INTERNATIONAL STANDARD

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Execution of concrete structures

Exécution des structures en béton

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22966 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and prestressed concrete*, Subcommittee SC 3, *Concrete production and execution of concrete structures*.

Introduction

This International Standard applies to the execution of concrete structures to achieve the intended levels of reliability and serviceability that are given in ISO 2394[3] and in standards for the design of concrete structures.

This International Standard has three functions:

— to transfer the requirements set during design from the designer to the constructor, i.e. to be a link between design and execution;

— to give a set of standardized technical requirements for the execution when ordering a concrete structure;

— to serve as a check list for the designer to ensure that he provides the constructor with all relevant technical information for the execution of the structure; see Annex A.

In order to achieve these objectives, it is necessary that the designer prepare a set of documents and drawings giving all information required for the execution of the work in accordance with the plans. This set of documents is in this International Standard referred to as the “execution specification”. This International Standard leaves a number of items open that can be decided by the execution specification.

It is necessary that the execution specification refer to national provisions in areas where these apply.

It is recognized in this International Standard that areas such as detailed requirements for competence of personnel and details related to quality management are within the competence of the member states.

A national annex can refer to national standards approved and published by an ISO member body and that supplement this International Standard; alternatively, the supplementing rules can be given directly in the national annex.

Execution of concrete structures

1 Scope

This International Standard gives common requirements for the execution of concrete structures and applies to both *in-situ* works and construction using prefabricated concrete elements.

This International Standard requires that the execution specification state all the specific requirements relevant to the particular structure.

This International Standard is applicable to temporary as well as permanent concrete structures.

Additional or different requirements can be considered and, if required, given in the execution specification when using

— lightweight aggregate concrete;

— other materials (e.g. fibres) or constituent materials;

— special technologies/innovative designs.

This International Standard does not apply to the following:

a) concrete members used only as equipment or construction aids for the execution;

b) specification, production and conformity of concrete;

c) production of precast concrete elements made in accordance with product standards;

d) safety and health aspects of execution, or third-party safety requirements;

e) contractual issues or responsibilities for the identified actions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6934 (all parts), *Steel for the prestressing of concrete*

ISO 6935-1, *Steel for the reinforcement of concrete — Part 1: Plain bars*

ISO 6935-2, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*

ISO 15630-1, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 1: Reinforcing bars, wire rod and wire*

ISO 17660-1, *Welding — Welding of reinforcing steel — Part 1: Load-bearing welded joints*

ISO 17660-2, *Welding — Welding of reinforcing steel — Part 2: Non-load-bearing welded joints*

ISO 22965-1, *Concrete — Part 1: Methods of specifying and guidance for the specifier*

ISO 22965-2, *Concrete — Part 2; Specification of constituent materials, production of concrete and compliance of concrete*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
back-propping
propping installed at levels below the slab that supports the falsework in order to distribute the load to suitable support

3.2
chair for reinforcement
device used to secure the position between reinforcement layers, e.g. supporting top reinforcement in a slab

3.3
construction works
everything that is constructed or results from construction operations

NOTE The term covers both building and civil engineering works. It refers to the complete construction comprised of both structural and non-structural components.

3.4
constructor
organization executing the works

3.5
erection specification
documents covering all drawings, technical data and requirements required for the safe erection of precast elements

3.6
execution
all activities carried out for the physical completion of the work, i.e. procurement, scaffolding, formwork, reinforcing, concreting, curing, erection of precast elements, etc., and the inspection and documentation thereof

3.7
execution class
classified set of requirements specified for the execution of the works as a whole or an individual component

3.8
execution specification
documents covering all drawings, technical data and requirements necessary for the execution of a particular project

NOTE The execution specification is not one document but signifies the total sum of documents required for the execution of the work as provided by the designer to the constructor and includes the project specification prepared to supplement and qualify the requirements of this International Standard, as well as referring to the national provisions relevant in the place of use.

3.9
falsework
temporary support for a part of a structure while it is not self-supporting and for associated service load

3.10
formwork
structure, permanent or temporary, for containing poured concrete, moulding it to the required dimensions and supporting it until it is able to support itself

NOTE Formwork consists of the face contact material and the bearers directly supporting the face contact material.

