FINNISH CENTRE FOR RADIATION AND NUCLEAR SAFETY
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Concrete structures for nuclear facilities

(continues)

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and section 29 of the Council of State Decision (395/91) on General Regulations for the Safety of Nuclear Power Plants, the Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL Guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

Translation. Original text in Finnish.

1 General

Guide YVL 1.1 summarises the regulatory activities of the Finnish Centre for Radiation and Nuclear Safety (STUK) during a nuclear facility's licence application review and during the construction and operation of the facility. Guide YVL 4.1 gives detailed requirements for the design and fabrication of concrete structures for nuclear facilities and for the documents to be submitted to STUK. The Guide also sets requirements for the inspection of concrete structures during the construction and operation of facilities.

For the purposes of this Guide, concrete structures mean concrete, reinforced concrete and post-tensioned concrete structures, unless it is necessary for the sake of clarity, to use more accurate expressions.

On the basis of their safety significance, a nuclear facility's structures, systems and components are assigned to Safety Classes 1, 2 and 3, and to Class EYT (non-nuclear). The requirements to be set for design, fabrication, installation, testing and inspection are determined on the basis of this classification. The classification criteria are given in Guide YVL 2.1. As prescribed in Guide YVL 1.1, safety classification shall be provided in the form of a separate classification document. Guide YVL 4.1 does not deal with Safety Class 1 concrete structures. Regulations and directions concerning such structures (mainly concrete reactor pressure vessels) will be issued separately, if necessary. As for Class EYT (non-nuclear) concrete structures, the regulations and directions in the Finnish Building Code (RakMK) shall be followed.

The requirements in this Guide primarily apply to new construction. As regards the repair and modification of nuclear facilities built before its publication, the Guide is followed to the extent appropriate.

STUK regulates concrete structures of nuclear facilities in accordance with this Guide. STUK's activities have no bearing on regulatory measures required under the Building Act (370/58) /2/ and Decree (266/59) /3/, unless authorities agree otherwise.

STUK's regulatory activities encompass the following measures:
— review of the preliminary and final safety analysis reports
— review of the classification document
— review of the quality assurance programmes
— review of the design documents for concrete structures
— supervision of concrete structure fabrication
— commissioning inspections
— control during operation.

2 Safety analysis report, classification document and quality assurance programmes

STUK handles the preliminary safety analysis report, the topical reports supplementing it, the draft classification document and the construction quality assurance reports in conjunction with the handling of the construction permit application.

The following descriptions of concrete structures shall be given in the preliminary safety analysis report and topical reports:

Safety Class 2 structures
— applicable regulations, codes and standards with their scopes of application
— design data
— test results important to design
— preliminary materials report
— preliminary dimensioning, applicable codes and computer programs
— criteria for the inservice inspection of containment structures.

Safety Class 3 and Class EYT structures
— description of structures and their functions as part of a nuclear power plant
— major design criteria
— general description of construction materials.

The safety classification of concrete structures shall be presented according to the criteria in Guide YVL 2.1. It shall also be ensured that functional entities of structures are classified into the same safety class. Drawings can be used in presenting the safety classification of concrete structures.

Quality assurance programmes concerning nuclear power plant design and construction are presented with the construction permit application, as presented in Guide YVL 1.4.

The final safety analysis report is handled in conjunction with the operating licence application. Guide YVL 1.1 contains regulations about safety analysis reports and topical reports. Other regulatory measures concerning concrete structures are addressed in the chapters below.

3 Design documents for concrete structures

3.1 General

Design documents for Safety Class 2 and 3 concrete structures must include the following documents which normally are to be building-specific (in parentheses reference is made to a more detailed description given later in this document):

— description of organisation (3.2)
— applicable regulations, codes and standards (3.3)
— design data (3.4)
— structural calculations (3.5)
— drawings (3.6)
— specification (3.7)
— quality control plan (3.8)
— inservice inspection plan (3.9)
— plan for containment building pressure and leakage tests (3.10).

Of these, the following design documents concerning Safety Class 2 concrete structures shall be submitted to STUK for approval not later than two months before construction work is started:

— description of designers
— description of applicable regulations, codes and standards
— design data
— structural calculations
— part of the drawings (e.g. those included in the tender invitation documents)
— preliminary quality control plan
— preliminary containment building inservice inspection plan.

If the licence-applicant wishes to deviate from the above supply schedule, a document supply plan with justifications shall be submitted to STUK for approval well in advance of a 6-month time limit.

