Annex 1
UNE standards list

Contents of the Annex

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The articles of this Structural Code establish a series of checks on the conformity of the products and processes included in their scope, which, in many cases, refer to UNE, UNE-EN or UNE-EN ISO standards.

The list of versions corresponding to the standards applicable in each case, with reference to their approval date, is as indicated in this annex, except in the following cases:

(*) Harmonized standards. The harmonized standards included in this annex will be used in the latest version published in the Official Journal of the European Union (DOUE)

(**) Standard cited in a harmonized standard. The version included in this annex will be used except within the scope of the harmonized standard, for which the version included in said harmonized standard shall be applied.

1 UNE Standards

UNE 14618:2017	Weld inspectors. Qualification and certification
UNE 22470:2015	Sustainable mining management system. Indicators.
UNE 22480:2015	Sustainable mining management systems. Requirements.
UNE 36060:2014	Steel welded fabric for structural use in concrete reinforcement. Steel welded fabric made out of steel bars B 500 SD.
UNE 36065:2011	Ribbed weldable steel bars with special characteristics of ductility for reinforced concrete reinforcement
UNE 36068:2011	Ribbed bars of weldable steel for the reinforcement of concrete.
UNE 36094:1997 UNE 36094:1997 Erratum	Steel wires and strands for prestressed concrete reinforcements.
UNE 36521:2018	Steel products. Hot rolled taper flange I sections (old IPN). Dimensions
UNE 36522:2018	Steel products. Section UPN. Dimensions.

UNE 36523:2018	Steel products. Section UPE. Dimensions.
UNE 36524:2018	Hot rolled steel sections. Broad, parallel faced flanged beams. Dimensions
UNE 36525:2018	Steel products. Section U. Dimensions
UNE 36526:2018	Hot rolled steel products. IPE beams. Dimensions.
UNE 36740:1998	Adherence test for steel for reinforcement of concrete. Beam test.
UNE 36831:1997	Reinforcing steel for concrete structures. Cutting, bending and placement of bars and welded fabric. Preferential schedules.
UNE 36901:2018	Iron and steel sustainability management systems. Requirements.
UNE 41184:1990	Prestressing systems for post-tensioned reinforcements, definitions, characteristics and tests
UNE 48103:2014	Paints and varnishes. Standardised colours.
UNE 53974:2011	Plastics. Expanded polystyrene (EPS) elements for floors with concrete applied in situ
UNE 67036:1999	Clay brick products. Moisture expansion test
UNE 67037:1999	Clay brick flooring blocks. Bending resistance test.
UNE 83115:1989 EX	Aggregates for concrete. Measurement of the friability coefficient of sand.
UNE 83460-2:2005	Concrete additions. Silica fume. Part 2. General recommendations for using silica fume.
UNE 83503:2004	Concretes with fibers. Measurement of the workability by means of the inverted cone.
UNE 83510:2004	Concretes with fibers. Determination of the toughness index and resistance to first crack.
UNE 83515:2010	Fibre reinforced concrete. Determination of cracking strength, ductility and residual tensile strength. Barcelona test.
UNE 83516:2015	Fibre reinforced concrete. Fibres for concrete. Alkali resistant glass fibres. Definitions, classification and specifications.
UNE 83607:2014 IN	Sprayed concrete. General recommendations.
UNE 83951:2008	Concrete durability. Water for mixing and aggressive waters. Sampling.

UNE 83952:2008	Durability of the concrete. Mixing waters and aggressive waters. Determination of the pH. Potentiometric method.
UNE 83954:2008	Durability of the concrete. Aggressive waters. Determination of the ion ammonium.
UNE 83955:2008	Durability of the concrete. Aggressive waters. Determination of the ion magnesium.
UNE 83956:2008	Durability of the concrete. Mixing waters and aggressive waters. Determination of the ion sulphate.
UNE 83957:2008	Durability of the concrete. Mixing waters and aggressive waters. Determination of the dry remainder
UNE 83958:2014	Concrete durability. Water for mixing and aggressive water. Determination of the chloride content
UNE 83959:2014	Concrete durability. Water for mixing. Determination of the sugar.
UNE 83960:2014	Concrete durability. Mixing water. Determination of the ether soluble organic substances content.
UNE 83963:2008 UNE 83963:2008 Erratum:2011	Concrete durability. Aggressive soils for concrete. Determination of the ion sulphate content.
UNE 83993-1:2013	Durability of concrete. Test method. Measurement of carbonation penetration rate in hardened concrete. Part 1: Natural method.
UNE 146403:2018	Determination of clay lumps in coarse aggregates for concrete.
UNE 146404:2018	Aggregates for concrete. Measurement of the friability coefficient of the sands.
UNE 146406:2018	Determination of the content, size typical maximum and grain sized unit of the coarse aggregates in the fresh concrete.
UNE 146508:2018	Test for aggregates. Determination of the alkali-silica and alkali-silicate potential reactivity of aggregates. Accelerated mortar bar test.
UNE 146509:2018	Determination of the potential reactivity of aggregates with alkalis. Concrete prism method

UNE 146513:2018	Aggregate test. Determination of the potential reactivity of aggregates. Chemical method. Determination of alkali-carbonate reactivity
UNE 146901:2008	Aggregates. Designation.
UNE 150008:2008	Environmental risk analysis and assessment.
UNE 166002:2014	R&D&i management: R&D&i management system requirements.
UNE 180201:2016	Formwork. General Design, performance requirements and verifications

2 UNE-EN Standards

UNE-EN 196-1:2018(**)	Methods of testing cement - Part 1: Determination of strength
UNE-EN 196-2:2014(**)	Method of testing cement - Part 2: Chemical analysis of cement
UNE-EN 196-3:2017(**)	Methods of testing cement - Part 3: Determination of setting times and soundness
UNE-EN 197-1 (*)	Cement - Part 1: Composition, specifications and conformity criteria for common cements
UNE-EN 206:2013+A1:2018 (**)	Concrete. Part 1: Specifications, Performance, Production and Compliance
UNE-EN 445:2009	Grout for prestressing tendons. Test methods.
UNE-EN 447:2009	Grout for prestressing tendons. Specification for common grout
UNE-EN 450-1 (*)	Fly ash for concrete. Part 1. Definitions, specifications and conformity criteria.
UNE-EN 451-1:2017(**)	Method of testing fly ash. Part 1. Determination of free calcium oxide content.
UNE-EN 451-2:2017(**)	Method of testing fly ash. Part 2. Determination of fineness by wet sieving.
UNE-EN 523 (*)	Steel strip sheaths for prestressing tendons. Terminology, requirements, quality control.

UNE-EN 524-1:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 1: determination of shape and dimensions.
UNE-EN 524-2:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 2: determination of flexural behaviour.
UNE-EN 524-3:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 3: to-and-fro bending test.
UNE-EN 524-4:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 4: determination of lateral load resistance.
UNE-EN 524-5:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 5: determination of tensile load resistance.
UNE-EN 524-6:1997(**)	Steel strip sheaths for prestressing tendons. Test methods. Part 6: determination of leaktightness (determination of water loss).
UNE-EN 772-19:2001(**)	Methods of test for masonry units - Part 19: Determination of moisture expansion of large horizontally perforated clay masonry units.
UNE-EN 933-1:2012(**)	Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method
UNE-EN 933-2:1996 UNE-EN 933-2:1996/1M:1999	Test for geometrical properties of aggregates. Part 2: determination of particle size distribution. Test sieves, nominal size of apertures.
UNE-EN 933-3:2012(**)	Tests for geometrical properties of aggregates - Part 3: Determination of particle shape - Flakiness index
UNE-EN 933-8:2012 +A1:2015(**) UNE-EN 933-8:2012+A1:2015/1M:2016(**)	Tests for geometrical properties of aggregates - Part 8: Assessment of fines - Sand equivalent test.
UNE-EN 933-9:2010 +A1:2013(**)	Tests for geometrical properties of aggregates - Part 9: Assessment of fines - Methylene blue test
UNE-EN 934-2 (*)	Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures - Definitions, requirements, conformity, marking and labelling

UNE-EN 934-5 (*)	Admixtures for concrete, mortar and grout - Part 5: Admixtures for sprayed concrete - Definitions, requirements, conformity, marking and labelling
UNE-EN 1062-3:2008(**)	Paints and varnishes - Coating materials and coating systems for exterior masonry and concrete - Part 3: Determination of liquid water permeability
UNE-EN 1065:1999 UNE-EN 1065:2001 Erratum	Adjustable telescopic steel props - Product specifications, design and assessment by calculation and tests
UNE-EN 1090-1 (*)	Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components
UNE-EN 1090-2:2019(**)	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures
UNE-EN 1097-2:2010(**)	Tests for mechanical and physical properties of aggregates - Part 2: Methods for the determination of resistance to fragmentation
UNE-EN 1097-6:2014(**)	Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption
UNE-EN 1263-1:2014	Temporary works equipment - Safety nets - Part 1: Safety requirements, test methods
UNE-EN 1363-2:2000	Fire resistance tests - Part 2: Alternative and additional procedures
UNE-EN 1365-3:2000	Fire resistance tests for loadbearing elements - Part 3: Beams
UNE-EN 1367-2:2010(**)	Tests for thermal and weathering properties of aggregates - Part 2: Magnesium sulphate test
UNE-EN 1504-2 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 2: Surface protection systems for concrete
UNE-EN 1504-3 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control

	and evaluation of conformity - Part 3: Structural and non-structural repair
UNE-EN 1504-4 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 4: Structural bonding
UNE-EN 1504-5 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 5: Concrete injection
UNE-EN 1504-6 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 6: Anchoring of reinforcing steel bar
UNE-EN 1504-7 (*)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 7: Reinforcement corrosion protection
UNE-EN 1504-9:2011(**)	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 9: General principles for the use of products and systems
UNE-EN 1542:2000(**)	Products and systems for the protection and repair of concrete structures. Test methods. Measurement of bond strength by pull-off.
UNE-EN 16031:2013	Adjustable telescopic aluminium props - Product specifications, design and assessment by calculation and tests
UNE-EN 16502:2015	Test method for the determination of the degree of soil acidity according to Baumann-Gully
UNE-EN 1744-1:2010 +A1:2013(**)	Tests for chemical properties of aggregates - Part 1: Chemical analysis
UNE-EN 1766:2000(**)	Products and systems for the protection and repair of concrete structural. Test methods. Reference concretes for testing.
UNE-EN 1990:2019	Eurocode - Basis of structural design.