3.11
inspection
conformity evaluation by observation and judgment accompanied as appropriate by measurement, testing or gauging

[ISO 9000:2005[6], 3.8.2]

3.12
method statement
documentation describing the methods and procedures that shall be used to perform the work

3.13
permitted deviation
permitted algebraic differences between the limits of size and the corresponding reference size

[Adapted from ISO 1803:1997[1], 3.8.]

3.14
precast concrete element
concrete element cast and cured in a place other than the final location of use (factory produced or site manufactured)

NOTE Precast concrete element manufactured in compliance with the relevant international product standard is called a “precast concrete product.” In this International Standard, the shorter terms “precast element” and “precast product” are used.

3.15
project specification
project-specific document describing the requirements applicable for the particular project

3.16
quality plan
document specifying which procedures and associated resources shall be applied by whom and when to meet the requirements of the specific project

NOTE Guidance can be found in ISO 9000[6] concerning the content of a quality plan.

3.17
reference line
line defined in the execution specification to which positions are related

3.18
secondary line
any line used for the purpose of setting-out the proposed building and for checking the compliance of the building or building parts

[ISO 4463-1:1989[2], 4.4]

3.19
spacer
device used to secure correct spacing between the formwork and the reinforcement

3.20
surface finish
description of the appearance of the concrete surface including aspects of geometry, texture, colour etc.

3.21
temporary structure
structure designed for a short design working life

3.22
tolerance
difference between upper limit of size and the lower limit of size

[Adapted from ISO 1803:1997[1], 3.11.]

NOTE 1 Geometrical tolerances for precast concrete elements are subdivided as follows:

— production tolerances;

— erection tolerances, i.e. geometrical tolerances relating to location, verticality, horizontality or other characteristics of the construction assembly;

— construction tolerances, i.e. geometrical tolerances that are a combination of production, site construction and erection tolerances.

NOTE 2 Tolerance is an absolute value without sign, it is however commonly expressed by “the sum of the positive and negative permitted deviation” so that the value of the tolerance is implicit.

3.23
normal tolerance

basic limit for geometrical deviations that ensures that the structure

— satisfies the design assumptions;

— achieves other functional requirements of the construction works.

NOTE In this International Standard, normal tolerances are referred to as tolerance class 1.

3.24
special tolerance
tolerance other than normal tolerance

3.25
works
those parts of the construction works that are structural concrete work and are described in the execution specification

4 Execution management

4.1 Assumptions

4.1.1 This International Standard assumes the following:

— availability of a comprehensive design of the structure;

— project management in charge of the supervision of the works that can enable the execution of a conforming structure;

— site management that can take charge of the organization of the works and enable the correct and safe use of the equipment and machinery, the required quality of materials, the execution of a conforming structure and its safe use up to the delivery of the works.

4.1.2 When precast elements are used, the following additional assumptions are made:

— availability of a specific design of the precast elements conforming to the relevant standards;

— availability of design coordination between precast elements and site manufactured components;

— technical specification of the precast structure with instructions for installation;

— availability of an erection management to direct the erection team.

4.1.3 This International Standard presupposes that the work is carried out with the necessary skill and adequate equipment and resources to perform the work in accordance with this International Standard and the requirements of the execution specification.

NOTE In some countries, there are special requirements regarding the level of knowledge, training and experience of personnel involved in the various tasks.

4.1.4 It is assumed that the constructor will comply with national regulations and standards, e.g. with respect to

— quality management;

— qualifications for the personnel doing the various activities covered by this International Standard;

— health and safety aspects of construction;

— environmental aspects.

4.1.5 This International Standard assumes that the structure after completion is used as intended in the design and submitted to the planned inspection and maintenance necessary to achieve the intended design working life and to detect weaknesses or any unexpected behaviour.

4.2 Documentation

4.2.1 Execution specification

4.2.1.1 Before commencement of the execution of any part of the works, the execution specification relevant to that part of the works shall be complete and available.