As regards documents concerning Safety Class 3 concrete structures, documents mentioned in connection with Safety Class 2 shall be submitted to STUK for approval at least two months before the start of construction work/work phase.

The rest of documents concerning Safety Class 2 and 3 structures can be submitted for approval later. However, all design documentation is subject to STUK's approval before the work phase in question is started.

The design documents of Class EYT structures and buildings need not be submitted to STUK.

The final inservice inspection plan is to be submitted to STUK for approval before the reactor is loaded.

Document-related source books not generally available, or copies thereof, shall be submitted to STUK with the documents in question.

3.2 Description of organisation

In the design documentation for concrete structures, a description of the organisation shall be presented describing how quality assurance related to the design and implementation of concrete structures has been arranged in the organisations of the licence applicant, the plant supplier, the structural designer and the contractor. The setting up of quality assurance in other organisations whose activities have a bearing on the quality of concrete structures shall be

accounted for, too. The quality assurance function shall be sufficiently independent of other functions, primarily of design and implementation.

Where operation is concerned, the organisation shall employ a sufficient number of competent personnel and the lines of responsibility shall be clear. The description of the organisation shall define the responsibilities and qualifications of the staff, and it must be confirmed by the company's management.

3.2.1 Qualifications of structural designer

Responsible designer

For each building or structure, a person responsible for design shall be assigned. The individual designated shall be a qualified designer of Class 1 concrete structures, or shall have corresponding qualifications determined abroad. The designer responsible for prestressed concrete structures shall have sufficient experience in design assignments in his special field.

Structural designer

The structural designer shall be qualified at least according to the regulations and directions in the RakMK and shall have sufficient experience of designing demanding structures.

During the construction of building structural frames, a representative of the structural design company shall be present at the construction site, or promptly available if required.

3.2.2 Supervision of construction work

Building owner

The person in charge of construction work at the site shall have at least a Bachelor of Science's (Civ.) degree and six years working experience of which not less than three years in constructing demanding structures.

The person responsible for Safety Class 2 structures and buildings shall have at least a Bachelor of Science's (Civ.) degree and three years working experience of constructing demanding structures.

The person responsible for Safety Class 3 structures and buildings shall have passed at least a Master Builder's examination and shall have three years working experience of constructing demanding structures.

The aforementioned persons shall be competent Class 1 concrete foremen (in accordance with RakMK).

If the license applicant is not the building owner, a separate description shall be submitted about the licence applicant's own supervisory activities.

The contractor

The contractor shall employ an individual who is in charge of the implementation of the quality control plan. This person shall have qualifications at least equal to those of the individual in charge of the supervision implemented by the building owner.

The person in charge of the implementation of Safety Class 2 construction work shall have qualifications at least equal to those of the individual in charge of the supervision implemented by the building owner.

The individual in charge of the process of making concrete shall be a qualified Class 1 concrete foreman (in accordance with RakMK). During the making of concrete there shall be a person at the site with sufficient knowledge of the process itself and of the properties of concrete. The person in charge of the concrete laboratory must be a concrete laboratory technician with sufficient knowledge of concrete technology.

Staff participating in the construction of Safety Class 2 structures shall be experienced and suitable for their jobs.

3.3 Regulations, codes and standards

The limits of their scopes of application with justifications shall be given of the applicable regulations, codes and standards.

Structures, materials and the tests they are subject to shall meet Finnish requirements. If Finnish regulations, codes and standards are insufficient, foreign standards may be applied. It must then be ensured, however, that the regulations, codes and standards used form an applicable entity.

3.4 Design data

At least the following basic data employed in the design of concrete structures shall be given:

— layout drawings
— a structure's function as part of a nuclear power plant
— loads
— materials to be used
— general description of construction methods
— classification of coatings of concrete surfaces
— inservice inspection criteria.

More detailed instructions are given below for presenting information about loading, materials and coatings.

3.4.1 Loads

All loads, including radiation-induced thermal loads, shall be justified by making reference to the regulations, codes and standards used and to the information provided by manufacturers or to explanations of forces transmitted to concrete structures by components and pipework under operational and accident conditions. When load combinations are calculated, care shall be taken not to overestimate loads reducing maximum stress.

3.4.2 Materials

The properties of the types of concrete, concrete constituent, reinforcement and tendon used and their fitness for purpose shall be described. The acceptance criteria shall be unambiguously defined.