UNE-EN 1991-1-2:2019	Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire
UNE-EN 1991-2:2019	Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges.
UNE-EN 1992-1-1:2013 UNE-EN 1992-1-1:2013/A1:2015	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
UNE-EN 1992-1-2:2011	Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design
UNE-EN 1992-2:2013	Eurocode 2 - Design of concrete structures - Concrete bridges - Design and detailing rules
UNE-EN 1993-1-1:2013 UNE-EN 1993-1-1:2013/A1:2014	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
UNE-EN 1993-1-2:2016	Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design
UNE-EN 1993-1-4:2012	Eurocode 3 - Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
UNE-EN 1993-1-5:2013	Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements
UNE-EN 1993-1-8:2013	Eurocode 3: Design of steel structures - Part 1-8: Design of joints
UNE-EN 1993-1-9:2013	Eurocode 3: Design of steel structures - Part 1-9: Fatigue
UNE-EN 1993-1-10:2013	Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
UNE-EN 1993-2:2013	Eurocode 3 - Design of steel structures - Part 2: Steel Bridges
UNE-EN 1994-1-1:2013	Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings
UNE-EN 1994-1-2:2016	Eurocode 4 - Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design.

UNE-EN 1994-2:2013	Eurocode 4 - Design of composite steel and concrete structures - Part 2: General rules and rules for bridges
UNE-EN 6892-1:2017	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2016)
UNE-EN 10024:1995	Hot roller taper flange i sections. Tolerances on shape and dimensions.
UNE-EN 10025-1 (*)	Hot rolled products of structural steels - Part 1: General technical delivery conditions
UNE-EN 10025-2:2006(**)	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
UNE-EN 10025-3:2006(**)	Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
UNE-EN 10025-4:2007(**)	Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
UNE-EN 10025-5:2007(**)	Hot rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
UNE-EN 10025-6: 2007/A1:2009(**)	Hot rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
UNE-EN 10029:2011	Hot-rolled steel plates 3 mm thick or above - Tolerances on dimensions and shape
UNE-EN 10034:1994	Structural steels i and h sections. Tolerances on shape and dimensions.
UNE-EN 10051:2012	Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels - Tolerances on dimensions and shape
UNE-EN 10055:1996	Hot rolled steel equal flange tees with radiused root and toes. Dimensions and tolerances on shape and dimensions.

UNE-EN 10056-1:2017	Structural steel equal and unequal leg angles - Part 1: Dimensions
UNE-EN 10056-2:1994	Structural steel equal and unequal leg angles - Part 2: Tolerances on shape and dimensions
UNE-EN 10058:2004	Hot rolled flat steel bars for general purposes - Dimensions and tolerances on shape and dimensions
UNE-EN 10059:2004	Hot rolled square steel bars for general purposes - Dimensions and tolerances on shape and dimensions
UNE-EN 10060:2004	Hot rolled round steel bars for general purposes - Dimensions and tolerances on shape and dimensions
UNE-EN 10061:2005(**)	Hot rolled hexagon steel bars for general purposes - Dimensions and tolerances on shape and dimensions
UNE-EN 10079:2008	Definition of steel products
UNE-EN 10080:2006	Steel for the reinforcement of concrete - Weldable reinforcing steel - General
UNE-EN 10083-1:2008	Steels for quenching and tempering - Part 1: General technical delivery conditions
UNE-EN 10088-1:2015(**)	Stainless steels - Part 1: List of stainless steels
UNE-EN 10088-4 (*)	Stainless steels - Part 4: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
UNE-EN 10088-5 (*)	Stainless steels - Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes
UNE-EN 10131:2007	Cold rolled uncoated and zinc or zinc-nickel electrolytically coated low carbon and high yield strength steel flat products for cold forming - Tolerances on dimensions and shape
UNE-EN 10149-2:2014	Hot rolled flat products made of high yield strength steels for cold forming - Part 2: Technical delivery conditions for thermomechanically rolled steels
UNE-EN 10149-3:2014	Hot rolled flat products made of high yield strength steels for cold forming - Part 3:

	Technical delivery conditions for normalized or normalized rolled steels
UNE-EN 10162:2005(**)	Cold rolled steel sections - Technical delivery conditions - Dimensional and cross-sectional tolerances
UNE-EN 10164:2007(**)	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions
UNE-EN 10204:2006(**)	Metallic products - Types of inspection documents
UNE-EN 10210-1 (*)	Hot finished structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions
UNE-EN 10210-2 (*)	Hot finished structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties
UNE-EN 10219-1:2007(*) UNE-EN 10219-1:2007 Erratum 2010	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions
UNE-EN 10219-1:2007(*) UNE-EN 10219-1:2007	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions
UNE-EN 10219-2:2007(**)	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties
UNE-EN 10279:2001(**)	Hot rolled steel channels. Tolerances on shape, dimensions and mass.
UNE-EN 10346:2015	Continuously hot-dip coated steel flat products for cold forming - Technical delivery conditions
UNE-EN 12350-1:2009	Testing fresh concrete - Part 1: Sampling
UNE-EN 12350-2:2009(**)	Testing fresh concrete - Part 2: Slump-test
UNE-EN 12350-5:2009	Testing fresh concrete - Part 5: Flow table test
UNE-EN 12350-6:2009	Testing fresh concrete - Part 6: Density

UNE-EN 12350-7:2010(**)	Testing fresh concrete - Part 7: Air content - Pressure methods
UNE-EN 12350-8:2011	Testing fresh concrete - Part 8: Self-compacting concrete - Slump-flow test
UNE-EN 12350-9:2011	Testing fresh concrete - Part 9: Self-compacting concrete - V-funnel test
UNE-EN 12350-10:2011	Testing fresh concrete - Part 10: Self-compacting concrete - L box test
UNE-EN 12350-11:2010	Testing fresh concrete - Part 11: Self-compacting concrete - Sieve segregation test
UNE-EN 12350-12:2011	Testing fresh concrete - Part 12: Self-compacting concrete - J-ring test
UNE-EN 12390-1:2013	Testing hardened concrete - Part 1: Shape, dimensions and other requirements for specimens and moulds
UNE-EN 12390-2:2009	Testing hardened concrete - Part 2: Making and curing specimens for strength tests
UNE-EN 12390-2:2009/1M:2015	Testing hardened concrete - Part 2: Making and curing specimens for strength tests
UNE-EN 12390-3:2009(**)	Testing hardened concrete - Part 3: Compressive strength of test specimens
UNE-EN 12390-3:2009/AC:2011	Testing hardened concrete - Part 3: Compressive strength of test specimens
UNE-EN 12390-8:2009	Testing hardened concrete - Part 8: Depth of penetration of water under pressure
UNE-EN 12390-8:2009/1M:2011	Testing hardened concrete - Part 8: Depth of penetration of water under pressure
UNE-EN 12390-13:2014	Testing hardened concrete - Part 13: Determination of secant modulus of elasticity in compression
UNE-EN 12499:2003	Internal cathodic protection of metallic structures
UNE-EN 12499:2003/AC:2006	Internal cathodic protection of metallic structures
UNE-EN 12504-1:2009	Testing concrete in structures - Part 1: Cored specimens - Taking, examining and testing in compression
UNE-EN 12620 (*)	Aggregates for concrete

UNE-EN 12810-1:2005	Façade scaffolds made of prefabricated components - Part 1: Products specifications
UNE-EN 12812:2008	Falsework - Performance requirements and general design
UNE-EN 13036-4:2012(**)	Road and airfield surface characteristics - Test methods - Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test
UNE-EN 13055-1 (*)	Lightweight aggregates - Part 1: Lightweight aggregates for concrete, mortar and grout
UNE-EN 13055-1/AC:2004 (*)	Lightweight aggregates - Part 1: Lightweight aggregates for concrete, mortar and grout
UNE-EN 13369:2013	Common rules for precast concrete products
UNE-EN 13374:2013	Temporary edge protection systems - Product specification - Test methods
UNE-EN 13381-1:2016	Test methods for determining the contribution to the fire resistance of structural members - Part 1: Horizontal protective membranes
UNE-EN 13381-2:2016	Test methods for determining the contribution to the fire resistance of structural members - Part 2: Vertical protective membranes
UNE-EN 13381-3:2016	Test methods for determining the contribution to the fire resistance of structural members - Part 3: Applied protection to concrete members
UNE-EN 13381-4:2014	Test methods for determining the contribution to the fire resistance of structural members - Part 4: Applied passive protection to steel members
UNE-EN 13381-5:2016	Test methods for determining the contribution to the fire resistance of structural members - Part 5: Applied protection to concrete/profiled sheet steel composite member
UNE-EN 13381-6:2014	Test methods for determining the contribution to the fire resistance of structural members - Part 6: Applied

	protection to concrete filled hollow steel columns
UNE-EN 13438:2014	Paints and varnishes - Powder organic coatings for hot dip galvanised or sherardized steel products for construction purposes
UNE-EN 13479 (*)	Welding consumables - General product standard for filler metals and fluxes for fusion welding of metallic materials
UNE-EN 13501-1:2007+A1:2010(**)	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
UNE-EN 13501-2:2009+A1:2010	Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services
UNE-EN 13577:2008	Chemical attack on concrete - Determination of aggressive carbon dioxide content in water
UNE-EN 13579:2003(**)	Products and systems for the protection and repair of concrete structures - Test methods - Drying test for hydrophobic impregnation.
UNE-EN 13670:2013	Execution of concrete structures
UNE-EN 14399-1 (*)	High strength structural bolting assemblies for preloading - Part 1: General requirements
UNE-EN 14399-2:2016(**)	High-strength structural bolting assemblies for preloading - Part 2: Suitability for preloading
UNE-EN 14399-3:2016(**)	High-strength structural bolting assemblies for preloading - Part 3: System HR - Hexagon bolt and nut assemblies
UNE-EN 14399-4:2016(**)	High-strength structural bolting assemblies for preloading - Part 4: System HV - Hexagon bolt and nut assemblies
UNE-EN 14399-5:2016(**)	High-strength structural bolting assemblies for preloading - Part 5: Plain washers