4.2.1.2 The following items shall be included in the execution specification:

— reference to this International Standard and, if published, its national annex;

— reference to other relevant International Standards and national technical approvals;

— reference to relevant national regulations and standards;

— project specification giving information and requirements for the particular project prepared to supplement and qualify the requirements of the above-listed documents;

— drawings and other technical documents needed for the execution.

Annex H gives guidance on the content of a national annex to this International standard; a national annex may cover any of the areas indicated as open for specification by the execution specification.

NOTE Table A.1 contains a checklist of requirements and information that it can be necessary to include in the execution specification, as appropriate.

4.2.1.3 In addition, where relevant, procedures shall be established for

— making alterations to previously agreed requirements;

— distribution, filing and recording of technical documents used for the works.

4.2.2 Quality plan

4.2.2.1 Where a quality plan is required by the execution specification, it shall be available on site.

4.2.2.2 There may be one quality plan covering all activities or one overall plan supplemented by separate plans for the various phases and activities to be performed.

4.2.3 Execution record documentation

A record shall be made giving the required information as specified for the execution class in Tables 1, 2 and 3.

4.2.4 Special record documentation

If special documentation is required, the type and extent of the documentation shall be stated in the execution specification.

4.3 Quality management

4.3.1 Execution classes

4.3.1.1 Supervision and inspection of the work shall ensure that the construction is completed in accordance with the execution specification.

4.3.1.2 Inspection in this context refers to verifying conformity of the properties of products and materials being used as well as inspection of the execution of the works.

4.3.1.3 Requirements for quality management are specified using one of the following three classes, for which the required strictness increases from class 1 to class 3:

— execution class 1;

— execution class 2;

— execution class 3.

4.3.1.4 The execution class may refer to the complete structure, to components of the structure or to certain materials/technologies used for the execution.

4.3.1.5 The execution class being used shall be stated in the execution specification.

4.3.1.6 This International Standard does not deal with provisions related to degree of independence of the personnel performing the inspection.

4.3.1.7 Further detailing of the requirements for the quality management regime in excess of what is given in this International Standard may be stated in the execution specification.

NOTE Annex B gives guidance on quality management.

4.3.2 Inspection of materials and products

The inspection requirements for conformity with the execution specification are given in Table 1.

Table 1 — Inspection for materials and products

Subject	Execution class 1	Execution class 2	Execution class 3
Materials for scaffold, formwork and falsework[a]	In accordance with 5.1 and 5.2		
Reinforcing steel[a]	In accordance with 6.2		
Prestressing system components[a]	Shall not be used in this class	In accordance with 7.2	
Fresh concrete, ready-mixed or site-mixed[ac]	In accordance with 8.1 and 8.3 At reception of ready-mixed concrete a delivery ticket shall be present		
Other items[ab]	In accordance with the execution specification		
Precast elements[a]	In accordance with 9.2 and 9.3		
Inspection report	Not required	Required	

[a] Products bearing a recognized quality mark or certified by an approved certification body shall be checked against the delivery ticket and visually inspected. In cases of doubt, further inspection shall be undertaken to check that the product conforms to its specification. Other products shall be subject to inspection and acceptance testing as defined in the execution specification.

[b] For example, items such as embedded steel components, etc.

[c] If prescribed concrete is used, the relevant properties shall be checked by tests.

4.3.3 Inspection of execution

The inspection requirements for conformity with the execution specification are given in Tables 2 and 3.

Table 2 — Inspection requirements

Subject for inspection of execution	Execution class 1	Execution class 2	Execution class 3
Scaffolding, formwork and falsework	According to requirements given in Clause 5		
Embedded items	According to requirements given in 5.6		
Ordinary reinforcement	According to requirements given in Clause 6		
Prestressing reinforcement	Shall not be used in this class	According to requirements given in Clause 7	
Site transport and casting and curing of concrete	According to requirements given in Clause 8		
Erection of precast elements	According to requirements given in Clause 9		
As-built geometry	Not required	According to execution specification	