3.4.3 Coatings

Under accident conditions, the coatings of containment internal structures will be subjected to loads which deviate essentially from those encountered during normal operation. The coatings used shall be such that they will not have an unfavourable effect on accident management. It shall be demonstrated, therefore, i.a. that coatings will not come off to an extent which would block flow paths and endanger core coolability or removal of residual heat. Furthermore, it shall be demonstrated that under accident conditions chemical changes, if any, in coating material do not create new risk factors.

In the design data, the requirements placed on the coatings of concrete structures inside the containment shall be presented. They are as follows:

— radiation resistance
— decontaminability
— chemical resistance
— durability under operating conditions
— durability under postulated accident conditions
— fire technical properties.

In the design data also the methods are presented by which the meeting of requirements set for coating materials, coating treatment combinations and the application of coatings is ascertained.

Only coatings which have passed tests demonstrating the meeting of these requirements are allowable in concrete structures inside the containment. The test results may not be older than five years.

Corresponding descriptions shall be given of containment building external coatings for which requirements relating to decontaminability are set.

3.5 Structural calculations

The structural analysis document describes how the dimensioning presented has been derived from load combinations and material properties. The document shall be so detailed that, on its basis, the accuracy of the analysis method and the fulfilment of the dimensioning requirements can be assessed.

Apart from strength assessments, a structure's stability, deformation, fatique, creep, relaxation and progressive collapse are to be assessed if necessary, to verify its durability and reliability under operational and accident conditions.

As set forth in Guide YVL 2.8, containment leak and failure mechanisms are to be analysed in conjunction with a Level 2 PSA; at the same time, probabilistic safety assessments must also be made to assess the reliability of the concrete containment building. When assessing containment reliability, use shall be made of the probability distributions of loads and material properties. The reliability levels of material properties shall be based on quality control documentation from the construction period.

If the computer programs employed for structural calculations are not commonly known, a description of them and of test run results shall be provided to assess their applicability and the reliability of the results they yield. The input values given, the element grid chosen, the assumptions made and an interpretation of the results shall be presented in a summary report.

The calculated deformations of structural elements to be subjected to test loads during the various phases of test loading are also given in the document.

The structural calculations shall be clearly presented and the necessary references to other documents, source literature and drawings shall be made.

3.6 Drawings

Drawings describe a concrete structure in such a manner that its shape and dimensions and the allowable tolerances are shown in sufficient detail. The drawings shall meet the requirements of the regulations and directions in the RakMK.

Any necessary further instructions on the implementation of construction work, on quality control and the requirements set for structures during construction, such as the sequence and time of formwork removal and the specified strength of concrete at the time of formwork removal, shall be presented in the drawings.

3.7 Specification

A specification sets forth requirements and instructions for the implementation of a structure. The specification shall be sufficiently detailed so that, with the help of it and structural drawings, structures can be implemented in compliance with the requirements. The specification to be included in the contract documents can be the specification meant here.

3.8 Quality control plan

The quality control plan presents:

— items subject to quality control, and the quality control measures and inspections to be performed (see subsection 3.8.1)
— instructions about each quality control measure or inspection (see subsection 3.8.2)
— recording of quality control results (see subsection 3.8.3).

The responsible organisation/persons and the date of implementation shall also be given of measures and inspections conducted in accordance with the quality control plan.

Quality control plans by concreting section

For the implementation of the quality control of Safety Class 2 concrete structures, concreting section specific quality control plans are to be presented.

As regards Safety Class 3 concrete structures, concreting section specific quality control plans are only presented for work which is considered demanding, such as
— massive concrete structures
— slipforming concretes
— injection work or work related to corrosion prevention.

Concreting section specific quality control plans shall present at least the following information:
— concrete constituents
— reinforcement steels and tendons
— steel components transmitting loads
— structures connecting to a concreting section
— formwork
— fresh concrete and concreting work
— curing of concrete
— date of inspection (before, during and after concreting).

3.8.1 Item-specific quality control requirements

Quality control measures and inspections of concrete structures are required at least for the items listed below:
— mixing plant and laboratory
— concrete constituents
— fresh concrete
— hardening and hardened concrete
— reinforcement steels
— reinforcement splicing sleeves of steel and end anchorage
— prestressing systems
— steel components transmitting loads
— special mortars and concretes
— application of paints and coatings
— type-approved products.

Appendix 1 sets requirements for the above quality control items; these requirements shall be taken into account in the quality control plan.