UNE-EN 14399-6:2016(**)	High-strength structural bolting assemblies for preloading - Part 6: Plain chamfered washers
UNE-EN 14399-7:2009(**)	High-strength structural bolting assemblies for preloading - Part 7: System HR - Countersunk head bolt and nut assemblies
UNE-EN 14399-8:2009(**)	High-strength structural bolting assemblies for preloading - Part 8: System HV - Hexagon fit bolt and nut assemblies
UNE-EN 14399-10:2010(**)	High-strength structural bolting assemblies for preloading - Part 10: System HRC - Bolt and nut assemblies with calibrated preload
UNE-EN 14487-1:2008	Sprayed concrete - Part 1: Definitions, specifications and conformity
UNE-EN 14488-1:2006	Testing sprayed concrete - Sampling fresh and hardened concrete
UNE-EN 14488-2:2007	Testing sprayed concrete - Part 2: Compressive strength of young sprayed concrete
UNE-EN 14488-5:2007	Testing sprayed concrete - Part 5: Determination of energy absorption capacity of fibre reinforced slab specimens
UNE-EN 14488-7:2007	Testing sprayed concrete - Part 7: Fibre content of fibre reinforced concrete
UNE-EN 14630:2007(**)	Products and systems for the protection and repair of concrete structures - Test methods - Determination of carbonation depth in hardened concrete by the phenolphthalein method
UNE-EN 14647(*)	Calcium aluminate cement - Composition, specifications and conformity criteria
UNE-EN 14651:2007+A1:2008	Test method for metallic fibre concrete - Measuring the flexural tensile strength (limit of proportionality (LOP), residual)
UNE-EN 14721:2006+A1:2008	Test method for metallic fibre concrete - Measuring the fibre content in fresh and hardened concrete
UNE-EN 14889-1 (*)	Fibres for concrete - Part 1: Steel fibres - Definitions, specifications and conformity

UNE-EN 14889-2 (*)	Fibres for concrete - Part 2: Polymer fibres - Definitions, specifications and conformity
UNE-EN 14489-7:2007	Testing sprayed concrete - Part 7: Fibre content of fibre reinforced concrete
UNE-EN 15037-2:2009+A1:2011	Precast concrete products - Beam-and-block floor systems - Part 2: Concrete blocks
UNE-EN 15037-3 (*)	Precast concrete products - Beam-and-block floor systems - Part 3: Clay blocks
UNE-EN 15037-4 (*)	Precast concrete products - Beam-and-block floor systems - Part 4: Expanded polystyrene blocks
UNE-EN 15037-5 (*)	Precast concrete products - Beam-and-block floor systems - Part 5: Lightweight blocks for simple formwork
UNE-EN 15048-1 (*)	Non-preloaded structural bolting assemblies - Part 1: General requirements
UNE-EN 15048-2:2017(**)	Non-preloaded structural bolting assemblies - Part 2: Fitness for purpose
UNE-EN 15305:2010	Non-destructive Testing - Test Method for Residual Stress analysis by X-ray Diffraction
UNE-EN 15773:2019	Industrial application of powder organic coatings to hot dip galvanized or sherardized steel articles [duplex systems] - Specifications, recommendations and guidelines
UNE-EN 15804:2012+A1:2014	Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
UNE-EN 16247-1:2012	Energy audits - Part 1: General requirements
UNE-EN 16757:2018	Sustainability of construction works - Environmental product declarations - Product Category Rules for concrete and concrete elements
UNE- 83460-2:2005	Additions for concrete. Silica fume. Part 2: Recommendations for the use of silica fume.

UNE- 83503:2004	Concrete with fibres. Measurement of workability with the inverted cone.
UNE- 83510:2004	Concrete with fibers. Determination of the index of tenacity and strength with the first crack
UNE- 83515:2010	Fibre reinforced concrete. Determination of cracking strength, ductility and residual tensile strength. Barcelona test.
UNE- 83516:2015	Fibre reinforced concrete. Fibres for concrete. Alkali resistant glass fibres. Definitions, classification and specifications.
UNE- 83607:2014 IN	Sprayed concrete. General recommendations.

3 UNE-EN ISO Standards

UNE-EN ISO 148-1:2017	Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016)
UNE-EN ISO 286-2:2011	Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts (ISO 286-2:2010)
UNE-EN ISO 868:2003(**)	Plastics and ebonite - Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868:2003)
UNE-EN ISO 898-1:2015(**)	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1:2013)
UNE-EN ISO 898-2:2013(**)	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 2: Nuts with specified property classes - Coarse thread and fine pitch thread (ISO 898-2:2012)
UNE-EN ISO 1461:2010	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2009)
UNE-EN ISO 2063-1:2018	Thermal spraying - Zinc, aluminium and their alloys - Part 1: Design considerations and quality requirements for corrosion protection systems (ISO 2063-1:2017)

UNE-EN ISO 2063-2:2018	Thermal spraying - Zinc, aluminium and their alloys - Part 2: Execution of corrosion protection systems (ISO 2063-2:2017)
UNE-EN ISO 2409:2013(**)	Paints and varnishes - Cross-cut test (ISO 2409:2013)
UNE-EN ISO 2812-1:2018(**)	Paints and varnishes - Determination of resistance to liquids - Part 1: Immersion in liquids other than water (ISO 2812-1:2017)
UNE-EN ISO 2812-2:2007	Paints and varnishes - Determination of resistance to liquids - Part 2: Water immersion method (ISO 2812-2:2007)
UNE-EN ISO 3452-1:2013	Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1:2013, corrected version 2014-05-01)
UNE-EN ISO 3506-1:2010	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs (ISO 3506-1:2009)
UNE-EN ISO 3834-2:2006	Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements (ISO 3834-2:2005)
UNE-EN ISO 3834-3:2006	Quality requirements for fusion welding of metallic materials - Part 3: Standard quality requirements (ISO 3834-3:2005)
UNE-EN ISO 3834-4:2006	Quality requirements for fusion welding of metallic materials - Part 4: Elementary quality requirements (ISO 3834-4:2005)
UNE-EN ISO 4014:2011	Hexagon head bolts - Product grades A and B (ISO 4014:2011)
UNE-EN ISO 4016:2011	Hexagon head bolts - Product grade C (ISO 4016:2011)
UNE-EN ISO 4017:2015	Fasteners - Hexagon head screws - Product grades A and B (ISO 4017:2014)
UNE-EN ISO 4018:2011	Hexagon head screws - Product grade C (ISO 4018:2011)
UNE-EN ISO 4032:2013	Hexagon regular nuts (style 1) - Product grades A and B (ISO 4032:2012)
UNE-EN ISO 4033:2013	Hexagon high nuts (style 2) - Product grades A and B (ISO 4033:2012)
UNE-EN ISO 4034:2013	Hexagon regular nuts (style 1) - Product grade C (ISO 4034:2012)

UNE-EN ISO 4063:2011	Welding and allied processes - Nomenclature of processes and reference numbers (ISO 4063:2009, Corrected version 2010-03-01)
UNE-EN ISO 4624:2016	Paints and varnishes - Pull-off test for adhesion (ISO 4624:2016)
UNE-EN ISO 4628-2:2016(**)	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 2: Assessment of degree of blistering (ISO 4628-2:2016)
UNE-EN ISO 4628-3:2016	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 3: Assessment of degree of rusting (ISO 4628-3:2016)
UNE-EN ISO 4628-4:2016(**)	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 4: Assessment of degree of cracking (ISO 4628-4:2016)
UNE-EN ISO 4628-5:2016(**)	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 5: Assessment of degree of flaking (ISO 4628-5:2016)
UNE-EN ISO 4885:2017	Ferrous materials - Heat treatments - Vocabulary (ISO 4885:2018)
UNE-EN ISO 5470-1:2017(**)	Rubber- or plastics-coated fabrics - Determination of abrasion resistance - Part 1: Taber abrader (ISO 5470-1:2016)
UNE-EN ISO 5817:2014	Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2014)
UNE-EN ISO 6270-1:2002	Paints and varnishes - Determination of resistance to humidity - Part 1: Continuous condensation (ISO 6270-1:1998)
UNE-EN ISO 6272-1:2012(**)	Paints and varnishes - Rapid-deformation (impact resistance) tests - Part 1: Falling-weight test, large-area indenter (ISO 6272-1:2011)
UNE-EN ISO 6507-1:2018(**)	Metallic materials - Vickers hardness test - Part 1: Test method (ISO 6507-1:2018)

UNE-EN ISO 6507-2:2007	Metallic materials - Vickers hardness test - Part 2: Verification and calibration of testing machines (ISO 6507-2:2005)
UNE-EN ISO 6507-3:2007	Metallic materials - Vickers hardness test - Part 3: Calibration of reference blocks (ISO 6507-3:2005)
UNE-EN ISO 6507-4:2018	Metallic materials - Vickers hardness test - Part 4: Tables of hardness values (ISO 6507-4:2005)
UNE-EN ISO 6892-1:2017	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2016)
UNE-EN ISO 7089:2000	Plain washers. Normal series. Product grade A. (ISO 7089:2000).
UNE-EN ISO 7090:2000	Plain washers, chamfered. Normal series. Product grade A. (ISO7090:2000).
UNE-EN ISO 7091:2000	Plain washers. Normal series. Product grade C. (ISO 7091:2000).
UNE-EN ISO 7092:2000	Plain washers. Small series. Product grade A. (ISO 7092:2000).
UNE-EN ISO 7093-1:2000	Plain washers. Large series. Part 1: Product grade A. (ISO 7093-1:2000).
UNE-EN ISO 7093-2:2000	Plain washers. Large series. Part 2: Product grade C. (ISO 7093-2:2000).
UNE-EN ISO 7094:2000	Plain washers. Extra-large series. Product grade C. (ISO 7094:2000).
UNE-EN ISO 7438:2016	Metallic materials - Bend test (ISO 7438:2016)
UNE-EN ISO 7783:2012	Paints and varnishes - Determination of water-vapour transmission properties - Cup method (ISO 7783:2011)
UNE-EN ISO 8501-1:2008	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings (ISO 8501-1:2007)
UNE-EN ISO 8502-3:2017	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method) (ISO 8502-3:2017)
UNE-EN ISO 8503-1:2012	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates -

	Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces (ISO 8503-1:2012)
UNE-EN ISO 8503-2:2012	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel - Comparator procedure (ISO 8503-2:2012)
UNE-EN ISO 8503-3:2012	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 3: Method for the calibration of ISO surface profile comparators and for the determination of surface profile - Focusing microscope procedure (ISO 8503-3:2012)
UNE-EN ISO 8503-4:2012	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile - Stylus instrument procedure (ISO 8503-4:2012)
UNE-EN ISO 8503-5:2017	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 5: Replica tape method for the determination of the surface profile (ISO 8503-5:2017)
UNE-EN ISO 8504-1:2002	Preparation of steel substrates before application of paints and related products - Surface preparation methods - Part 1: General principles. (ISO 8504-1:2000)
UNE-EN ISO 8504-2:2002	Preparation of steel substrates before application of paints and related products - Surface preparation methods - Part 2: Abrasive blast-cleaning. (ISO 8504-2:2000)
UNE-EN ISO 8504-3:2002	Preparation of steel substrates before application of paints and related products - Surface preparation methods - Part 3: Hand- and power-tool cleaning. (ISO 8504-3:1993)
UNE-EN ISO 9001:2015(**)	Quality management systems - Requirements (ISO 9001:2015)

UNE-EN ISO 9013:2017	Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances (ISO 9013:2017)
UNE-EN ISO 9227:2017	Corrosion tests in artificial atmospheres - Salt spray tests (ISO 9227:2017)
UNE-EN ISO 9606-1:2017	Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2012 including Cor 1:2012 and Cor 2:2013)
UNE-EN ISO 9692-1:2014	Welding and allied processes - Types of joint preparation - Part 1: Manual metal arc welding, gas-shielded metal arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1:2013)
UNE-EN ISO 9712:2012	Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)
UNE-EN ISO 10675-1:2017	Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys (ISO 10675-1:2016)
UNE-EN ISO 11666:2011	Non-destructive testing of welds - Ultrasonic testing - Acceptance levels (ISO 11666:2018)
UNE-EN ISO 12696:2017	Cathodic protection of steel in concrete (ISO 12696:2016)
UNE-EN ISO 12944-4:2018	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 4: Types of surface and surface preparation (ISO 12944-4:2017)
UNE-EN ISO 12944-5:2018	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 5: Protective paint systems (ISO 12944-5:2018)
UNE-EN ISO 12944-6:2018	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods (ISO 12944-6:2018)
UNE-EN ISO 13918:2009	Welding - Studs and ceramic ferrules for arc stud welding (ISO 13918:2017, Corrected version 2018-05)
UNE-EN ISO 13920:1997	Welding. General tolerances for welded constructions. Dimensions for lengths and angles. Shape and position. (iso 13920:1996).
UNE-EN ISO 14001:2015	Environmental management systems - Requirements with guidance for use (ISO 14001:2015)

UNE-EN ISO 14025:2010	Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006)
UNE-EN ISO 14555 2017	Welding - Arc stud welding of metallic materials (ISO 14555:2017)
UNE-EN ISO 14713-1:2017	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance (ISO 14713-1:2017)
UNE-EN ISO 14713-2:2011	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 2: Hot dip galvanizing (ISO 14713-2:2009)
UNE-EN ISO 14713-3:2017	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 3: Sherardizing (ISO 14713-3:2017)
UNE-EN ISO 14731:2008	Welding coordination - Tasks and responsibilities (ISO 14731:2006)
UNE-EN ISO 14732:2014	Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013)
UNE-EN ISO 15609-1:2005	Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1:2004)
UNE-EN ISO 15610:2004	Specification and qualification of welding procedures for metallic materials - Qualification based on tested welding consumables (ISO 15610:2003)
UNE-EN ISO 15611:2004	Specification and qualification of welding procedures for metallic materials - Qualification based on previous welding experience (ISO 15611:2003)
UNE-EN ISO 15612:2005	Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure (ISO 15612:2004)
UNE-EN ISO 15613:2005	Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test (ISO 15613:2004)

UNE-EN ISO 15614-1:2018	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2017, Corrected version 2017-10-01)
UNE-EN ISO 15630-1:2011	Steel for the reinforcement and prestressing of concrete - Test methods - Part 1: Reinforcing bars, wire rod and wire (ISO 15630-1:2010)
UNE-EN ISO 15630-2:2011	Steel for the reinforcement and prestressing of concrete - Test methods - Part 2: Welded fabric (ISO 15630-2:2010)
UNE-EN ISO 15630-3:2011	Steel for the reinforcement and prestressing of concrete - Test methods - Part 3: Prestressing steel (ISO 15630-3:2010)
UNE-EN ISO/IEC 17024:2012	Conformity assessment - General requirements for bodies operating certification of persons (ISO/IEC 17024:2012)
UNE-EN ISO 17635:2017	Non-destructive testing of welds - General rules for metallic materials (ISO 17635:2016)
UNE-EN ISO 17636-1:2013	Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1:2013)
UNE-EN ISO 17636-2:2013	Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2:2013)
UNE-EN ISO 17637:2017	Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637:2016)
UNE-EN ISO 17638:2017	Non-destructive testing of welds - Magnetic particle testing (ISO 17638:2016)
UNE-EN ISO 17640:2011	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640:2017)
UNE-EN ISO 17660-1:2008	Welding - Welding of reinforcing steel - Part 1: Load-bearing welded joints (ISO 17660-1:2006)
UNE-EN ISO 17659:2005	Welding - Multilingual terms for welded joints with illustrations (ISO 17659:2002)
UNE-EN ISO 17660-2:2008	Welding - Welding of reinforcing steel - Part 2: Non load-bearing welded joints (ISO 17660-2:2006)
UNE-EN ISO 23277:2015	Non-destructive testing of welds - Penetrant testing - Acceptance levels (ISO 23277:2015)

UNE-EN ISO 23278:2015	Non-destructive testing of welds - Magnetic particle testing - Acceptance levels (ISO 23278:2015)
UNE-EN ISO 50001:2018	Energy management systems - Requirements with guidance for use (ISO 50001:2018)

4 UNE-EN ISO/IEC Standards

UNE-EN ISO/IEC 17021-1:2015	Conformity assessment - Requirements for bodies providing audit and certification of management systems - Part 1: Requirements (ISO/IEC 17021-1:2015)
UNE-EN ISO/IEC 17025:2005	Conformity assessment. General requirements for the competence of testing and calibration laboratories
UNE-EN ISO/IEC 17025:2005 ERRATUM:2006	General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005/Cor.1:2006)
UNE-EN ISO/IEC 17065:2012	Conformity assessment - Requirements for bodies certifying products, processes and services (ISO/IEC 17065:2012)

5 Other Standards

ISO 29581-2 (**)	Cement. Test methods. Part 2. Chemical analysis using X-ray fluorescence.

Annex 2

Index of contribution of the structure to sustainability

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A2 Index of contribution of the structure to sustainability

A2.1 Index of contribution of the structure to sustainability (ICES)

A2.1.1 Definition of ICES

The Index of Contribution of the Structure to Sustainability (in Spanish “ICES") is defined as the sum of the contributions of each one of the processes involved in its project and construction, including the manufacturing and transformation of the materials it incorporates.

A2.1.2 Obtaining the ICES

The ICES shall be obtained by following the steps below:

a) Identification of the types of elements that make up the structure, according to A2.1.3,
b) Calculation of typological composition factors α_i , according to A2.1.4.
c) Identification of the processes involved in each of the types of structural elements obtained in a), according to table A2.2.
d) Identification of organizations, with their specific products or services, that contribute in each process, according to section A2.2.2.
e) Obtaining the index of contribution to the sustainability of each process $ICPS_{i,j}$, according to A2.2.

NOTE: In the event that more than one product or service participates for a specific process, the value weighted by the corresponding participation will be obtained.

f) Calculation of the ICES, according to the following expression:

$$ICES = \sum_{i=1}^{4} \alpha_i \cdot \sum_{j=1}^{11} \beta_{i,j} \cdot ICPS_{i,j}$$

where:

α_i : Typological composition factor corresponding to type i, according to A2.1.4.

$\beta_{i,j}$: Contribution factor corresponding to type i for the process or product j according to table A2.2.

$ICPS_{i,j}$: Index of contribution to sustainability for the process or product j in element i, according to section A2.2.4.

A2.1.3 Types of elements of the structure

The structure will be divided by types of elements, according to the following table:

Type, i	Definition
1	Reinforced concrete elements in situ
2	Prestressed concrete elements in situ
3	Prefabricated concrete elements
4	Structural steel elements

Table A2.1

Comments

The model contemplates the possibility that, in general, a structure is hybrid that is, formed by elements of up to four different types, which are those indicated in the table of the articles. However, in the most usual cases, the normal is that the number of typologies present in the structure is lower, as the following examples show:

- Structure of building with slab of reinforced in situ:
  A single typology (reinforced concrete in situ)
- Building structure with hollow slab:
  Two types (reinforced concrete in situ + prestressed concrete prefabricated)
- Prestressed deck bridge in situ:
  Two types (reinforced concrete in situ + prestressed concrete in situ)
- Mixed prestressed bridge:
  Three types (reinforced concrete in situ + prestressed concrete in situ + structural steel)

A2.1.4 Typological composition factor

For each of the types of elements i in Table A2.1, a typological composition factor is defined, linked to its mechanical capacity. This is obtained depending on the characteristic resistance of the concrete and the elastic limit of the structural steel that makes up each of the elements associated with each type of structure, weighted according to their corresponding masses.

The typological composition factor will be obtained from the characteristics defined in the project, except if they have been modified in the execution, in which case the final characteristics must be used.

For each type of element i, a typological composition α_i factor defined according to the following expression is defined

$$\alpha_i = \frac{\sum_{r=1}^{n} m_{r,i} \cdot R_{r,i}}{\sum_{r=1}^{N} m_r \cdot R_r}$$

Where:

$m_{r,i}$ is the measurement of all the elements that belong to type i, with characteristic resistance or elastic limit R_r, expressed in tonnes.

