot penetrate into the building in harmful quantities.

A building, which is not used for living or as a working place, can be designed to be built below the lowest acceptable building height, provided that the risks are low.

2.6.2
In areas where there is a risk of collapse or landslide, construction of residential buildings or buildings intended for working or construction of sophisticated structures is not allowed, unless the risks are eliminated by well-planned structural solutions.

Guideline
In accordance with section 4.1, the total safety requirement against areal collapse shall be at least 1.8. The safety requirement for organic soil layers against collapse shall be, in general, higher than 1.8 in order to restrict displacements in the building area and its surroundings. In yard, park and recreational areas, where there are only minor buildings or structures, which are not used for living or working, a lower safety level of 1.5 can be used.

Explanation
The selection of building height has been dealt with in part C2 of the National Building Code of Finland and in the related guide ”Kosteus rakentamisessa” (Moisture in Construction), Guide for part C2 of the National Building Code of Finland, Environmental Guide 51 Construction series, Oy Edita Ab, 1999; as well as in guides ”Ylimmät vedenkorkeudet ja sortumariskit ranta-alueille rakennettaessa” (Highest Water Levels and Risks of Landslide

when Building on Shores), Environmental Guide 52 Construction series, issued by Finnish Environmental Institute, Ministry of the Environment and Ministry of Agriculture and Forestry, Oy Edita Ab, 1999.

2.7 Contaminated soil

2.7.1
The degree of contamination of the soil at the construction site shall be determined. The concentrations of harmful substances transferred from the soil into a building shall not exceed the values defined on the basis of the intended use of the building. Precautions should be taken to prepare for the appearance of substances hazardous to health or to the surroundings during the construction time.

Guideline
At foundation construction sites where there is no reason to suspect soil contamination, field investigations are not necessarily required. Conclusions drawn on the basis of an advance survey, indicating that the soil is not contaminated shall, however, be presented in written form and attached to the design documents of the building project.

Investigation of contaminated soils requires knowledge of the previous activities carried on at the construction site and an assessment of the sufficiency of the investigations of the contamination degree at the site conducted earlier, e.g. at the zoning stage. On the basis of such advance investigation, the possible further need for field and laboratory investigations shall be assessed.

On the basis of the investigations, risks are assessed. In the risk assessment, the concentrations of harmful substances shall be compared with guideline values and, in the case of demanding objects, a specific risk assessment is carried out taking into account the migration routes of and the health risks caused by the substances, among other things.

If the risk assessment reveals that the environmental and health risks are so high that risk management actions are necessary, planning of remediation measures shall be commenced to permanently eliminate contamination of the soil and to significantly reduce the risks. Planning of the remediation measures is preferably carried out together with the rest of the foundation construction design.

Explanation
Matters concerning contaminated soil fall within the jurisdiction of environmental authorities. Provisions for decontamination of soil are laid down in Section 78 of the Environmental Protection Act (86/2000), which shall be followed, as well as the Environmental Protection Act at large, concerning contaminated soil.

2.8 Radon

2.8.1
In the design and construction work, radon risks at the construction site shall be taken into account.

Guideline
The limit value of 200 Bq/m^3, which is the design guideline value, is generally exceeded in the most part of Finland, if no countermeasures are taken. A radon-technical design may be left out only in case the local radon surveys clearly show that the radon concentration inside residential buildings is consistently below the permitted maximum value. If radon is not taken into account in the design, written grounds for that shall be attached to the design documents of the building project.

The original soil and soil brought elsewhere to the site for land filling, as well as drainage gravel, always have an impact on the risk of radon in the building ground. A filled thick gravel layer may indoors alone produce radon concentrations exceeding the limit value.

The radon concentration inside a building can be significantly influenced by the selection of base floor structures and foundation method.

Explanation
According to the Radiation Act and Decree and its amendment 1143/1998, the radiation concentration in regular work shall not exceed 400 Bq/m^3. According to a proposal presented in part D2 of the National Building Code of Finland, an annual average value of radon concentration of 200 Bq/m^3 should be used as the design guideline value.

The Finnish Radiation Safety Authority has issued a radiation safety guide ST 12. ”Säteilyturvallisuus luonnonsäteilylle altistavassa toiminnassa, 2000” (Radiation Safety in Practices Causing Exposure to Natural Radiation), and a guide 12.2 ”Rakennusmateriaalien, polttoturpeen ja turvetuhkan radioaktiivisuus” (Radioactivity of Construction Materials, Fuel Peat and Peat Ash) on radioactivity of materials used in housebuilding.

2.9 Quality test of foundations

2.9.1
The condition of foundations and other groundwork shall be investigated before any change in the load conditions occurs, modifications or reinforcements are made at the site or its immediate surroundings, and when maintenance of the foundations of buildings have been neglected.

2.9.2
In the case of category A and category AA projects, a sufficiently comprehensive quality test shall be conducted with the purpose of determining the function of the load-bearing structures and the durability of the foundations during their design life. Temporary load conditions during modifications shall be taken into account.

As part of the quality test, the stability of the foundations and structures resting against the ground against moisture and temperature shall be investigated and, if necessary, radon risks, contaminated soil layers at the construction site, and other materials hazardous to health and to the environment used in the construction work, as well as the vibration level caused by the activities carried on in the surroundings. Reasons for possible damage to foundations shall always be specified.

Guideline
A description of e.g. the function principles of the structures, the building risks known at the quality test stage, e.g. groundwater management, materials hazardous to health, radon, reasons for possible damages or imperfect condition and predicted service life of damaged structures, shall be included in a written quality test report.

2.9.3
The responsible foundation engineer is responsible for programming and supervision of the quality test of foundations and other groundwork.

2.10 Surveys of structures and surroundings

2.10.1
Before the construction work is started, it shall be verified that construction work does not cause harmful changes in the natural conditions of the surroundings, in the subgrade or bedrock, in groundwater or in the buildings and structures located in the construction area or in the surroundings. If harmful changes are to be expected, the impacts of the changes shall be analysed and, prior to the construction work, sufficiently extensive and detailed surveys shall be conducted. In order to provide for the occurrence of harmful effects, a monitoring program shall be prepared and, if necessary, a monitoring measuring system shall be set up.

Guideline
The quantity and accuracy of the measurements shall be such that harmful effects can be detected sufficiently early. Monitoring measurements shall be made sufficiently also below the ground surface. The more difficult the soil conditions are and the deeper the foundations extend, the wider the survey and monitoring area should be.

2.11 Traffic vibration

2.11.1
Before the construction work is started, vibration caused by traffic shall be analysed, if necessary. It must not cause damage to the building nor excessive disturbance to the people inside the building.

Guideline
The magnitude of traffic vibration can be assessed on the basis of measurements made earlier in the similar conditions. When a traffic lane causing vibration already exists in the vicinity of the construction site, vibration measurements can be performed at the construction site. When vibration is measured only from the ground, the amplification of vibration in a building shall be assessed separately.

3. MATERIALS USED IN FOUNDATIONS AND EARTH STRUCTURES

3.1 Soil materials

3.1.1
The technical properties of soils used in earth structures of a housebuilding object shall be technically suitable to the application site. Soils to be brought to the construction site shall not contain harmful quantities of impurities. The radon concentration of the soil materials shall be taken into account in the design work.