3.8.2 Instructions concerning quality control measures and inspections

For every quality control measure or inspection conducted in accordance with the quality control plan, written instructions shall exist stating the method and scope of and the requirements for the inspection and the person performing it; also the drawing up of records and the submission of reports shall be described. As regards detailed information, standards may be referred to.

3.8.3 Recording of the results of quality control measures

Item-specific quality control measures are recorded according to the applicable instructions. The following items must be included in the records:
— item inspected and action taken
— result of test/inspection
— date of recording and author
— distribution.

The licence applicant shall review all records, prepare summary protocols of the inspections and send these to STUK for information.

3.9 Inservice inspection plan

The inservice inspection plan contains the inspections to be conducted on structures at specified intervals during plant operation, the manner of performance of the inspections and the criteria for assessment and recording of the inspection results.

The plan for the inservice inspection of containment building concrete structures shall include the following information:
— inspection of structural deformations at specified intervals and in conjunction with leakage and pressure tests

— inspection of the condition of post-tensioned concrete containment tendons and anchorages at specified intervals
— inspection of structures essential for the containment function by test loading or by other reliable methods, if necessary.

3.10 Plan for containment building pressure and leakage tests

This document presents the plan for containment building pressure and leakage tests. /4/ and /5/ give useful guidance relating to the plan.

Unambiguous pressure and leakage test acceptance criteria for at least the below items are to be presented in the document:
— containment building deformations under various loads
— recovery of the deformations
— cracking
— stresses
— temperatures
— leak volumes.

4 Quality control during construction

4.1 General

The fabrication of concrete structures is based on STUK-approved design documents of structures and on plans for individual work phases or work assignments.

The fabrication of Safety Class 2 structures may be started after STUK has approved the design documentation for the structures. However, concreting, injection or prestressing may only be started after an inspector from the Centre has approved detailed work plans and ascertained on the site that there is sufficient readiness to start work.

The fabrication of Safety Class 3 structures may be started after STUK has approved the design documents for the structures. In its decision STUK will separately list structures whose concreting, injection or prestressing may only be started after an inspector from the Centre has approved detailed work plans and ascertained on the site that there is sufficient readiness to start work.

Application of paint and coatings on Safety Class 2 and 3 concrete structures may be started after STUK has approved the relevant documents.

4.2 Concreting plan and other work plans

Detailed requirements for the concreting plan and other work plans are presented in Appendix 2.

4.3 Procedure tests

In at least the following cases, procedure tests are required to demonstrate the validity of a work method:
— the work method, e.g. a demanding injection work, is used for the first time
— it is difficult to ascertain the results and validity of accomplished work
— accomplished work is difficult to repair.

Plans and justifications for the procedure tests shall be presented for the assessment of the test results.

The procedure tests may also be necessary for demonstrating worker qualifications.

4.4 Audits

The licence applicant shall supervise the implementation of quality assurance in various organisations to the extent deemed necessary and in accordance with Guide YVL 1.4. Audits are particularly important if deviations from approved documents and plans have been observed.

Independently of the licence applicant's follow-up inspections STUK carries out audits at various sites before the commencement of and during construction work in a scope the Centre considers

necessary; these visits are made in particular to the below production plants which supply materials:
— cement works
— steel works (reinforcement steel and tendons)
— production plans manufacturing components for the prestressing method
— production plants manufacturing steel components transmitting loads
— concrete and concrete element works.

4.5 Approval of inspection agencies performing supervision of fabrication

Inspection agencies inspecting and monitoring concrete structures of nuclear power plants, and materials and structural components related to the fabrication of the concrete structures are subject to approval by the Ministry for the Environment or by STUK. The requirements for documents concerning accreditation of the inspection agencies are given in Guide YVL 1.3.

An inspection agency may, to an extent approved by STUK, replace some of the quality control implemented by the licence applicant or the manufacturer. However, the use of an inspection agency does not reduce the licence applicant's overall responsibility as regards the sufficiency and effectiveness of quality control.

4.6 Deviation report

If deviations from approved documents are detected in fabrication, a deviation report shall be drawn up in which at least the following information is presented:
— description of item
— who detected the deviation
— author of report
— persons handling the matter
— description of the deviation
— proposal/plan for action
— notes indicating inspection/approval
— distribution of deviation report.

4.7 Submission of reports to STUK

Reporting aims to provide prerequisites for the monitoring of work progress and of the control actions taken and for the rapid assessment of test results.

The licence applicant is responsible for reporting the following information to STUK:

Work schedules
— overall schedules
— monthly schedules
— weekly schedules for concreting work; work schedules for the next two weeks are submitted weekly.