$R_{r,i}$ is the characteristic resistance of the concrete or the elastic limit of the steel of the elements associated with type i, expressed in MPa.

n is the total number of characteristic resistances of the concrete or elastic limits of the steel of the elements associated with the type of elements i

m_r is the measurement of all the elements contemplated in the project with characteristic resistance or elastic limit R_r, expressed in tonnes

R_r is the characteristic resistance of the concrete or the elastic limit of the steel contemplated by the project, expressed in MPa.

N is the total number of characteristic resistances of the concrete or elastic limits of the steel contemplated in the project

These typological composition factors shall be facilitated in the project.

Comments

By way of example for the application of the method, suppose the case of a mixed structure, a concrete building, constituted by the four types of elements.

The elements of reinforced concrete in situ (type 1), contemplated in the project use two types of concrete, HA-25 and HA-30 and two types of steel, SD-400 and SD-500. The prestressed concrete elements in situ (type 2) use HP-35 and HP-50 concrete as well as SD-400 and SY-1770 steels.

For the prefabricated elements (type 3) the concrete HA-35 and HP-45 and 3 types of steel, SD-400, SD-500 and SY1770 are used. Finally, structural steel elements (type 4) use S-355 steel.

The measurements of each one of the concretes and steels used, for each one of the types of elements, are shown in the following table, both in tons and in percentage with respect to the total measurement of the project.

	TYPES OF ELEMENTS		$R_{r,i}$ (Mpa)	$m_{r,i}$ (T)	$m_{r,i}$ (%) ($m_{r,i}/M_{total\ project}$)	m_i (%) $R_{r,i}$	$\alpha_i = \frac{\sum m_{r,i} R_{r,i}}{\sum m_r R_r}$
1	**Reinforced concrete elements in situ**						0,372
	Concrete 1	HA-25	25	144,90	34,5	862,5	
	Concrete 2	HA-30	30	86,10	20,5	615,0	
	Steel 1	SD-400	400	3,36	0,8	320,0	
	Steel 2	SD-500	500	8,40	2,0	1000,0	
						2797,5	
2	**Prestressed concrete elements in situ**						0,215
	Concrete 1	HP-35	35	63,00	15	525,0	
	Concrete 2	HP-50	50	10,50	2,5	125,0	
	Steel 1	SD-400	400	0,84	0,2	80,0	
	Steel 2	SY-1770	1770	2,10	0,5	885,0	
						1615,0	
3	**Prefabricated concrete elements**						0,215
	Concrete 1	HA-35	35	52,50	12,5	437,5	
	Concrete 2	HP-45	45	27,30	6,5	292,5	
	Steel 1	SD-400	400	0,84	0,2	80,0	
	Steel 2	SD-500	500	0,84	0,2	100,0	
	Steel 3	SY-1770	1770	1,68	0,4	708,0	
						1618,0	
4	**Structural steel elements**						0,198
	Steel 1	S-355	355	17,64	4,2	1491,0	
						1491,0	
			∑	420	100	7521,5	1

The typological composition factor for each type of element will be:

For reinforced concrete elements in situ:

$$\alpha_1 = \frac{25 \cdot 34{,}5 + 30 \cdot 20{,}5 + 400 \cdot 0{,}8 + 500 \cdot 2}{7.521{,}5} = \frac{2.797{,}5}{7.521{,}5} = 0{,}372$$

For pre-stressed concrete elements in situ:

$$\alpha_2 = \frac{35 \cdot 15 + 50 \cdot 2{,}5 + 400 \cdot 0{,}2 + 1.770 \cdot 0{,}5}{7.521{,}5} = \frac{1.615}{7.521{,}5} = 0{,}215$$

For prefabricated concrete elements:

$$\alpha_3 = \frac{35 \cdot 12{,}5 + 45 \cdot 6{,}5 + 400 \cdot 0{,}2 + 500 \cdot 0{,}2 + 1.770 \cdot 0{,}4}{7.521{,}5} = \frac{1.618}{7.521{,}5} = 0{,}215$$

And for structural steel elements:

$$\alpha_2 = \frac{355 \cdot 4{,}2}{7.521{,}5} = \frac{1491}{7.521{,}5} = 0{,}198$$

A2.2 Index of process to contribution to sustainability (ICPS)

A2.2.1 Processes to be considered for each type of element

Depending on the type of element, you can identify those processes that are involved in your project and execution, and the products that it incorporates.

Table A2.2 shows the contribution factors of process and product $\beta_{i,j}$, defined as the participation percentages of each process or product j in the elements of each type i.

Process and product contribution factors $\beta_{i,j}$ [x10^{-2}]						
j	Process and product		$\beta_{i,j}$ (according to the type of element, i)			
			Type 1 Reinforced concrete elements in situ	Type 2 Prestressed concrete elements in situ	Type 3 Prefabricated concrete elements	Type 4 Structural steel elements
1	Design		5	5	5	5
2	Manufacture of basic products	Cements	27	26	27	0
3		Aggregates	3	3	3	0
4		Additives	3	3	3	0
5		Steel (1)	27	26	27	55/ 45 (4)
6	Manufacture of processed products	Ready-mixed concrete	10	10	0/ 6,6	0
7		Precasting plant (2)	0	0	20/ 13,4/ 6,8	0
8		Transformed steel (3)	10	4	0 /6,6	0/ 10 (4)
9		Metal structures workshop	0	0	0	25
10		Prestressing system “in situ” (5)	0	8	0	0
11	Construction on site		15	15	15	15

NOTES:

(1) Includes steel production processes and manufacturing of the following products:

- Long products manufactured by hot rolling (bars and rolls of steel for reinforcement steel, wire rod for further processing, profiles for structural steel).
- Flat products manufactured by hot or cold rolling (sheets for structural steel, coils and strips for further processing).

(2) The contribution factor shall be 20 in the case of prefabrication plants include the processes of concrete manufacture and transformation of steel. For those plants that do not contemplate the manufacture of concrete or the transformation of steel, the factor of contribution shall be reduced by 6.6 and 13.2, if it did not include either of the two previous processes.

(3) Includes the manufacturing processes of the following products:
- Hollow cross section profile finished in hot or cold rolled and profiles of open section cold rolled for structural steel.
- Drawn steel or cold rolled products for reinforcement steel and prestressing steel.
- Reinforcement steel (steel framework, electrowelded mesh and basic electrowelded latticework).

When a transformed product includes two consecutive transformation processes, both shall be considered by weighting them at 50%. For example, the manufacture of reinforcement steel from steel products obtained by cold drawing (includes the processes of cold drawing and mesh processing)

The products of the processed steel manufacturer are defined in the articles of this Code. Thus, reinforcement steel are defined in article 35 and the percentage of participation should be distributed according to the relative weight of the types of elements that make up a certain passive reinforcement (steel framework, etc.).

(4) For fabricated structural steel elements which do not use processed steel products, the share percentage of the steel basic product shall be, for example, hot-rolled full-section sections and sheets. For structural steel elements which use processed steel products, the share percentage of the steel basic product shall be 45 and for transformed product shall be 10, for example, the transformation of hot rolled flat products (coil, strip) for the manufacture of steel structural products (open cross section structural profiles or hollow cross section profiles). For structural steel elements which use processed steel and non-processed steel products, calculation of ICES must be weighted according to the quantity of each type.

(5) Includes the Own Elements (Kits) of Prestressed System "in Situ" and the Application of the prestressing load in the construction.

Table A2.2. Process and product contribution factors $\beta_{i,j}$ [x10^{-2}]

Comments

The model considers each structure as the aggregation of a series of elements which may be made of different types (concrete or steel, reinforced concrete or prestressed concrete, precast or executed in situ). The ICES calculation considers the contribution of some processes or others depending on the type of element.

When a factor β_{ij}takes the value zero, it indicates that the corresponding process has no participation in the project, manufacture or construction of that type of element. Thus, for example $\beta_{4,6} = 0$, it indicates that the prepared concrete manufacturing process has no participation in case of a structural steel element.

For a structure in which all its elements were made of reinforced concrete in situ, the ICES calculation is obtained as:

$$ICES = [0{,}05\ ICPS_{project} + 0{,}27\ ICPS_{cement} + 0{,}03\ ICPS_{aggregates} + 0{,}03\ ICPS_{additives} + 0{,}27\ ICPS_{steel} + 0{,}10\ ICPS_{prepared\ concrete} + 0{,}10\ ICPS_{transformed\ steel} + 0{,}15\ ICPS_{building}]$$

For structure with reinforced concrete elements in situ and prestressed concrete elements in situ, the calculation of the ICES is obtained as:

$$ICES = \alpha_1[0{,}05\ ICPS_{project} + 0{,}27\ ICPS_{cement} + 0{,}03\ ICPS_{aggregates} + 0{,}03\ ICPS_{additives} + 0{,}27\ ICPS_{steel} + 0{,}10\ ICPS_{prepared\ concrete} + 0{,}10\ ICPS_{transformed\ steel} + 0{,}15\ ICPS_{building}] + \alpha_2[0{,}05\ ICPS_{project} + 0{,}26\ ICPS_{cement} + 0{,}03\ ICPS_{aggregates} + 0{,}03\ ICPS_{additives} + 0{,}26\ ICPS_{steel} + 0{,}10\ ICPS_{prepared\ concrete} + 0{,}0\ 4ICPS_{transformed\ steel} + 0{,}08\ ICPS_{prestressed\ system} + 0{,}15\ ICPS_{building}]$$

For a steel structure with all its elements made of steel, the calculation of the ICES is obtained as:

$$ICES = [0{,}05\ ICPS_{project} + 0{,}45\ ICPS_{steel} + 0{,}10\ ICPS_{transformed\ steel} + 0{,}25\ ICPS_{steel\ workshop} + 0{,}15\ ICPS_{building}]$$

For a structure in which all its elements were precasted concrete, and involving a prefabrication center that produces both the concrete and the processed steel used in the manufacture of its precasted elements, the calculation of the ICES get as:

$ICES=[0{,}05\ ICPS_{project}+0{,}27\ ICPS_{cement}+0{,}03\ ICPS_{aggregate}+0{,}03\ ICPS_{additive}+0{,}27\ ICPS_{steel}+0{,}20\ ICPS_{prefabrication\ central\ A}+0{,}15\ ICPS_{builgding}]$

Whether it is the same structure where the precast plant produces its own concrete, but not the processed steel, which is supplied by an external workshop, the calculation of the ICES is obtained as:

$ICES=[0{,}05\ ICPS_{project}+0{,}27\ ICPS_{cement}+0{,}03\ ICPS_{aggregate}+0{,}03\ ICPS_{additive}+0{,}27\ ICPS_{steel}+0{,}134\ ICPS_{prefabrication\ central\ B}+0{,}066\ ICPS_{transformed\ steel}+0{,}15\ ICPS_{building}]$

A2.2.2 Agents participating in the structure

For the purposes of this Code, agent is understood as the public or private person, who prepares structural projects, builds structures or manufactures the basic or processed products indicated in table A2.2. The performance of the functions of the agents will be carried out through an organization.