Guideline
In natural soil layers, local variations always occur. For this reason, the fulfilment of the granulation requirements imposed on soil materials shall be followed by means of grain size analyses during the construction work.

3.2 Crushed aggregates

3.2.1
The technical properties of the crushed aggregates used in earth structures of a housebuilding object shall be technically suitable to the application site and be sufficiently homogenous. The radon concentration of the crushed aggregates shall be taken into account in the design work.

Guideline
The fulfilment of the granulation and quality requirements imposed on crushed aggregates shall be followed by means of analyses during the construction work. The required analysis frequency depends on the requirement classification and width of the object where the material is used. Special attention shall be paid to the prevention of sorting of crushed aggregates during transport and handling operations.

3.3 Recycled materials

3.3.1
The technical properties of the recycled materials used in earth structures of a housebuilding object shall be technically and construction-wise suitable to the application site and be sufficiently homogenous. When recycled materials are used in loaded earth structures, their long-term stability shall be tested using the combination of the stress volume and stress level to which an earth structure can be subjected during its service life.

3.3.2
The use of recycled materials shall not cause harm or danger to the persons living, working or staying in a building and the use of such materials shall be not cause risk of pollution of groundwater or risk of contamination of the subgrade or damage, such as corrosion in structures in contact with such materials, at the construction site or its surroundings.

Explanation
Environmental permits for recycled materials are dealt with in the Environmental Protection Act (86/2000) and Decree (169/2000) .

3.4 Concrete materials

3.4.1
In respect of concrete foundations and other concrete groundwork, the requirements imposed on load-bearing concrete structures shall be met.

Guideline
In the case of driven concrete piles or otherwise very demanding (AA) foundations and groundwork, the Structural Category 1 is used.

3.5 Grouting mortars

3.5.1
Grouting mortar shall be treated as a load-bearing structure, if a gap between a foundation and earth or rock is filled with grouting mortars with the purpose of fixing anchor steels or tension piles to rock or ground.

Guideline
If the grouting mortar is only intended to increase the skin resistance of a tension or compression pile, the mortar does not need to be treated as a load-bearing structure.

3.5.2
If the fabrication of a grouting mortar does not fall into the supervision of an inspection body approved by the Ministry of the Environment, test samples shall be prepared of the mortar for testing at the construction site.

Guideline
For verifying acceptability, the guidelines laid down in part B4 ”Concrete structures”, item 6.3.8, of the National Building Code of Finland on concrete, shall be followed.

Attention shall be paid to the frost resistance of the grouting mortar.

Acceptability of a grouting mortar used as a load-bearing structure shall be verified by means of a certified product declaration, which can be checked on-site.

3.6 Steel structures

3.6.1
In respect of steel structures, stainless steel structures or composite foundations or other groundwork, the requirements imposed on load-bearing structures concerning such materials shall be met.

3.7 Timber foundations

3.7.1
In respect of timber foundations, the requirements imposed on load-bearing timber structures shall be met.

Guideline
Timber foundations shall be designed in accordance with part B10 ”Timber structures” of the National Building Code of Finland, in the Humidity Category 4.

Unimpregnated timber can be used as a structural element only, if it is ensured that these structural elements stay at least 0.5 m below the during-use groundwater or water level of the lowest structure. Pressure impregnated timber can, on justified grounds, used on spots susceptible to rot at construction sites, where underwater currents do not occur.

3.8 Geosynthetic materials

3.8.1
The stability of the mechanical and hydraulic properties of geosynthetic materials in long-term use and their durability in the actual service conditions against the relevant chemical, biological and thermal strains, as well as ultraviolet light, shall be ensured in advance.

Guideline
Geosynthetic materials are most commonly used as separators between two soil or soil structure layers. In this case, the utilization classification according to VTT/GEO can be applied to the assessment of the acceptability for fibre cloths. As to other applications, in the assessment of the acceptability of synthetic materials special attention shall be paid to ensure that the test methods employed correspond to the function of the synthetic material and the load and environmental conditions to be expected to occur at the construction site.

3.9 Frost protection materials

3.9.1
The materials used for preventing damage by groundfrost shall maintain their thermal insulation capacity in the moisture conditions prevailing at the installation site at the level corresponding to the design values used in the design of the frost protection measures during the whole design life of the frost protection.

Also the mechanical, chemical, thermal and biological stability of the frost protection materials shall be sufficient so as not to loose their functioning capacity due to strains present at their installation site.

3.10 Grouts and stabilizers

3.10.1
The mechanical properties of soil layers in a natural state and materials used in earthworks or rock can be improved and their water permeability reduced by grouting and stabilising. The quality and the required duration of action, as well as the permanence of action of a grout or a stabilizer suitable for achieving the desired effect, shall be ensured by means of sufficient advance tests conducted by an independent research institute, unless the user has earlier experiences in the use of the agent in the corresponding conditions.

3.10.2
The grouts and stabilizers to be used shall not, as such or with each other or when reacting with materials or substances in the soil, cause pollution of groundwater or contamination of soil at the construction site or in its surroundings. The chemical composition and non-toxicity of grouts and stabilizers and their components shall be ensured before they are taken into use. Data on the origin of all grouts and stabilizers shall be verified and stored.

Guideline
The tests for verifying the technical usability and environmental safety of grouts and stabilizers shall be commenced sufficiently early so that, among other things, a reliable picture of the effectiveness and the speed of action attainable with the agent is obtained. In connection with these preliminary tests, the limits of the application range of the agent and its handling technique shall always be tested in the case the soil conditions at the construction site deviate from the conditions assumed during the tests.

4. FOUNDATION DESIGN

4.1 General requirements

4.1.1
Foundation design includes, in general, geotechnical design and structural design of foundations. These plans shall contain a description how the designed buildings and structures fulfil the provisions laid down in the Land Use and Building Act and those laid down by virtue of the Act. By means of geotechnical design, together with other design work, the geotechnical functioning and dimensioning of the structures and, in sufficient detail, the procedures by means of which the planned result can be achieved, shall be determined.

4.1.2
Foundations shall be designed taking into account the climate, soil, ground, surface and open waters, foundations of nearby buildings and structures, as well as other ground constructions. In addition, attempts shall be made to forecast future development, excavations and land filling, as well as possible variations in the groundwater level so that their impacts can be taken into account and the future development is not unnecessarily hindered.

When it is necessary to extend a new building, space or structure deeper than a building or a structure in the vicinity, the buildings or structures in the vicinity shall be reinforced or protected in order to prevent damage, or such foundation construction methods should be used that damaging of the buildings or structures is avoided.

4.1.3
Foundations and earth structures shall be designed, dimensioned and constructed in such a way that settling, displacements, rotations and deformations of structures, taking also into account sinking of groundwater and fillings, remain so small that they do not hinder the use of the structure and the structures do not crack or deform permanently, and the stability of the subgrade and the structures against breaking is sufficient, both during the construction time and the use of the structure. The design work shall be done in such a way that the stresses in the structures and in a sufficiently large part of the subgrade supporting the structure remain below yield limit stresses.

Guideline
The geotechnical and structural dimension calculations shall be made using methods commonly accepted in Finland.