Combinations of major results concerning concreting work
— cement test results
— test results from construction site and mixing plant
— grading strengths of Safety Class 2 structures by concreting section
— moving average and grading strength of nine test pieces from the construction site test results
— test results of reinforcement steels and tendons
— other results required.

The licence applicant draws up a plan on how to inform STUK before the construction of the plant is commenced and submits the plan to STUK for approval. The plan shall contain the following information:
— research institutes submit their reports direct to STUK
— combinations of major results concerning concreting work are sent to STUK every month.

STUK shall be notified without delay if any part of the concrete test results deviates from the acceptable range of fluctuation. The same applies if any unexpected matters which may affect the acceptability of the structures arise at the construction site.

Upon completion of a nuclear facility's concrete structures, a concrete work report shall be drawn up which must be submitted to STUK before buildings are commissioned. The report shall contain i.a. the following information:

— the contractor's work arrangements
— quality assurance and control
— quality control of materials
— quality control of work performance
— concreted structures
— acceptability of hardened concrete
— concrete acceptance tests at the mixing plant
— concrete acceptance tests at the site
— special concretings
— groutings and other concretings made afterwards
— prestressing work
— deviations and how they are addressed
— summary.

Annual statistics on concreting may replace the concrete work report if the information required of the work report is included in the said statistics.

5 Commissioning inspections

Buildings and structures can be commissioned after they have been accepted in a commissioning inspection. The commissioning inspections of Safety Class 2 and 3 buildings and structures are conducted by an inspector from STUK. The commissioning inspections of Safety Class EYT (non-nuclear) buildings and structures are the responsibility of the licence applicant.

The procedures by which the licence applicant accepts the completed buildings and structures for commissioning shall be presented to STUK.

In the commissioning inspection it is inspected that

— structures and buildings conform to the design documents approved by STUK (document review and visual inspection)
— deviations have been handled in an acceptable manner
— quality control records have been reviewed and approved by the licence applicant and by STUK's representative
— the licence applicant has, on his part, performed the commissioning inspections.

The licence applicant shall submit to STUK a written request for a commissioning inspection at least one week before the date of inspection of the structures.

Before the reactor is loaded, the commissioning inspections of the plant's buildings and structures shall have been acceptably performed to the extent required by nuclear safety.

6 Control during plant operation

6.1 Inservice inspections

During the operation of a nuclear facility, the licensee shall conduct inservice inspections of buildings and structures according to a separate programme. The inservice inspection requirements presented in the design data shall be taken into consideration in the inspection programme. Detailed instructions for the inspections can be sent to STUK for approval later, however, not later than one month before the first inspection date planned.

STUK oversees the licensee's inservice inspections at its discretion and, in addition to this, also conducts inservice inspections of Safety Class 2 and 3 buildings and structures according to an own programme.

6.2 Repairs and modifications

This Guide is to be applied, to the extent appropriate, when concrete structures are repaired or modified during operation of nuclear facilities.

7 References

1 The Finnish Building Code (RakMK)

2 The Building Act 370/58

3 The Building Decree 266/59

4 USNRC Regulatory Guides

5 The Code of Federal Regulations (CFR), Part 50, Appendix J

Appendix 1 Item-specific quality control requirements for concrete structures

Appendix 2 Concreting plans and other work plans

Appendix 1

Item-specific quality control requirements for concrete structures

Items subject to quality control

1 Mixing plant and laboratory
2 Concrete constituents
3 Fresh concrete
4 Hardening and hardened concrete
5 Reinforcement steels
6 Reinforcement splicing sleeves of steel and end anchorage
7 Prestressing systems
8 Steel components transmitting loads
9 Special mortars and concretes
10 Application of paints and coatings
11 Type approved products

1 Mixing plant and laboratory

When quality control at the mixing plant and laboratory is subject to inspection approved by the Ministry of the Environment (concrete manufacture under certified quality control), a separate report on concrete quality control at the mixing plant is not required. It is then sufficient that the concrete mixing company's quality manual is sent to STUK for information.

If the mixing plant is not subject to inspection approved by the Ministry of the Environment (concrete manufacture under non-certified quality control), a separate report on concrete quality control at the mixing plant is required (App. 2, point 1.1) which shall be submitted to STUK for approval. The concrete quality control shall satisfy the requirements of the regulations and directions in the Finnish Building Code (RakMK) and the requirements of the instructions for ready-mixed concrete plants issued by the Quality Control Association of Finnish Concrete Industry (BLT).