A2.2.3 Definition of ICPS

The contribution index of the process or product *j* to sustainability in the structural element *i*, $ICPS_{i,j}$ represents the contribution of the agent (ICAS, see section A2.3) and of the project, product or specific work (ICS, see section A2.4).

The contribution indicator of the process or product *j* and the sustainability for the structural element *i*, $ICPS_{i,j}$ represents the agent contribution (ICAS, see section A2.3) and of the project, product or concrete work contribution (ICS, see section A2.4) .

In the case of having more than one agent in a process or product *j*, it should be weighted according to corresponding participation.

This weighting shall take into account the real supplies of the work and shall ensure traceability between the intervening agents and their ICPS. The breakdown of basic products that supply the different agents which supply processed products should be carried out, generally, on a case-by-case basis. The documentation that allows calculations of the final ICES of the work shall include the one referred to in Annex 4 of this Code.

A2.2.4 Obtaining the ICPS

For each type of element *i* and for each type of process or product j, the contribution index of the process or product to sustainability is defined, according to the following expression:

$$ICPS_{i,j} = \left(\varepsilon_{a,j} \cdot ICAS_{j,n} + \varepsilon_{c,j} \cdot ICS_{j,n}\right)$$

where:

$ICAS_{j,n}$ is the contribution index of agent *j* to sustainability, according to A2.3,

$ICS_{j,n}$ is the index of complementary contribution of the project, product or work, as the case may be, to sustainability, according to A2.4,

$\varepsilon_{a,j}, \varepsilon_{c,j}$ are weighting factors, which take the values indicated in table A2.3 depending on the type of process or product *j* relevant.

WEIGHTING FACTORS $\varepsilon_{a,j}$ AND $\varepsilon_{c,j}$				
j	Process or product		Weighting Factor	
			$\varepsilon_{a,j}$	$\varepsilon_{c,j}$
1	Project		0,25	0,75
2	Basic Products	Cement	0,70	0,30
3		Aggregates	0,70	0,30
4		Additives	0,70	0,30
5		Steel	0,70	0,30
6	Processed Products	Ready-mixed concrete	0,65	0,35
7		Precasting plant	0,65	0,35
8		Processed Steel	0,65	0,35
9		Metal structures workshop	0,65	0,35
10		Prestressing system “in situ”	0,50	0,50
11	Construction on site		0,70	0,30

Table A2.3. Weighting Factors

Comments

Below are two examples of calculation of ICPS with participation of more than one agent for the same process, the first one for a structure type 1 made entirely with reinforced concrete in situ and the second one for a structure type 2 formed by precasted concrete elements, whose processes have been carried out by different agents under the following conditions:

Example 1: "In situ" reinforced concrete structure

Project: The project of the structure has been carried out in the same organization

$$\mathrm{ICPS}_{1,1} = 0{,}25 \cdot \mathrm{ICAS}_{\text{designer}} + 0{,}75 \cdot \mathrm{ICS}_{\text{project}}$$

Ready-mixed concrete: The structure has two types of concrete (HA-25 and HP-70) that are supplied from two different A and B plants. The first of the plants supplies a part of the HA-25 concrete that accounts for 45% of the concrete of the structure. The central B, for its part, supplies both HA-25 and HP-70, in volumes that represent, respectively, 35% and 20% of the concrete of structure

$$\mathrm{ICPS}_{1,6} = 0{,}65 \cdot (0{,}45 \cdot \mathrm{ICAS}_{\text{central A}} + 0{,}55 \cdot \mathrm{ICAS}_{\text{central B}})$$

$$+0{,}35 \cdot (0{,}45 \cdot \mathrm{ICS}_{\text{concrete HA-25 central A}} + 0{,}35 \cdot \mathrm{ICS}_{\text{concrete HA-25 central B}} + 0{,}20 \cdot \mathrm{ICS}_{\text{concrete HA-70 central B}})$$

The concrete plants declare, for the production of said concretes, cements, aggregates and additives have been used by the following suppliers:

Cement: As a result of the dosages used, it is known that two types of cement are used, used in each of the concrete with proportions of 60% and 40% from a single manufacturer.

$$\begin{aligned}\mathrm{ICPS}_{1,2} &= 0{,}70 \cdot (0{,}60\ \mathrm{ICAS}_{\text{fab cement 1}} + 0{,}40\ \mathrm{ICAS}_{\text{fab cement 2}}) + 0{,}30 \cdot (\mathrm{ICS}_{\text{cement 1}} + \mathrm{ICS}_{\text{cement 2}}) \\ &= 0{,}70 \cdot (\mathrm{ICAS}_{\text{fab cement}}) + 0{,}30 \cdot (0{,}60\ \mathrm{ICS}_{\text{cement 1}} + 0{,}40\ \mathrm{ICS}_{\text{cement 2}})\end{aligned}$$

Aggregates: The aggregates come from two different manufacturers: the first of them supplies a single aggregate, which represents 41% of the one used in the work site and the second supplies two different aggregates, which represent respectively 36% and 23% of the aggregates used in the work site:

$$\begin{aligned}\mathrm{ICPS}_{1,3} = 0{,}70 \cdot [0{,}41 \cdot \mathrm{ICAS}_{\text{fab aggregate 1}} + (0{,}36 + 0{,}23) \cdot \mathrm{ICAS}_{\text{fab aggregate 2}}] + 0{,}30 \cdot (0{,}41 \cdot \mathrm{ICS}_{\text{aggregate 1}} \\ + 0{,}36 \cdot \mathrm{ICS}_{\text{aggregate 2}} + 0{,}23 \cdot \mathrm{ICS}_{\text{aggregate 2}})\end{aligned}$$

Additives: For both concretes a single additive is used from a single manufacturer:

$$\mathrm{ICPS}_{1,4} = 0{,}70 \cdot \mathrm{ICAS}_{\text{fab additive}} + 0{,}30 \cdot \mathrm{ICS}_{\text{additive}}$$

Ready-mixed concrete: The structure has two types of concrete (HA-25 and HP-70) that are supplied from two different A and B plants. The first of the plants supplies a part of the HA-25 concrete, which accounts for 45% of the concrete of structure. The central B, for its part, supplies both HA-25 and HP-70, in volumes that represent, respectively, 35% and 20% of the concrete of structure.

$$\mathrm{ICPS}_{1,6} = 0{,}65 \cdot (0{,}45 \cdot \mathrm{ICAS}_{\text{central A}} + 0{,}55 \cdot \mathrm{ICAS}_{\text{central B}})$$

$$+0{,}35 \cdot (0{,}45 \cdot \mathrm{ICS}_{\text{concrete HA-25 central A}} + 0{,}35 \cdot \mathrm{ICS}_{\text{concrete HA-25 central B}} + 0{,}20 \cdot \mathrm{ICS}_{\text{concrete HA-70 central B}})$$

Steel: The reinforcing steel of the structure is 90% formed by reinforcements manufactured in a steel framework installation from hot rolled ribbed bars. The remaining 10% of the reinforcing steel is formed by electrowelded meshes from a single manufacturer.

In turn, the reinforcing steel used in the rebar come from two different steelmakers, in proportions of 42% and 58%, respectively. The meshes for its part, are manufactured with cold drawn wire from wire rod from two different manufacturers, in proportions of 67% and 33%.

$$\text{ICPS}_{1,5} =$$

$$0{,}70 \cdot \begin{pmatrix} 0{,}9\ [0{,}42 \cdot \text{ICAS}_{\text{fab rebar 1}} + 0{,}58\ \text{ICAS}_{\text{fab rebar 2}}] \\ +0{,}1 \cdot [0{,}67 \cdot \text{ICAS}_{\text{fab wire rod 1}} + 0{,}33 \cdot \text{ICAS}_{\text{fab wire rod 2}}] \end{pmatrix} + 0{,}30 \begin{pmatrix} 0{,}9[0{,}42 \cdot \text{ICS}_{\text{rebar 1}} + 0{,}58 \cdot \text{ICS}_{\text{rebar 2}}] \\ +0{,}1[0{,}67 \cdot \text{ICS}_{\text{wire rod 1}} + 0{,}33 \cdot \text{ICS}_{\text{wire rod}}] \end{pmatrix}$$

Processed steel: Following the example of steel, with the same values and conditions for rubbed bars and welded mesh.

$$\text{ICPS}_{1,8} = 0{,}65 \cdot \left(0{,}9 \cdot \text{ICAS}_{\text{fab steel framework}} + 0{,}1 \cdot \left[0{,}5 \cdot \text{ICAS}_{\text{fab wire drawing}} + 0{,}5 \cdot \text{ICAS}_{\text{fab wire mesh}}\right]\right)$$

$$+0{,}35 \cdot \left(0{,}9 \cdot \text{ICS}_{\text{steel framework}} + 0{,}1 \cdot \left[0{,}5 \cdot \text{ICS}_{\text{wire drawing}} + 0{,}5 \cdot \text{ICS}_{\text{wire mesh}}\right]\right)$$

Construction: On-site construction is carried out by a UTE in which two construction companies participate with a participation of 35% and 65% respectively:

$$\text{ICPS}_{1,11} = 0{,}70 \cdot (0{,}35 \cdot \text{ICAS}_{\text{builder 1}} + 0{,}65 \cdot \text{ICAS}_{\text{builder 2}}) + 0{,}30 \cdot \text{ICS}_{\text{building}}$$

Example 2: Structure of Precast concrete elements

The structure is completely precast concrete, composed of beams and columns of a company A and forged alveolar slabs of a company B. The concrete of the beams is HA-35 and accounts for 25% of the total weight of the structure. The concrete of the columns is HA-40 and accounts for 30% of the total weight of the structure. And the concrete of the alveolar slabs is HP-40 and accounts for 45% of the remaining weight of the structure. In this case, both companies produce both the concrete and the processed steel used in the manufacture of the precast elements.