4.1.4
In the computational dimensioning of the bearing capacity of permanent foundations, the total safety factor shall be at least 2.0, and in the computational dimensioning of the bearing capacity of piles, the total safety factor shall be at least 2.2. If pit, retaining structures or foundations support permanent foundations or their yield can cause damage to permanent foundations or foundations, which are intended as permanent structures, their total safety factor shall in the computational dimensioning be at least 1.8. When foundations are dimensioned experimentally by means of a reliable test method, the total safety factor shall be at least 1.6. The required total safety factor indicates the required safety level, which shall be achieved also when dimensioning using the partial safety factor method. When dimensioning for a water buoyancy, the total safety factor shall be at least 1.2. The geotechnical safety requirements for category A foundations in the most common ground and load conditions are listed in Table 4.1.

Table 4.1. Minimum values of total safety factors in the geotechnical design of category A foundations.

Object	Safety factor
Areal collapse of building ground	1.8
Areal collapse of building ground in yard, park and recreational areas, where there are no residential buildings or buildings intended for working or structures of a lower requirement class	1.5
Bearing capacity of a ground-supported foundation	2.0
Bearing capacity of a pile	2.2
Bearing capacity of a ground-supported foundation or a pile verified by means of reliable test methods on the basis of experimental dimensioning	1.6
Collapse of a permanent structure supporting the ground or foundations	1.8
Landslide and base rise of a temporary excavation and collapse of a retaining structure, when there are structures other than temporary structures in the affected zone of a possible collapse	1.8
Landslide and base rise of a temporary excavation and collapse of a retaining structure	1.5
Water buoyancy	1.2

When dimensioning very demanding (AA) foundations, where collapse or landslide may cause personal injuries or great financial losses, or if the base and load conditions are exceptionally difficult, the need to use values higher than the minimum values of the total safety factors presented in Table 4.1 should be considered.

Guideline
In construction stages of short duration and for foundations and earth structures of a lower requirement class, a slight exceeding of the yield limit stresses can be allowed. In that case, the total safety factor should be at least 1.5. In the case of yard area structures, unimportant amounts of settling after the construction time may be allowed.

Explanation
The use of the partial safety factor system has been dealt with e.g. in the ”Foundation Guidelines” of Finnish Association of Civil Engineers (RIL), in the preliminary standards SFS-ENV 1997-1: 1994 and in the standard EN 1997-1, which will repeal the preliminary standard, being drafted.

4.1.5
The foundations shall be designed in such a way that deformation occurring as a result of settling differences does not cause harmful stresses in the structures. The total settling and inclination of buildings and structures shall be limited as moderate because of the connected structures, pipelines, working and living convenience, health and appearance.

Guideline
The limit values of total settling and the limit values of the angular rotations caused by uneven settling of adjoining foundations, or deflection of a mat foundation, for different structure types are presented in Table 4.2. The values presented in the table are determined on the basis of requirements set as the condition for the serviceability of the load-bearing superstructures of conventional buildings and, for this reason, they do not concern structures on which special requirements are imposed.

Guideline

Table 4.2. Indicative limit values of total settling of buildings and angular rotations of load-bearing structures.

Type of structure	Limit values of total settling (mm)	Tolerances of limit values of angular rotations	
		Moraine or coarse-grained subgrade	Fine-grained subgrade
Massive rigid structures	100	1/250 – 1/200	1/250 – 1/200
Statically determined structures	100	1/400 – 1/300	1/300 – 1/200
Statically undetermined structures			
– Timber structures	100	1/400 – 1/300	1/300 – 1/200
– Steel structures	80	1/500 – 1/200	1/500 – 1/200
– Masonry	40	1/1000 – 1/600	1/800 – 1/400
– Pre-cast concrete structures	60	1/1000 – 1/500	1/700 – 1/350
– Pre-cast reinforced concrete structures	40	1/1200 – 1/700	1/1000 – 1/500
– Reinforced concrete frame structures	30	1/2000 – 1/1000	1/1500 – 1/700

Guideline

When the values of angular rotations are compared with the values presented in Table 4.2, the settling differences occurring before a superstructure is subjected to additional stresses due to settling differences can be ignored in the analysis. When the limit values presented in the table are used, small aesthetical harmful effects may sometimes occur, especially in non-bearing structures connected with load-bearing structures. Possible cracking and opening of joints caused by settling differences shall not reduce the structural strength, living comfort or health of the apartment. Instead of the total settling of short-term and temporary structures, the settling during service life can be studied.

When designing very demanding (AA) structures, the additional strains caused by settling differences shall be taken into account in the dimensioning of a superstructure.

4.1.6

Foundations and other groundwork shall be designed and constructed in such a way that the strength and correct functioning are ensured during their whole designed service life. The service life of foundations and groundwork shall be verified using solutions and materials functioning of which as foundations and other groundwork is known from sufficiently long period of time. Otherwise, the solutions and materials shall be tested by an independent research institute using the combination of the stress volume and stress level, which a foundation or other corresponding structure may be subjected to during its service life.

4.2 Building ground

4.2.1 Subgrade

4.2.1.1

Natural subgrade, made-up ground, replaced subgrade (replacement of quantities) and reinforced subgrade (subgrade reinforcement) are regarded as subgrade. When building on a subgrade, the geotechnical soil layers and their geotechnical design values shall be determined by means of general soil exploration methods or an analysis method suitable for the foundation or subgrade reinforcement method in question before the design and construction work is started.

Guideline
The bearing capacity of moraine layers and coarse-grained soil layers is, in general, very high so that in that case the design and construction of ground-supported foundations on them is possible, if they are not subject to abnormal loads. Coarse-grained soil layers can be lateral depositions on top of fine-grained soil layers, in which case building of ground-supported foundations on them is risky.

Fine-grained soil layers will settle by the action of a long-term load, in which case in such areas buildings and structures shall, in general, be set up by means of piles.

Also the soil material of organic soils compresses and creeps under load, which results in continuous, though decelerating settling. For this reason, founding on organic soil layers is not appropriate.

4.2.1.2
When building on unplanned land filling areas, the decree of contamination or the need of remediation of such areas and the foundation construction methods suitable for such areas, shall be carefully examined and determined by means of investigations and foundation designs.

Uncompacted filling and replacements of quantities shall not, in general, be used as a subgrade supporting buildings or structures.

Guideline
Previous, unplanned layers of made-up ground are usually extremely non-homogenous. They may contain rocks, boulders, construction waste and other debris, as well as often also contaminated soils and even problem waste.

Designed land filling shall be consolidated layer by layer in conformity with the requirements for foundations and earth structures to be constructed as dry work. Filling under the water level for construction purposes must be done only by removing soft soil layers and filling with a coarse material consolidated by deep consolidation.

Replacements of quantities shall also be performed by layered consolidation in a ditch kept dry.

4.2.1.3
Reinforced soil shall be treated as subgrade, which shall be surveyed and designed by geotechnical methods.

4.2.2 Bedrock

4.2.2.1
The quality of bedrock shall be determined on the basis of rock type and cleavage.

If there are gouges in the rock or if the cleavage of the rock is disadvantageous to the functioning of the foundations, their impacts shall be analysed and, if necessary, reinforcement of the rock designed. A completely weathered gouge or rock may have expansion properties, the impact of which on foundations and other groundwork shall be investigated.