Table 3 — Type and documentation of inspection

	Execution class 1	Execution class 2	Execution class 3
Type of inspection	Visual inspection and random measurements	Visual inspection and systematic and regular measurements of major works	Visual inspection Detailed inspection of all works which are significant for the load-bearing capacity and durability of the structure
Party which carries out the inspection	Self inspection	Self inspection Inspection in accordance with the procedures of the constructor Possible additional requirements by execution specification	Self inspection Inspection in accordance with the procedures of the constructor Additional requirements by project execution specification
Extent	All works	In addition to the self inspection, there shall be a systematic and regular inspection of the works	In addition to the self inspection, there shall be a systematic and regular inspection of the works
Inspection report	Not required	Required	
As-built geometry	Not required	According to execution specification	

4.4 Action in the event of a non-conformity

4.4.1 Where inspection reveals a non-conformity, appropriate action shall be taken to ensure that the structure is able to perform as designed.

4.4.2 The following aspects shall be investigated in the listed order:

a) implications of the non-conformity on further execution and fitness for intended design purpose;

b) measures necessary to make the component acceptable;

c) necessity of rejection and replacement of the non-repairable component.

4.4.3 If required in the execution specification, the rectification of non-conformity shall be in accordance with a procedure stated in the execution specification or as agreed upon.

5 Falsework and formwork

5.1 Basic requirements

5.1.1 Falsework and formwork including their supports and foundations shall be designed and constructed so that they are

— capable of resisting any foreseeable action to which they are submitted during the construction process;

— stiff enough to ensure that the tolerances specified for the structure are satisfied and the integrity of the structural member is not affected.

5.1.2 The form, function, appearance and durability of the permanent works shall not be impaired or damaged due to the performance of the falsework, formwork and back-propping or their removal.

5.1.3 Falsework and formwork shall comply with this International Standard and the relevant International Standard, if available, or be demonstrably fit for the intended use.

NOTE 1 Annex C gives guidance on falsework and formwork.

NOTE 2 Falsework and formwork that comply with International Standards prepared for systems for temporary equipment can be deemed to satisfy this International Standard.

5.2 Materials

5.2.1 General

Any material may be used provided that its use fulfils the criteria for the structure given in 5.1 and Clause 8. The material should comply with the relevant product standard or, where none exists, the material may be used provided that the characteristics of the material are taken into account.

5.2.2 Release agents

5.2.2.1 Release agents, where used, shall be selected and applied in such a way that they are not harmful to concrete, reinforcing steel, prestressing steel or formwork and in such a way that they have no detrimental effects on the permanent structure.

5.2.2.2 Release agents shall have no unintended effect on the colour, surface quality of the permanent structure or specified subsequent coatings.

5.3 Design and installation of falsework

5.3.1 A method statement, where required by the execution specification, shall give the design parameters/class adopted and describe the method of erection and dismantling of temporary structures including back-propping. It shall specify the requirements for handling, adjusting, intentional precambering, loading, unkeying, striking and dismantling.

5.3.2 The design of the falsework shall take into account the deformation during and after concreting to prevent deleterious cracking in the young concrete.

5.3.3 The layout of falsework shall not restrain the elastic deformation of the concrete during post-tensioning.

5.3.4 Where the design of the finished permanent structure requires support of part of the structure until further parts or supporting structures, including backfilling, are completed, such requirements shall be stated in the execution specification.

5.4 Design and installation of formwork

5.4.1 A method statement, where required by the execution specification, shall describe the methods of support, erection and dismantling. It shall specify the requirements for handling, adjusting, tying, intentional precambering, loading, unkeying, striking and dismantling.

5.4.2 Formwork shall keep the concrete in its required shape until it is sufficiently hardened.

5.4.3 Formwork and joints shall be sufficiently tight so as to minimize loss of fines.

5.4.4 Formwork likely to absorb significant amounts of water from the concrete or facilitate evaporation shall be suitably treated to reduce water uptake from the concrete, unless intended specifically for that purpose.

5.4.5 The internal surface of the formwork shall be clean. If the formwork is required by the execution specification to produce visible concrete surfaces, the treatment of the formwork surfaces shall be such that the specified finish is achievable.