The results of concrete quality control shall also be presented in the form of graphs which are to be displayed at the premises of the concrete laboratory.

2 Concrete constituents

Cement

The acceptability of construction cements and the mineral additives of concrete shall be verified according to the regulations and directions in the RakMK. However, samples must always be taken of cement if there is any reason to doubt its acceptability. The tests shall be conducted at an approved testing laboratory.

Aggregate

Before concreting work is started, the aggregate to be used in concrete mixing is subject to acceptance tests at an approved testing laboratory; the mineralogical composition, strength, purity, particle shape, density etc of the aggregate is determined by the tests. The tests shall be repeated if the aggregate essentially changes, or, if there is any reason to doubt its acceptability.

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Water

Before commencement of construction, the quality of the water used for concrete mixing shall be determined by tests. The water shall be subjected to tests during the construction phase if there is any reason to doubt its acceptability.

Admixtures

In the use of concrete admixtures, the regulations and directions in the RakMK shall be complied with. Product declarations shall be sent to STUK for information when the concrete preliminary test programme is submitted.

3 Fresh concrete

The properties of fresh concrete shall be monitored both at the mixing plant and the construction site as follows:

— Mixing plant

Concrete manufacture under certified quality control: concrete shall be mixed and the properties of fresh concrete shall be determined according to the instructions issued by the BLT.

Concrete manufacture under non-certified quality control: a description of matters concerning concrete mixing and the quality control of fresh concrete shall be given. The properties required of freshly mixed concrete shall always be tested in connection with sampling. For every testing, at least two tests are conducted.

— Construction site

The consistency of freshly mixed concrete shall always be determined in connection with the making of test pieces. Other properties of freshly mixed concrete are monitored, where necessary.

4 Hardening and hardened concrete

Preliminary testing of concrete

Preliminary tests shall be undertaken to determine the correct composition of fresh concrete and to test the fulfilment of the properties required in plans, such as

— compressive strength
— permeability to water
— permeability to gas
— fluidity
— frost-resistance
— shrinkage/creep.

The preliminary testing programme shall be sent to STUK for information before testing is started. Test results are sent to STUK for information before concreting work is started. In the tests, the same concrete constituents shall be used as in actual work. Preliminary tests shall be repeated if essential changes occur in the constituents, admixture or composition of concrete, or in other conditions.

Concrete qualification tests

During construction work, the following tests shall be conducted to assess the acceptability of concrete:

— Mixing plant

Concrete manufacture under certified quality control: concrete qualification tests are conducted in compliance with the regulations and directions in the RakMK and with the instructions issued by the BLT.

Concrete manufacture under non-certified quality control: concrete qualification tests are conducted in compliance with the regulations and directions in the RakMK.

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— Concrete elements

Concrete qualification tests are conducted according to the regulations and directions in the RakMK and the instructions issued by the BLT.

— Construction site

Safety Class 2 concrete structures

For determining the standard strength of concrete, at least one test piece shall be made for each beginning 25 cubic metres of concrete and for each strength class; however, at least three test pieces shall be made for each concreting section (small concreting sections will be assessed case by case). Some test pieces can be tested before or after the actual quality assessment age.

For determining the permeability to water of concrete, at least three test pieces shall be made for each beginning 250 cubic metres of the concrete if a permeability-to-water requirement has been set for the concrete.

A separate, written plan shall be made, where necessary, to control tensile strength and bond strength, permeability to gas and other properties of the concrete.

Test pieces shall be taken of the finished structure or, reliable tests are to be performed by NDT methods to determine the compressive strength and possible other properties of the concrete in accordance with a separately approved programme. So many tests shall be conducted that, by their means and by means of the standard test pieces, a reliable idea is obtained of the properties of the concrete used for the structural element in question.

Safety Class 3 concrete structures

For determining concrete standard strength, at least one test piece shall be taken for each beginning 50 cubic metres and for each strength class. If the test pieces are subjected to tests before or after the actual quality assessment age, extra test pieces shall be made for the tests.

If a permeability requirement has been set for the concrete, at least one test piece shall be made for each beginning 250 cubic metres of the concrete to determine conformity with the requirement.

For controlling tensile and bond strength, permeability to gas and other properties of the concrete, a separate written plan shall be made, where necessary.