Guideline
If the inclination of the rock at the foundation level exceeds 15^o, the foundation level shall be levelled or stepped by blasting. However, if the shape of the rock surface underneath the foundation prevents sliding, levelling is not necessary. Sliding can also be prevented by fixing the foundation or other groundwork to the rock by means of anchor bolts.

The strength of the Finnish bedrock is normally, even in fractured condition, sufficient to be used as a foundation for buildings and structures. The strength of sedimentary rocks, however rare in Finland, is poorer, but also their strength is usually sufficient to be used as a foundation for buildings and structures.

Founding on surface-blasted and compacted bedrock shall usually be treated as founding on subgrade with very high bearing capacity.

If the rock is completely weathered, it shall usually be treated as dense moraine in the design and dimensioning.

4.2.2.2
When performing rock excavation beside a foundation of a building or a structure below the foundation level, a rock excavation and reinforcement plan for the rock shall be prepared.

4.3 Loads on foundations and other groundwork

4.3.1
Loads on foundations and other groundwork shall be determined for geotechnical and structural design.

Guideline
If foundations and other groundwork are subjected to high concentrated loads, considerable horizontal loads or moment loads, the construction object shall be considered as belonging to the very demanding category (AA). A concentrated load is high, when it exceeds 5 MN. If foundations or other groundwork are subjected to considerable cyclic or dynamic loads, the construction object shall also be considered as belonging to the very demanding category (AA). Loads with the frequency of 1 Hz or less are regarded as cyclic loads. Loads with the frequency exceeding 1 Hz are regarded as dynamic loads

Buildings and structures subjected to wind loads are not considered as very demanding (AA), unless the building or a structure is high or narrow. Neither loads caused by traffic vibration are regarded as considerable loads.

A horizontal load is considerable, when it is more than one third of the vertical load on the foundation, i.e. of the vertical load transferred on the foundation from the superstructures and from the weight of the foundation and the soil on top of it.

A moment load is considerable, when the rotation of the foundation in the geotechnical design of the foundation is determining.

The strength and stiffness of the soil are many-fold in the case of loads of especially short duration. This can be utilized, especially when designing foundations and other groundwork for impact loads. Earth pressure and groundwater pressure loads do not always have time to influence at the same time as an impact load of short duration.

4.4 Foundations

4.4.1 Footings

4.4.1.1
The size of footings shall be geotechnically designed in such a way that their stability against breaking of the subgrade is sufficient and settling and settling differences of the foundations remain within the limits the structures to be founded tolerate (cf. section 4.1).

Guideline
Column and wall loads shall usually be distributed either to coarse-grained subgrade or a moraine base through footings.

The foundation depth of footings shall be at least 0.5 m measured from the adjoining ground surface. In inside areas of a building the foundation depth may be lower. The width of a plinth footing shall be at least 0.3 m and the size of a column footing at least 0,4 x 0,4 m^2. The thickness of a footing is usually so great that it can be regarded as stiff, compared with a bearing stratum.

The bearing capacity of a footing shall be dimensioned using a known formula for calculating the bearing capacity, in which the depth of the foundation, the size of the foundation and the skew of the load resultant and, if necessary, the obliquity of the ground surface are taken into account. The foundation depth and the obliquity of the ground surface shall be taken into account according to the lowest ground surface or floor level, which can occur during the construction time or during the use of the building, when the foundation is loaded.

The most important part of the geotechnical design of footings is the calculation of settling and settling differences, because it usually determines whether a footing can be used as a foundation or not. As a prerequisite for laying footings on fine-grained soil layers, the load-bearing structures must tolerate the settling differences caused by the compression of fine-grained soil layers. Laying footings on organic or soft fine-grained soil layers is not appropriate.

4.4.1.2
On a frost-susceptible subgrade, the ground-supported foundations and other structures subjected to movements caused by groundfrost shall be installed in frost-free depth measured from the assumed ground surface, i.e. in frost-resistant depth foundation depth, or frost-protected. Any permanent structure must not be built on frozen ground. Freezing of the subgrade under the structures during the construction period shall be prevented by using during-work frost protection, or the frozen subgrade shall be thawed in a reliable manner before the foundation work.

In the design and dimensioning of frost protection, the need of frost protection of the base floor, basement structures and thermal insulation shall be taken into account. The frost protection elements shall be placed and protected in such a way that their breaking is avoided.

Guideline
In the case of warm buildings, the frost-proof depth of a foundation depends on the temperature of the spaces resting

against the ground and the thermal insulation of the base floor or the temperature of the crawling space, as well as the structure of the foundations.

4.4.2 Mat foundations

4.4.2.1
Solid mat foundations shall be designed in relation to the bearing stratum as ductile structures, in such a way that the stability against breaking of the subgrade is sufficient and settling and deflections remain within the limits that the structure to be founded tolerate. The need of frost protection shall be taken into account in the design work.

Guideline
The foundation depth of mat foundations along the exterior walls shall be at least 0.5 m. Mat foundations are used when founding on stiff clays, silts or loose sands. Building beside mat foundations may considerably change the function of a mat foundation, which means that the use of mat foundations in densely built urban areas is not recommenced. In addition, in clay areas the use of mat foundations entails a settling risk as a result of drainage of the construction site, deep main pits or sinking of the groundwater level as a result of a long lasting drought.

4.4.3 Pile foundations

4.4.3.1
If founding of a building or a structure against the ground is not possible or reasonable due to the magnitude of settling, displacement or rotation caused by loads on the foundations, breaking of the subgrade or insufficient stability or for some other reason, such as the location of or the foundation methods used for founding the surrounding buildings and structures, the building shall be founded on piles on a deeper bearing stratum or on rock.

Guideline
A pile is a load-bearing structure. This requires that a pile shall be made of materials, which meet the requirements imposed on load-bearing structures, and that a pile is a reinforced concrete structure, composite structure, steel structure or timber structure.

2000 mm is regarded as the maximum diameter of a pile. The minimum permitted design length of piles displacing soil is usually 3 m, unless special measures are taken.

4.4.3.2
Methods, quality, scope and depth of the soil explorations to be conducted for the design of pile foundations shall be selected on the basis of the requirement category, the mode of operation and pile type to be used concerning the piling object.

The soil explorations of piles resting on the soil layers shall be extended below the target levels of the piles, employing such methods that the mode of operation and the geotechnical design values of the piles and pile groups can be reliably determined.

4.4.3.3
A pile foundation shall be designed in such way that it withstands the loads transferred from a structure and from external loads to the foundation and loads caused by the soil. In addition, displacement of the foundations shall remain within permitted limits.

4.4.3.4
The bearing capacity of a pile shall be determined in such way that, taking into account of the strength and stiffness of the pile material and the properties of the subgrade, the piles can bear the assumed loads with sufficient safety in accordance with section 4.1, while the settling, displacement and rotation remain within the limits that the structures tolerate.

The bearing capacity of a pile is determined on the basis of either structural or geotechnical bearing capacity and the bearing capacity of a pile group on the basis of either the sum of the bearing capacities of the individual piles or the bearing capacity of a piece formed by the piles and the ground between them, the lowest value being always determining. The total stability of the piling area shall be checked in the design situation prevailing before the piling, and the decrease in the total stability of the area during the piling work shall be taken into account.