The values of $\text{ICPS}_{3,1}$ to $\text{ICPS}_{3,5}$ and $\text{ICPS}_{3,11}$ shall be considered equal to those of Example 1.

$$\text{ICPS}_{3,6} = 0$$

$$\text{ICPS}_{3,7} = 0{,}65 \cdot (0{,}55 \cdot \text{ICAS}_{\text{central A}} + 0{,}45 \cdot \text{ICAS}_{\text{central B}}) + 0{,}35 \cdot (0{,}25 \cdot \text{ICS}_{\text{beam HA}-35\text{ central A}} + 0{,}30 \cdot \text{ICS}_{\text{column HA}-40\text{ central A}} + 0{,}45 \cdot \text{ICS}_{\text{slab HP}-40\text{ central B}})$$

$$\text{ICPS}_{3,8} = 0$$

A2.2.5 Requirements related to sustainability

The indicators used in this annex are structured according to the three dimensions of sustainability (economic, environmental and social) together with quality or performance criteria, as shown in table A2.4 below.

n	Type of requirement

1	Performance
2	Economic
3	Environmental
4	Social

Table A2.4

A2.3 Index of contribution of the agent to sustainability (ICAS)

A2.3.1 Design of ICAS

The processes and products of a structure may be performed by different agents (project author, manufacturer of basic materials, and manufacturer of transformed products or constructor).

For each of the processes or products j, an "agent contribution to sustainability" index, ICAS, is defined, which is obtained by means of the following equation:

$$ICAS_{j,n} = \sum_{n}^{4} \delta^{a}_{j,n} \cdot CAS_{\mathrm{j,n}}$$

where:

$\delta^{a}_{j,n}$ is a weighting factor of requirement type n for process j, according to Table A2.5. For each process or product j, the sum of the weighting factors of its requirements is unit.

$CAS_{j,n}$ is the contribution of agent j to sustainability, relative to each type of requirement n (performance, economic, environmental or social) calculated according to section A2.3.3.

WEIGHTING FACTOR $\delta_{j,n}^{a}$ (ICAS)						
j	Type of process or product		Type of requirement			
			Performance $n=1$	Economic $n=2$	Environmental $n=3$	Social $n=4$
1	Project		0,25	0,25	0,25	0,25
2	Basic Products	Cement	0,25	0,10	0,45	0,20
3		aggregates	0,15	0,10	0,40	0,35
4		Additives	0,15	0,15	0,50	0,20
5		Steel	0,05	0,05	0,50	0,40
6	Processed Products	Prepared Concrete	0,25	0,10	0,50	0,15
7		Prefabrication Center	0,25	0,30	0,35	0,10
8		Processed Steel	0,10	0,05	0,45	0,40
9		Structural steel workshop.	0,10	0,05	0,45	0,40
10		"In situ" prestressing system	0,25	0,25	0,25	0,25
11	Construction site		0,30	0,20	0,30	0,20

Table A2.5. Values of $\delta_{j,n}^{a}$ for the calculation of ICAS

Comments

In other words, the contributions of the agents in each of the dimensions of sustainability are weighted through a coefficient δ, as follows:

$$ICAS_{j,n} = \sum_{n}^{4} \delta^{a}_{\mathrm{j,n}} \cdot CAS_{\mathrm{j,n}}$$

$$= \delta^{a}_{j,prestacional} \cdot CAS_{j,prestacional} + \delta^{a}_{j,económico} \cdot CAS_{j,economic} + \delta^{a}_{j,medioambiental} \cdot CAS_{j,environmental} + \delta^{a}_{j,social} \cdot CAS_{j,social}$$

The ICAS value for each agent exclusively reflects the conditions that the organization meets. Furthermore, it does not depend on the characteristics of the project, product or work.

A2.3.2 Criteria and indicators of agent sustainability

This Code contemplates for each process or product j a series of criteria l for each type of requirement n. Appendix A defines the associated indicators, in order to calculate the agent's contribution to sustainability.

In general, unless express order, the evaluation period for the indicators will be one year.

Comments

Section 1 of Appendix A contains a list of all the indicators considered in this Code sorted according to the type of requirement. Then, it is section 3 of said Appendix that defines which are applicable to each agent, type of requirement and criterion.

The obligatory nature of the indicators refers to the fact that these must necessarily be considered for the evaluation of index in all cases, regardless of the value they take.

A2.3.3 Contribution of the agent to sustainability (CAS)

For each agent j, their contribution to the sustainability associated with each type of requirement n (performance, environmental, economic or social) is calculated, CAS_{jn} according to the following expression:

$$CAS_{j,n} = \frac{\sum_{l=1}^{10} \gamma_{j,l} \cdot \lambda^{a}_{j,l}}{\sum \gamma_{j,l}}$$

where:

$\gamma_{j,l}$ is a weighting factor of criterion l for agent j, according to the tables in Appendix A. For each requirement n, the sum of the factors γ_{jl} is unit

$\lambda^{a}_{j,l}$ it is the assessment of the obligatory and voluntary indicators related to criteria l and applicable for agent j according to what is indicated in A2.3.4.

A2.3.4 Assessment criteria

For each agent j, all applicable indicators shall be identified for each criterion l, as indicated in section 3 of Appendix A. These indicators shall be:

— the obligatory, and

— in this case, those that have been voluntarily adopted by the agent, among those collected for that criterion in section 3 of Appendix A.

For each criterion l and for each agent j, its assessment λ_{jl} shall be determined as:

$$\lambda_{j,l}^{a} = \lambda_{j,l,B}^{a} + \lambda_{j,l,V}^{a} \not> 100$$

where:

$\lambda_{j,l}^{a}$ is the valuation obtained for criterion l by agent j.

$\lambda_{j,l,B}^{a}$ is the valuation of the obligatory part obtained for criterion l by agent j according to the systems indicated in column 5 "Assessment systems" of the indicator tables included in section 1 of Appendix A.

$\lambda_{j,l,V}^{a}$ is the valuation of the voluntary part obtained for criterion l by agent j according to the systems indicated in column 5 "Assessment systems" of the indicator tables included in section 1 of Appendix A.

For each agent j and each criterion l, the assessment of the obligaroty part of the criterion $\lambda_{j,l,B}^{a}$ shall be determined as:

$$\lambda_{j,l,B}^{a} = \frac{\sum_{b=1}^{M_{j,l}^{b}} \lambda_{j,l,b}^{a}}{M_{j,l}^{b}}$$

being:

$\lambda_{j,l,b}^{a}$ valuation of obligatory indicator b for criterion l and agent j, as indicated in Appendix A.

$M_{j,l}^{b}$ total number of obligatory indicators corresponding to criterion l and agent j, in accordance with what is indicated in Appendix A.

For its part, the assessment of the voluntary part of the criterion $\lambda_{j,l,V}^{a}$, shall be obtained by means of the following equation:

$$\lambda_{j,l,V}^{a} = \sum_{v=1}^{M_{j,l}^{v}} \frac{\lambda_{j,l,v}^{a}}{5 \cdot M_{j,l}^{v}} \not> \frac{\lambda_{j,l,B}^{a}}{2}$$

being:

$\lambda_{j,l,v}^{a}$ valuation of voluntary indicator v for criterion l and agent j, as indicated in Appendix A.

$M_{j,l}^{v}$ number of voluntary indicators corresponding to criterion l and the process or product j, as indicated in Appendix A.

In any case, the final assessment of each group of indicators which belong to the same criterion shall never be negative.

A2.4 Complementary index of contribution to sustainability (ICS)

A2.4.1 Design of ICS

For each project, product or work j, an "index of complementary contribution to sustainability" is defined, ICS defined as:

$$ICS_{j,n} = \sum_{n}^{4} \delta_{j,n}^{c} \cdot CCS_{\mathrm{j,n}}$$

where:

$\delta_{j,n}^{c}$ it is a weighting factor of the type of requirement *n* for the process or product *j*, according to table A2.6. For each project, product or work *j*, the sum of the weighting factors of its requirements is unity.

$CCS_{j,n}$ is the complementary contribution to the sustainability of each project, product or work j, relative to each type of requirement n, (performance, economic, environmental or social) calculated according to section A2.4.3.

WEIGHTING FACTOR $\delta_{j,n}^{c}$ (ICS)						
j	Type of process or product		Type of requirement			
			Performance $n=1$	Economic $n=2$	Environment $n=3$	Social $n=4$
1	Project		0,34	0,33	0,33	-
2	Basic products	Cement	0,8	-	0,20	-
3		Aggregate	0,50	-	0,50	-
4		Additive	0,50	-	0,50	-
5		Steel	0,10	-	0,90	-

WEIGHTING FACTOR $\delta_{j,n}^{c}$ (ICS)						
j	Type of process or product		Type of requirement			
			Performance $n = 1$	Economic $n = 2$	Environment $n = 3$	Social $n = 4$
6	Processed Product	Prepared Concrete	0,35	-	0,65	-
7		Prefabrication Central	0,50		0,50	
8		Processed Steel	0,20	-	0,80	-
9		Structural steel workshop	0,40	-	0,60	-
10		"In situ" prestressed concrete	0,50	-	0,25	0,25
11	Construction site		0,35	-	0,40	0,25

Table A2.6. Values of $\delta_{j,n}^{c}$ for the calculation of ICS

Comments

When the coefficients $\delta_{j,n}^{c}$ are not defined, it is considered that, for the purposes of this Code, the particular conditions of the project, the product or the work have no additional influence on the corresponding performance, environmental, economic or social requirement, which has not already been considered in the contribution of the agent.