5 Reinforcement steels

The quality control of reinforcement steels shall meet the requirements of the regulations and directions in the RakMK. In addition, the following measures shall be contained in the quality control plan:

— Three specimens idential in size are to be taken of each batch of reinforcement steel for Safety Class 2 concrete structures; the samples shall undergo both tensile and bending tests.

— Specimens are to be taken of reinforcement steels for Safety Class 3 structures if there is any reason to doubt their acceptability.

— The tensile and bending tests of reinforcement steels are to be conducted at an approved testing laboratory.

The reinforcement steel test results shall be available before the structures are concreted from whose reinforcement steels the samples have been taken.

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6 Reinforcement splicing sleeves of steel and end anchorage

The quality control of reinforcement steel splices shall meet the regulations and directions in the RakMK. Furthermore, the following measures shall be included in the quality control plan:

— For the compliance verification of splicing sleeves for Safety Class 2 concrete structures, one specimen for each beginning 200 splices shall undergo a tensile test.
— Tensile tests of splicing sleeves shall be carried out at an approved testing laboratory.

The results of the splicing sleeve tensile tests shall be available before the structures are concreted from whose reinforcement steels the samples have been taken.

7 Prestressing systems

Sufficient preliminary descriptions shall exist of the properties of a prestressing system and of items relating to its implementation, such as bendings, anchors and splices. These descriptions shall be in the form of a certified product declaration.

Tendons

The quality control of tendons shall comply with the requirements of the regulations and directions in RakMK. Furthermore, the following measures shall be included in the quality control plan:

— Lists specifying the quality, nominal diameter, volume, batch number and factory materials testing results of various tendon delivery lots shall be presented.
— Of tendons for Safety Class 2 structures, one specimen shall be taken of every beginning fifty tonnes/batch/nominal diameter for both tensile and bending tests; however, at least three specimens shall be taken of each batch for tensile and bending tests.
— Tendons for Safety Class 2 structures are subjected to a stress corrosion test programme, if necessary.
— Specimens shall always be taken of tendons intended for Safety Class 3 structures if there is any reason to doubt their acceptability.
— Tensile, bending, relaxation and stress corrosion tests are conducted at the Technical Research Centre of Finland (VTT) or under VTT's supervision, whereupon VTT verifies the acceptability of the tendons.
— The results of tendon tensile and bending tests must be available before prestressing work is started on the tendons manufactured of the batch under examination.

The results of the 1000 hr relaxation test to which all tendons are subjected must be available before the grouting of prestressing cables manufactured of the batch studied is started.

Work related to the prestressing system and the installation and prestressing of tendons.

For the installation of the prestressing system and for the prestressing and grouting of tendons, a separate quality control plan shall be drawn up presenting the following items:

— corrosion protection of components of the prestressing system during transport, and during storage at the factory and the construction site
— installation of prestressing system components (ducts, tendons and anchorage)
— condition monitoring of prestressing system components during various work phases
— prestressing
— grouting.

8 Steel components transmitting loads

Anchor plates

The compliance verification of metal components in structures transmitting loads

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shall be arranged either as required in the regulations and directions of RakMK or in compliance with Guide YVL 4.2, Steel structures for nuclear facilities.

Anchor plates to be mechanically installed afterwards

Compliance of the type of anchor plate used shall be verified in accordance with the RakMK regulations and directions.

The use of anchor plates for the following purposes must always be justified
— anchorages which may be subjected to dynamic loads
— anchorage of Safety Class 1 and 2 equipment and piping.

A separate instruction shall be prepared for the installation and quality control of anchor plates; the instruction must also determine the qualifications of staff installing the anchor plates.

Other fastenings

A description shall be drawn up on the use and installation of other fastenings, such as grouted bolts and chemical anchors, covering the quality control measures concerning respective fastenings and their installation.

9 Special mortars and concretes

The quality control of special mortars and concretes shall conform to the requirements of the regulations and directions in the RakMK.

Special mortars

There shall be a quality control plan for grouting work carried out to repair structures and to protect steel structures against corrosion; the plan shall satisfy the requirements in the RakMK regulations and directions. Furthermore, the following requirements shall be included in the quality control plan for injection grout:
— For compressive strength tests, at least three 7-day and three 28-day specimens shall be made per each work shift/item; however, at least one 7-day and one 28-day specimen shall be fabricated per each beginning cubic metre of injection grout.
— 7-day and 28-day specimens shall be made of one batch of injection grout manufactured.
— Injection grout volume change shall be greater than bleeding.
— Specimens for the determination of injection grout bleeding and volume change shall always be made at the same time as compressive strength specimens.
— The consistency of injection grout is always determined during the fabrication of compressive strength test specimens.