Guideline
Dimensioning of the geotechnical compressive strength of a pile can be done using methods, the suitability of which has been verified either earlier or in connection with the work in question by comparing the results with the results of static test loads on the same pile type, with piles of the same size and in the similar soil conditions.

If the piles are subjected to often repeated or cyclic tensile loads, the piles are treated as category AA foundations. In such a case, the design of the tension capacity shall be done by means of load tests corresponding to the actual load on a pile in tension. Otherwise, the tension capacity calculations can be made on the basis of soil explorations.

4.4.3.5
When a pile group is used as a pile foundation, the piles shall be tied to form a pile group by means of a pile foot, which is dimensioned as a structurally stiff flat-slab. Fixing of the piles to the pile foot shall be presented in the foundation construction plan. A pile foot shall be designed structurally in such a way that it, with the required safety factor, withstands the impact of permitted pile dislocations on the pile loads and on the stresses that the pile foot is subjected to. Pile foots shall be frost-protected, unless the impact of frost heave on the pile foot is prevented in some other way.

4.4.3.6
The lateral capacity of a pile or a pile group shall be checked, if the pile or pile group is used for taking up lateral loads or they become loaded sideways, e.g. by movements of soil or constraint actions.

Guideline
If piles or pile groups are subjected to considerable horizontal loads, the piles are treated as very demanding (AA) foundations. In that case, the assessment of lateral capacity is done by means of load tests simulating the actual lateral load or by means of a numerical method, the validity of which has been verified on the basis of a load test simulating the actual load on the pile or load tests conducted in corresponding conditions.

4.4.3.7
If soil around a pile settles more than the pile, negative skin friction is generated in the pile, which shall be taken into account as an additional load on the pile.

Guideline
Negative skin friction does not, however, need to be taken into account at the same time with loads of short duration.

4.4.3.8
In the structural dimensioning of a pile, the structural strength of the pile shall be inspected in respect of compression, tensile, bending or shearing stress and, if necessary, buckling resistance of the pile.

Guideline
The structural design of piles shall be done in accordance with the guidelines laid down in part B4 of the National Building Code of Finland concerning reinforced concrete piles, part B7 concerning steel piles and part B10 concerning timber piles.

4.4.3.9
In the structural design of an on-site cast pile, the outside diameter of the casing pipe or the outside dimension of the hole-making tool is used as the pile diameter. The stability of the pile pit or hole of an on-site cast pile during casting shall be checked and the need of using a shaft tube determined.

4.4.3.10
Piles shall be designed structurally in such a way that, in addition to compression and tensile stresses, they withstand e.g. the possible bending stresses caused by warping of the pile due to the installation, eccentricity of loads, lateral loads, one-sided earth pressure, and the bending stresses possibly caused by settling of the ground surrounding raked piles so that the strength during the service life is not jeopardized, e.g. due to corrosion of steel structures caused by a too wide cracking. In the buckling design, a pile shall always be assumed to be buckled, in which case the radius of curvature depends, among other things, on the soil conditions, cross-section of the pile, number of pile splices and installation method. In dimensioning steel piles, a corrosion reduction shall be made, unless corrosion protection designed for the service life is used.

4.4.3.11
The piles shall withstand, without being damaged, the stresses they are subjected to during transport, storage, handling and installation (cf. section 5.2.4). In the dimensioning of a pile, the impact of soil in the stress situation during driving shall also be taken into account. The compression and tensile stresses during driving must not exceed the structural strength of the pile.

4.4.3.12
Introduction of a new piling method, a new pile type or the use of a pile type that has been used earlier in Finland in such soil conditions, on which the constructor has no experience, always requires installation and testing of test piles before commencing the actual piling work.

Guideline
By means of test piles, the suitability of the piling method and/or the pile type to the actual operating conditions and the correctness of the design assumptions shall be determined. In addition, a test piling is recommended when, on the basis of soil explorations, problems can be expected in the installation of the piles or when reaching a sufficient geotechnical bearing capacity with the designed pile length is uncertain.

4.5 Reinforcement of old foundations

4.5.1
Foundations shall always be reinforced, if load changes, damage to the foundations, neglected maintenance, making a basement deeper, building close or deeper, or other corresponding reason so requires.

Guideline
To begin with, in the design of the reinforcements of foundations, loads transferred from the superstructures to the foundations shall be calculated. If structures are taken down, the superstructures shall be supported in such a way that these loads are transferred to the bearing stratum or rock during the reinforcement work so that

deformations causing damage the structures are avoided. Such loads and settling caused by such loads shall be monitored during the whole foundation reinforcement work, because settling will result in load changes.

4.5.2
New foundations shall be designed on the basis of reliable initial data and using such foundation construction methods that the structures are not damaged. Renovated or repaired foundations and other groundwork shall be designed in accordance with the requirements laid down in section 4.1. If the intended use of a building is changed, the requirements imposed on the foundations and groundwork shall be determined in accordance with the new intended use of the building, and the building must withstand the stresses caused by the new intended use.

Guideline
As horizontal displacement of structures, maximum one third of the total settling values presented in Table 4.2 are usually allowed.

4.5.3
Before starting the construction work, the transfer of loads shall be preliminary designed in such a way that the need of reinforcing the superstructures for the transfer of loads is determined and the basic solutions for the load transfer are presented. Especially the need of preloading the foundations shall be determined. If the loads can be transferred to new foundations causing so small settling that the superstructures are not damaged, the foundations do not need to be preloaded.

4.5.4
When planning the working order for the construction of new foundations and transfer of loads, it shall be ensured that the assumed deformation and, therefore, also the loading of the structures take place as evenly as possible so as not to cause unnecessary damage to the structures.

4.6 Base floor and basement structures

4.6.1
Base floor and basement structures shall be designed and constructed in such a way that settling and other deformations are so small and the structures so tight that the designed function of the structures and the building is not jeopardized during the service life of the building and the structures. The impacts of frost heave on the structures shall be prevented. A load-bearing base floor shall be used, if it is assumed that the settling of the ground-supported base floor would become too large.

Guideline
A ground-supported base floor can, in general, be used, when the building is founded on moraine, coarse-grained soil or rock and the fill under the floor is laid in layers to the designed tightness so that the base floor settles, at most, 5 mm more than the building.

A ground-supported base floor can be designed and laid also in basements founded on piles, if the settling difference in relation to other structures is sufficiently small. In such a case the requirements imposed by pipelines and equipment, as well as structures sensitive to settling, shall be taken into account.

If living or working spaces are to be built on top of a ground-supported base floor, a sufficiently ventilated crawl space shall be constructed underneath the base floor. A crawl space does not need to be built, if it is ensured that the fill underneath the base floor laid against the ground cannot settle and is kept dry.

The vertical structures of the basement structures resting against the ground shall, in general, be designed for pressure at rest.

4.6.2
Pipelines, cables and equipment to be installed underneath base floors and outside basement structures shall be easy to maintain and replace without the need to modify the load-bearing structures.

4.6.3
The building ground shall be drained in such a way that capillary flow of water is cut off and the groundwater level is kept in a sufficient distance from the floor or the ground surface of the crawl space, as well as the surface waters filtrating into the ground are conducted away from the foundations and from underneath the building. The space underneath base floors shall be provided with a structure cutting off the capillary rise of water, unless the base floor is provided with tanking. The drainage of main pits and canals shall be arranged in such way that the water possibly conveyed into them does not to a harmful extent increase the moisture stress on the structures.

Ground-supported basement structures shall be separated from the ground by means of a structure, which cuts off capillary flow of water, unless the structure is provided with tanking, or unless it can be verified in some other way that capillary transfer of water has no harmful effect on the structures or the function of the building.

The function of the basement structures resting against the ground, in respect of the effect of moisture, shall be designed and executed in such a way that the structures are allowed to dry sufficiently.

The function, inspection and maintenance of the drainage structures shall be described in the maintenance manual for the care and use of buildings.

Guideline
A tanked or watertight structure does not usually need to be drained. Possible seep and percolating waters in the tanked structures shall, if necessary, be taken into account by means of an internal drainage system.

Proper attention shall be paid to the drainage of spaces adjacent to the basement structures bordered by ground or rock. The moisture stress on the spaces can be reduced by effective ventilation and drainage.

Soil layers, such as drainage layer and subsoil shall, if necessary, be separated from each other or from the subgrade by means of a fibre cloth or a filtration layer.

By ensuring tightness of the base floor and basement walls resting against the ground, the passage of air containing radon into the building can be prevented. In buildings equipped with a ventilating base floor, the radon concentrations are usually the lowest. A tight, uniform slab solution is also safe in respect of radon. Packing of the joint between a ground-supported slab and the enclosure wall is necessary, when the enclosure walls are constructed separately. By means of radon pipes installed underneath a ground-supported slab, the radon concentration of indoor air can, in most cases, kept in control, provided that the air leak spots in the base floor structure are small. Packing of lead-throughs is extremely important in all structural solutions. Wall structures made of a porous material shall be packed. A tight concrete structure not susceptible to cracking prevents the penetration of radon through the structure.

Explanation

Regulations and guidelines on the prevention of moisture damages are laid down on part C2 of the National Building Code of Finland.

Regulations and guidelines on thermal insulation in a building are laid down in part C3 of the National Building Code of Finland.

Regulations and guidelines on water supply and drainage installation for buildings are laid down in part D1 of the National Building Code of Finland.

4.7 Yard area structures

4.7.1
Yard area structures shall be designed and constructed in such a way that settling, lateral strains, frost heaves and other deformations are so small and drainage arranged in such a way that no unreasonable harm is caused to the function of the yard or the buildings and structures in the yard area during the service life of the yard area.

Drainage shall not unnecessarily cause harm to the vegetation and other natural conditions in the yard and its surroundings and, on the other hand, close to the drainpipe there shall not be such trees or bushes, whose roots can stop up the drainage system.

Guideline
Fills of the yard structures shall be compacted to the designed tightness in order to reduce problems caused by settling and settling differences.

When designing foundations for pipelines, the connections to structures settling in different ways, intersections with other pipelines, as well as fills and other additional loads shall be taken into account. If necessary, strain structures and collecting wells allowing a sufficient settling difference shall be used.

The quality classification and the recommended structural requirements concerning yard areas are presented in Table 4.3. Large industrial areas, lawns and corresponding areas can also be designed for settling larger than those laid down for Class 2.

Guideline
Table 4.3. Quality classification and recommended structural requirements concerning yard areas.

Quality class	Surface course	Requirements Appearance	Permitted long-term settling (in the period of over 30 years)	Frost motions (F_{10})
Class 1 Yard and areas on which particularly strict requirements in respect of function and appearance are imposed	bound unbound	Pavement remains intact -----------	less than 100 mm less than 100 mm	up to 50 mm up to 50 mm
Class 2 Other yards of residential buildings as well as office and business premises	bound unbound	In the pavement there are small cracks, which can be remedied by regular care ------------	less than 300 mm less than 300 mm	up to 100 mm up to 100 mm

4.7.2
The function, inspection and maintenance of the yard area shall be described in the maintenance manual for the care and use of buildings.

4.8 Retaining structures and earth pressure

4.8.1
Retaining structures, which include retaining and supporting walls, wall structures against the ground and platform structures against the ground, shall be designed and constructed in such a way that the stability of the retaining structures is sufficient to withstand the soil and water pressure and possible external loads they are subjected to, and the displacements of the retaining structures are so small that they do not cause problems to the structures and the surroundings.

The structural design of permanent retaining structures and such temporary structures, which support permanent buildings and structures and in the affected zone on which there are permanent buildings or structures, shall be done in accordance with the safety level requirements for permanent structures.

When there are permanent buildings or structures in the affected zone of a strutted excavation, the deformations in the retaining structures according to the service state and the displacements in the surroundings as a result of them, shall be determined by geotechnical design.

The water levels on each side of the retaining structure used as the design criteria shall be determined on the basis of reliable water level observations and based on the designed lowering of groundwater at different working stages. During the construction time, the designed lowering of groundwater shall be monitored, if necessary.

Guideline
In the geotechnical and structural design of a retaining structure, the dimensioning earth pressure and its distribution as well as the dimensioning water pressure shall be calculated, the force quantities of the retaining structure shall be determined, the retaining structure shall be structurally dimensioned, and the total stability and vertical stability of the retaining structure shall be checked.

The vertical stability and the vertical displacements of a retaining structure resting at its bottom end against the ground shall always be checked when the retaining structure is subjected to external diagonal or vertical loads or diagonal supporting forces.

The geotechnical design of a foot of a ground-supported retaining wall is made in the same way as the geotechnical design of a ground-supported foundations, taking into account the impact of diagonal and eccentric loads caused by earth pressure on the bearing capacity, settling and rotation of the foot.

The magnitude of the dimensioning earth pressure shall be calculated in accordance with the classical earth pressure theory or by using some other reliable, generally accepted method, e.g. the finite-element method. The shape, stiffness and the possibility of movement of a structure supporting the ground, as well as the quality of soil and the influence of time on earth pressure dependent on the soil quality, the groundwater level, the state of flow of groundwater and vibration, have an impact on the magnitude of earth pressure and its distribution.

The dimensioning water pressure shall be determined in accordance with the dimensioning water levels and state of flow.

The surface of a fine-grained or organic soil layer behind temporary retaining walls is assumed to be cracked, in which case the retaining wall is subjected at least to the water pressure.

If the soil or retaining structure is subjected to vibration caused by heavy traffic, rock excavation, piling work or other groundwork or to other intense vibration, the impact on earth pressure shall be determined taken into account the type of the vibration, the distance of the vibration source and the properties of the soil layers. Unless no other calculation method is available, the active earth pressure is increased at least by 25 % and the passive earth pressure decreased at least by 20 % in the vicinity of the vibration centre.

4.8.2
Harmful freezing of frost-susceptible soil behind a retaining structure shall be prevented.

4.9 Building pits and drainage during work

4.9.1
A building pit shall be designed in such a way that the stability against collapse of the pit is sufficient at all working stages and, if necessary, also for a period of long duration and the building pit does not cause any danger or undesirable displacement in the surroundings of the pit.

If there are permanent buildings or structures in the affected zone of a building pit, the building pit shall be designed in accordance with the requirements imposed on permanent structures. Otherwise, the safety requirements for temporary excavations apply.