Before the grouting work phase is started, preliminary tests on the injection grout shall be conducted to verify compliance with requirements.

10 Application of paints and coatings

A plan shall be drawn up covering the quality control of paint and coatings application. The plan shall describe the quality control measures taken by the various parties and the recording of the results.

11 Type approved products

Products type approved in Finland can be used in accordance with the type approval certificate and with the related manufacturers' instructions. The validity of the products need not be separately verified at the construction site, unless otherwise stated in the type approval certificate, or unless there is reason to assume that a product is not in conformity with the type approval certificate.

If the type approval certificate does not cover the installation of a product, an installation instruction shall be drawn up covering the quality control of installation.

Type approval certificate regarding all type approved products shall be sent to STUK.

Appendix 2
Concreting plan and other work plans

1 Concreting plan

A concreting plan is drawn up for every concreting section to provide additional information on details regarding the manufacture and quality control of structures.

1.1 Making of concrete

The concreting plan must be accompanied by a description of the process of making concrete. In case of concrete manufacture under certified quality control (App. 1, point 1), a separate description of the mixing plant and laboratory is not required.

In case of concrete manufacture under non-certified quality control (App. 1, point 1), a description shall be provided of the mixing plant and laboratory. In the report, the following items are presented:

— job descriptions and professional training of mixing plant staff
— general drawings of mixing plant and laboratory
— mixing plant equipment
— storage of concrete constituents
— inspections of equipment and measuring instruments
— description of concrete fabrication
— making of concrete in the cold season
— concrete laboratory and its equipment
— inspections of mixing plant and laboratory
— reserve mixing plant.

The mixing plant shall conform to the requirements in the BLT's instructions for ready-mixed concrete plants.

There shall be sufficient instructions for the making of concrete at the mixing plant. The instructions shall conform to the BLT's instructions for ready-mixed concrete plants, and they shall be sent to STUK for information.

1.2 Contents of concreting plan

The concreting plan consists of the following descriptions

— description of concreting section and work
— quality control plan for concreting section.

The concreting plan is drawn up by the contractor, and is reviewed by the building owner who adds to it his own quality control plan, if necessary. It is not necessary to repeat in the plan items which have been brought up in the design documentation, unless this is necessary for emphasising some measure related to quality control or work performance. A common concreting plan may be drawn up for small concreting sections for which similar concreting methods are used.

The concreting plan shall be submitted to STUK at least two weeks before concreting is started. However, if the concreting process in question is particularly extensive or demanding, the plan shall be submitted at least three weeks before concreting is commenced.

Appendix 2

1.3 Description of concreting section and work

— work schedule
— work supervision and workforce
— volumes of fresh concrete
— formwork (with dimensions, if necessary)
— reinforcements
— blockouts
— tendons, ducts and anchors
— preparatory work at the site
— concreting equipment
— concrete admixtures and their dispensing
— description of concreting work
— compaction of concrete
— construction joints
— temperature measurements of fresh concrete during hardening
— curing of concrete surfaces
— date of formwork removal.

1.4 Quality control plan for concreting section

The quality control plan for a concreting section contains a detailed description of all the inspection and quality control measures related to the manufacture of the section.

Inspection and quality control items relating to the manufacture of a concreting section are as follows:
— requirements which the concreting of a section places on other structures
— preliminary testing related to the concreting
— tests to be conducted on concrete constituents
— tests to be conducted on fresh concrete
— concrete test specimen plan
— tests to be conducted on hardened concrete
— tests to be conducted on reinforcement steels and tendons and their splices
— concrete transportation equipment
— concrete target temperatures
— provisions made for blasting and other vibrations
— monitoring of the strength gain of hardened concrete
— action plan in case concreting work is discontinued
— dimensions of structure
— curing of concrete.

2 Other work plans

Detailed other plans, e.g. prestressing and injection work plans, concerning work performance and quality control shall be submitted to STUK three weeks before the work in question is started. When drawing up the work plans, the procedures for concreting shall be applied.

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YVL 3.9 Nuclear power plant pressure vessels. Construction and welding filler materials, 6 April 1995 (in Finnish)

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YVL 5.6 Ventilation systems and equipment for nuclear power plants, 23 Nov. 1993 (in Finnish)

YVL 5.7 Pumps at nuclear facilities, 23 Nov. 1993 (in Finnish)

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The YVL-guides without any language marking are available both in English and Finnish.