Guideline
In the foundation construction plan, detailed instructions for the construction of a building pit at the different working stages shall be given, e.g. concerning the space requirement for the pit, strutting or sloping of the pit walls, earth structures to be made on the bottom or the slopes of the pit, and drainage of the pit.

In order to foresee displacements caused by the pit, a monitoring measuring program shall be prepared, in accordance of which displacements in the surroundings are monitored during the excavation of the building pit and afterwards.

4.9.2
By means of drainage of the building pit during the construction work, the pit shall be kept sufficiently dry and free from surface water and groundwater filtrating into the pit.

If it is to be expected that the groundwater level sinks during the excavation of the pit or as a result of draining the pit, the impacts of the sinking of the groundwater level in the surroundings of the pit shall be investigated and, if necessary, the sinking of the groundwater level in the surroundings prevented or a plan to prevent harmful effects caused by sinking of the groundwater level prepared.

Guideline
In respect of drainage of the building pit during the construction time, structures, which are needed to remove groundwater filtrating into the pit or to prevent hydraulic breaking of the bottom of the pit, as well structures, which are to be used to prevent the risk of erosion in the pit or risk of erosion caused by the infiltration of water into the soil layers, shall be presented in the foundation construction plan for the excavation. In addition, the foundation construction plan shall, if necessary, contain a description of measures to be taken to prevent problems caused by sinking of the groundwater level in the surroundings.

For monitoring the groundwater level a monitoring program shall be prepared, if necessary, in accordance of which the groundwater level in the pit and in the surroundings is monitored during the construction time and, if necessary, afterwards.

4.10 Protection of surroundings

4.10.1
The foundation construction work shall be designed using such methods that vibration, noise and emissions, as well as other effects harmful to the health of people living in the surroundings and to their comfort, to the adjoining buildings, to the other activities and the natural environment, are kept within permitted limits and, when no limit values exist, are otherwise reasonable.

The growing stock and vegetation to be preserved shall be protected.

Guideline
Attempts shall be made to restrict harms already at the design stage. The principles and requirements for the prevention of environmental harms concerning category A and AA foundation construction works shall be presented in the foundation construction plan.

In order to be able to foresee harmful effects of the construction work, a monitoring and a monitoring measuring program shall be prepared, if necessary.

Explanation
Limit values for noise are laid down in the document: ”Valtioneuvoston päätös melutason ohjearvoista 993/1992” (Council of State Decision on Limit Values for Noise Level)

Restriction of noise in construction work is dealt with in the document: ”Valtioneuvoston päätös rakennuskoneiden ja –laitteiden melupäästöjen rajoittamisesta ja määrittämisestä 994/1992” (Council of State Decision on the Restriction and Determination of Noise Emissions caused by Building Machinery)

Limit values for vibration caused by rock excavation are laid down in the publication of the Ministry of Social Affairs and Health: ”Räjäytysalan normeja, turvallisuusmääräykset 16:0, 1998” (Standards in the Field of Rock excavation, Safety Regulations).

Limit values for the quality of air are laid down in the Council of State Decree on Air Quality (711/2001).

4.11 Plans

Guideline
A foundation construction plan shall be the more detailed the higher the requirements imposed on the construction object are in respect of soil relations, structures and working methods. The foundation construction plan shall include, in respect of category AA and A projects, the foundations, other permanent groundwork and frost protection to be built, the radon-technical solution, drainage and excavations planned for the construction object, as well as the connection of the building to pipelines and construction of the pipelines and the yard.

In respect of category B projects, the design of foundations, frost protection, radon-technical solution and drainage is usually sufficient.

At the construction stage, the foundation engineer and the structural engineer shall prepare an ”as-built drawing”.

When a project subject to building permission has been completed, the constructor who had undertaken the project hands over to the owner of the building the soil exploration and the foundation construction plan documents necessary in respect of the use, maintenance and future repairs of the premises.

Explanation
It is appropriate that the owner retains the documents necessary in respect of the use, maintenance and repairs during the whole service life of the building.

5. FOUNDATION CONSTRUCTION WORK

5.1 General requirements

5.1.1
The foundation construction work shall be done in accordance with a foundation construction plan and a working and quality plan prepared in advance. The work shall not at any stage cause hazard or health risks to persons staying in the affected zone or damage or unreasonable harm to the buildings, structures, pipelines or

cables in the construction area or in its surroundings, or harmful changes in the subgrade, bedrock or groundwater in the surroundings.

Guideline
Quality assurance is the responsibility of the supervisor of the foundation construction work, who shall be qualified for the supervision of projects in the requirement class in question. At least for category AA construction projects, a geotechnical foundation engineer is appointed to supervise the implementation of the foundation construction work in his/her field of expertise.

Explanation
Supervision of construction work is dealt with in part A1 of the National Building Code of Finland.

5.1.2
If soil relations, groundwater relations or the surrounding structures are found to deviate from the data presented in the foundation construction plan, the plan shall be revised and altered as necessary.

The implementation of the quality control of the foundation construction work in the case of category AA and A construction objects shall be presented in the working and quality plan, which is a part of the inspection document of the construction work and shall be presented sufficiently early before commencing this work stage.

It shall be possible to verify the acceptability and quality of the foundation construction work reliably.

5.2 Foundations and earth structures

5.2.1 Foundations

5.2.1.1
Foundations shall be constructed on rock, unfrozen subgrade in a natural state or unfrozen filled layer compacted in layers, or unfrozen bedrock blasted by rock excavation. Side fillings of the foundations and other groundwork shall be made by layered compaction using unfrozen, fit-for-purpose frost resistant material.

5.2.1.2
Frost insulation of foundations and other groundwork shall be laid on so even surface and covered immediately in such a way that their breaking during the construction time is prevented. The installation depth of the frost insulations shall be such that their breaking during normal yard and gardening work is avoided.

5.2.1.3
Drains shall be supported against the lower drainage layer in such a way that the movement of the drain while constructing the upper drainage layer is prevented. The selection of correct materials, sufficient thickness, uniformity in the whole building or structure area and continuous connection to the drains, shall be ensured by means of quality control measures. Freezing of the drains and their discharge pipes shall be prevented.

5.2.1.4
Harmful passage of rain and melt waters into the building ground shall be prevented both during the construction work and the use of the building.

5.2.2 Earth structures

5.2.2.1
In the construction of earth structures such methods and equipment shall be used that homogenous, reliably functioning earth structures, the technical properties of which meet the requirements stated in the plans, can be achieved.

The earth structures in housebuilding objects shall always be constructed by layered compaction. An exception of this is deep stabilization of the building ground or a yard area; the requirements and instructions for the implementation and quality assurance of such work shall always be presented in a work-specific work and quality specification.

In constructing blasted rock fills, mixed quarry-run rock shall always be used so that the empty spaces in the fill remain as small as possible. In addition, the surface of the blasted rock fill shall be always be blocked by means of small-size rock waste and/or coarse crushed gravel in such a way that dropping of materials installed on top of the blasted rock structure into the empty spaces in the blasted rock layer is prevented. The compaction of a blasted rock fill shall always be done using sufficiently powerful compacting equipment and an effective working method.

Excluding landscaping structures and other technically less demanding minor filling objects, the designed state of consolidation of the earth structures used in housebuilding shall be always be verified either by means of measurements or, at least, by supervision based on monitoring of work procedures. The suitability of the used methods to local conditions shall always be verified in connection with the monitoring of work procedures, by means of measurements both at the beginning of the work and when the quality or moisture status of the building material or the construction conditions change.

Guideline
The most important matters to be monitored in connection with earthworks are, in general, the control of grain size distribution of the materials used and the state of consolidation of compacted soil. In addition, measures shall be taken to prevent sorting of the materials during transport, spreading and other handling operations.

The thickness of the layer to be compacted at one time depends on the type of the material to be compacted and the compacting equipment to be used. The maximum grain size of the material used in construction shall be not exceed 2/3 of the thickness of the layer to be compacted at one time. The maximum permitted boulder size both as to blasted rock and soil materials is 600 mm.

5.2.2.2
When building in winter, it shall be ensured that as small area as possible of the earth structure under construction is exposed to the influence of cold at one time. Before spreading the material, snow, ice and frozen soil shall be removed carefully from the surface to be covered by the earth structure. If frozen soil melts or is melted artificially, instead of removal, unfrozen soil shall be compacted carefully before spreading the material on top of it. Materials to be used shall not freeze before they are compacted to the tightness conforming to the requirements stated in the plans. The compacted material shall not contain snow, ice or frozen soil.

Guideline
When constructing in winter, the materials to be used for earth structures should be as dry as possible and they shall not be frozen.

5.2.3 Building pits

5.2.3.1
Construction of a building pit shall be made in accordance with a foundation construction plan and a working and quality plan prepared in advance for the pit. The excavation work shall not at any stage cause hazard or unreasonable harm to the surroundings or buildings, structures or equipment in the affected zone of the excavation, e.g. due to vibration, displacements or noise.

5.2.3.2
A street area and other public area shall be supported in such a way that the area and the equipment, pipelines or cables located in the area will not be damaged. Structures, equipment and pipelines in the surroundings shall, if necessary, be protected against freezing and other harmful effects.

5.2.3.3
It shall be possible to reliably verify the acceptability and quality of the construction work of the building pit.

Guideline
The acceptability and quality shall be verified by means of follow-up and monitoring measurements performed during the construction time, by comparing performance protocols, soil relations and the groundwater level, as well as the as-built data on the excavation and strutting, with values stated in the design of the foundation construction documents.

5.2.4 Piles and piling

5.2.4.1
Piling work shall be designed and executed in such a way that it is possible to install the piles without damage in the places and with the inclinations stated in the plan and to penetrate down to the minimum levels stated in the plans without causing damage to the buildings or structures located close by.

Piles shall be not be driven through such fill layers which cause a risk of damage to the piles, unless the obstructions are displaced or removed away in front of the piles before installation. It shall be ensured that the installation hole stays open before installing the pile. In addition, it shall be ensured that the displaced obstructions do not cause damage to already installed piles.

Damage to prefabricated piles shall be prevented by handling, transporting and storing the piles appropriately and in accordance with the manufacturer’s instructions.

5.2.4.2
The responsible supervisor, who may be the responsible supervisor of the construction work or a separately approved supervisor in a special field, shall be in charge of the piling work.

5.2.4.3
A measuring plan, results of the measurements and other piling documents shall be included in the inspection document.

Guideline
The quality assurance of the piling work shall be done in such a way that the result and acceptability of the work can be reliably verified by comparing performance protocols and reports with the design documents.

After the piling work is completed, an as-built drawing shall be prepared containing data on the location of the piles, pile sizes and foundation level, as well as the accessories used on the piles.

5.3 Monitoring of the state of structures and surroundings

5.3.1
The construction work shall not cause harmful changes in the natural conditions of the surroundings, subgrade or bedrock, groundwater or the buildings or structures in the construction area or its surroundings. If harmful changes are to be expected, the impacts of such changes shall be investigated and, prior to the construction work, sufficiently extensive and detailed surveys conducted. During the construction work, measurements shall be carried out in accordance with a monitoring program prepared in advance. The measuring devices shall be installed and the measurement started in such a way that the situation, which existed before the construction work was started, can be determined.

Guideline
Monitoring measurements shall be made sufficiently in the whole affected zone of the construction work and, if necessary, also below the ground level. Monitoring measurements are especially important, when new foundation construction methods are used, when constructing in down town areas, or if during the construction work arise matters, the impacts of which cannot reliably be specified in advance.

In order to obtain information on the variations in the groundwater levels and the flow directions of groundwater during the construction time, observation tubes shall be placed in the whole risk zone at intervals from 20 to 100 metres, depending on the variation of the soil relations. Data on the variations in the groundwater levels measured during the construction time shall be compared with the requirements laid down in the plan and with the groundwater levels measured before the construction work was started. In addition, settling of the surrounding terrain and buildings and the quantity of seep waters pumped from the pits shall be measured, if necessary.

If necessary, sinking of the groundwater level and problems caused by seep water shall be prevented and restricted.

Pore water pressure shall be measured employing methods by means of which fast changes taking place during the construction work can be immediately detected. In addition to the measurements of pore water pressure, measurement of displacements shall be carried out at the same time.

In order to prevent damage to the buildings and structures located in the affected zone of the construction work, measurements of displacements, cracking and vibration should be carried out on the structures and subgrade in addition to groundwater level and pore water pressure measurements. The measuring points of the vibration measurements shall be located in such a way that the impacts of vibration can be determined as accurately as possible.

As horizontal displacements of structures, up to one third of the values presented in Table 4.2 can be allowed. In the affected zone of pits, the risk zone usually extends at least on a distance identical to the excavation depth measured from the edge of the pit.

5.3.2
At the beginning of each construction stage, a plan for the prevention of environmental harms prepared at the planning stage included in the foundation construction plan shall be checked on the basis of the working methods used. If necessary, the plan shall be complemented. The plan shall be available at the construction site. Before the construction work is started, the necessary surveys shall be conducted in the immediate surroundings.

5.4 Inspection document

5.4.1
In order to verify the quality and acceptability of the foundation construction work, a sufficiently detailed performance protocol on each individual work performance shall be kept during the work, including the results of the relevant measurements and observations.

Guideline
In the working and quality plan it shall be stated, with which accuracy and how often reaching of the planned quality is measured. A working and quality plan shall also contain samples of the required performance protocols.

The survey protocols, quality control reports and performance protocols shall be collected into an inspection document always kept up to date at the construction site.

The performance protocols shall be submitted to the geotechnical foundation engineer without delay. In case no performance protocols concerning work performance are required, the acceptance of the work shall, in any case, be recorded in the inspection document.

Performance protocols shall be kept especially on:
- pilings,
- construction of excavations, including driving and anchoring of restraining walls, pumping volumes of seep waters and groundwater levels,
- subgrade reinforcements, such as injection, spray injection and deep consolidation, and
- quality and monitoring of the tightness of materials used in earth structures.

The inspection document forms the basis of the maintenance manual for the care and use of buildings or the structure.

Explanation
Regulations and guidelines on the inspection documents are laid down in part A1 of the National Building Code of Finland.

Regulations and guidelines on the maintenance manual for the care and use of buildings are laid down in part A4 of the National Building Code of Finland.

Annex 1
Information for guidance

Publication ”Pohjarakennusohjeet” RIL 121 (Guidelines on Foundation Constructions) of Finnish Association of Civil Engineers.