That is, the contributions of the products or services in each of the dimensions of sustainability are weighted through a coefficient δ, as follows:

$$ICS_{j,n} = \sum_{n}^{4} \delta_{j,n}^{c} \cdot CCS_{\mathrm{j,n}}$$

$$= \delta_{j,prestacional}^{c} \cdot CCS_{j\ prestacional} + \delta_{j,económico}^{c} \cdot CCS_{j,económico} + \delta_{j,medioambiental}^{c} \cdot CCS_{j,medioambiental} + \delta_{j,social}^{c} \cdot CCS_{j,social}$$

The index of complementary contribution to sustainability does not depend on the characteristics of the organization but on those of the project, product or specific work.

A2.4.2 Criteria and indicators of sustainability of the process or product

This Code contemplates for each process or product j a series of criteria l for each type of requirement n. Appendix B defines the associated indicators, in order to calculate the contribution of the process or product to sustainability.

In general, unless express order, the evaluation period for the indicators will be one year.

Comments

Section 1 of Appendix B contains a list of all the indicators considered in this Code, sorted according to the type of requirement. Then, it is section 3 of Appendix B that defines which are applicable to each agent, type of requirement and criterion.

A2.4.3 Complementary contribution of the process to sustainability (CCS)

For each project, product or work j, its complementary contribution to sustainability is calculated CCS_{jn} associated with each type of requirement n (performance, economic, environmental or social), according to the following expression:

$$CCS_{j,n} = \frac{\sum_{l=1}^{7} \gamma_{j,l} \cdot \lambda_{j,l}^{c}}{\sum \gamma_{j,l}}$$

where:

$\gamma_{j,l}$ it is a weighting factor of criterion l for the project, product or work j, according to the tables in Appendix B. For each type of requirement n, the sum of the factors γ_{jl} is unity.

$\lambda_{j,l}^{c}$ it is the valuation of the indicators related to criterion l and applicable for the project, product or work j according to what is indicated in 14.4.4.

A2.4.4 Assessment criteria

For each project, product or work j, all applicable indicators for each criterion l shall be identified, as indicated in section 3 of Appendix B.

For each of the indicators m so identified, we shall proceed to determine its valuation $\lambda_{j,l}^{c}$.

The assessment of each criterion $\lambda_{j,l}^{c}$ shall be the average of the obtained assessments for all the indicators belonging to the criterion, in the following way:

$$\lambda_{j,l}^{c} = \frac{\sum_{m=1}^{M_{j,l}^{m}} \lambda_{j,l,m}^{c}}{M_{j,l}^{m}}$$

where:

$\lambda_{j,l,m}^{c}$ the assessment of indicator m for criterion l and the project, product or work j, according to the systems indicated in column 5 "Assessment systems" of the indicator tables included in section 1 of Appendix B.

$M_{j,l}^{m}$ the total number of indicators corresponding to criterion l and the project, product or work j, in accordance with that indicated in Appendix B.

In any case, the final assessment of each set of indicators that belong to the same criterion shall never be negative

APPENDIX A. Contribution of agent to sustainability

1. Definition of indicators for the agents according to the type of criteria

NOTE 1. Continuous improvement.

Most indicators measure continuous improvement although it is not expressly included in the tables. Some indicators, alternatively, may also be measured through classes. In many of the indicators of continuous improvement it is also indicated whether the trend should be increasing or decreasing.

NOTE 2. Reference Objectives.

In some of the indicators/parameters, reference objectives are established with limit values, defined in this Appendix. In other cases, the reference objective shall be established by the company and shall be documented internally.

The objectives or limits should always be more restrictive than the legal limit; in the case of a discrepancy between a value defined in this Appendix and applicable regulatory value, the most restrictive value should always be used.

In general, and in line with the principle of continuous improvement, the reference objectives of an organization should be better than the results of previous years and the applicable legal limit, unless there are technical or economic limitations that may be justified when defining the objective. When the reference objectives are not maintained or progressively increase to more demanding values with respect to the results obtained the previous year, it should be justified that:

- the value is associated with the best available techniques (BAT) or
- the previous year has been exceptionally good or a significant reduction in production is foreseen for the following year.

NOTE 3. Local environment and territorial scope.

Although the concept of local environment can be variable depending on each organization, for the purposes of this Annex, it is understood as the radius of action over which may affect the decisions taken by the installation and which influence on the whole natural, social values and existing cultural as well as, on the life of people and the whole of society. That is to say, it is not only about the space in which industrial activity takes place but it also includes living beings, objects, water, soil, air and the interactions between them, as well as immaterial elements such as culture. Once this concept has been defined for each installation, the same criteria should be maintained over time.

As an example, the local environment can be defined as the municipality in which the installation is located, the set of municipalities encompassed under a previously defined radius of action (radius in km), and even, a more extensive area such as the province.

In any case, the influence of actions on the set of natural, social and cultural values, as well as on the life of people and the whole of society is limited to the territorial area (country) where the installation is physically located. .

NOTE 4. Management systems.

References to Management Systems in accordance with International Standards should always be understood as certificates in force issued by a certification body accredited by the National Accreditation Entity (ENAC) or by another national body in accordance with Regulation (EC) No. 765/2008 of the European Parliament and the Council of 9 July 2008. The scope of these Management Systems should include the relevant activity (process), for example, in the case of manufacturers, the production process and quality control of the products to those that apply the sustainability label.

NOTE 5. Projects for the purpose of indicators

For the purposes of the indicators, projects are considered those actions that respond to a documented previous planning (a modification maintenance work order would be considered sufficient), with a goal, defined means and deadlines, and having a subsequent evaluation of the results.

The projects may only be taken into account in one of the possible categories (water saving, energy efficiency, reduction of CO2 emissions, environmental improvement and conservation and restoration of natural spaces). Exceptionally, only R+D+i projects may be included in the category of R+D+i projects and in any of the categories mentioned above.

Whether there are projects that are developed over several years, the total investment may choose to divide in equal parts over these years, or consider the annual disbursement actually made. The organization should choose one of the two criteria when the project begins, defining its duration and keeping it in time. In the years of start and end a project shall be accounted for provided that its duration in the year is, at least, six months.

NOTE 6. Integrated Environmental Authorization (AAI)

Article 3 of Law 16/2002, of July 1 (which develops the IPPC Directive), defines the Integrated Environmental Authorization (AAI) as the resolution of the competent body of the Autonomous Community in which the installation is located, by the that, for the purposes of protecting the environment and the health of people, it is allowed to exploit all or part of an industrial installation in Spain, under certain conditions designed to guarantee that it complies with the object and the provisions of the Law 16/2002 (IPPC Law).

The Integrated Environmental Authorization (AAI) sets the environmental conditions that shall be required for the operation of the facilities and shall specify the limit values (legal) of emissions of pollutants into the atmosphere, noise emissions and pollutants from the discharges.

NOTE 7. Parameters with measurement obligation

The measurement of the parameters subject to legal limit values in the AAI is carried out by Collaborating Entities with the Administration (ECA). The measurements are reflected in a report available in the installation

NOTE 8. Parameters without obligation of measurement

The measurement of the parameters not subject to legal limit values in the AAI is carried out by Accredited Control Organizations. The measurements are reflected in a report available at the facility.

NOTE 9: Definition of the organization

For the purposes of this Code, organization is understood as that, company, corporation, firm or institution, or part or combination thereof, whether or not society, public or private, that elaborates structures projects, constructs structures, applies construction processes or manufactures the basic or processed products indicated in table A2.3.1 and that has its own functions, administration and NIF.

For the calculation of the ICPS, therefore, reference must be made to each organization, defined by its NIF and company name, and calculated according to this annex depending on the type of process or product with which they participate in the structure.

As indicated in this annex, the value of the ICES depends in turn on the sum of the contribution indices of each product or process to sustainability, ICPS, corresponding to each one of the agents. These ICPS indices are obtained, in turn, as an addition of two so-called summands, agent contribution index, ICAS, and complementary index of contribution to sustainability, ICS.

In the case that an organization contributes several processes or products to the structure, both the ICAS and the ICS should be calculated for each one of said processes or products.

The organization is responsible for the ICPS declaring and the ICAS and ICS values that determine it may only be declared by the organization that performs the relevant process and product, and may not be substituted by those of another organization regardless of the contractual nexus that may exist between them.

In the case of manufacturers of basic or processed products, if the organization is composed of more than one installation, the ICAS and ICS should be calculated at installation level unless the definition of the indicator indicates otherwise.

In the case of on-site construction, the scope of "the organization" should be defined with the activities/centers on which the indicators shall be applied to calculate the ICAS. The scope must cover at least the works that are within the scope of this Code.

For the proper calculation of the ICES should be taken into account, in each product or process involved, the percentage of participation in the product or process, have their different suppliers with their corresponding contributions to it. Considering as suppliers, for these purposes, the different agents that contribute the products or processes identified in section A2.2.

When appropriate and with a general character, the agent that provides the products or processes shall declare the participation in them of those other products or processes, basic and/or processed, identified in Table A2.2 (section A2.2.1), quantifying said participation and indicating the agents that act as suppliers of the latter.

Comments

Regarding the providers of the different agents, for example:

- The prepared concrete plant shall declare the relative to the cements, aggregates and additives that constitute the concrete.
- The precast plant shall declare what is related to the concretes used and, therefore, to its cements, additives and aggregates; as well as the reinforcing steels.
- The steel processors and structural steel workshop shall declare the relative to the basic steel products from which the steel, prestressed reinforcements and steel structural elements are constituted,
- The "in situ" prestressing systems, or the agents that supply the prestressing steels, shall declare what is related to the basic steel and processed steel products that constitute these prestressing steels.

1. PERFORMANCE INDICATORS				
Num.	**Indicator**	**Definition/Parameter**	**Objectives**	**Assessment system**
1.1	UNE-EN ISO 9001	Quality management system in accordance with UNE-EN ISO 9001 certified.	It has a valid certificate issued by an accredited organism. Maximum valuation in the case of having an officially recognized quality label (DCOR).	10 (n=100)
1.2	Installation audits	External audits to the company that guarantee the compliance with technical, environmental and occupational risk prevention issues in the concrete manufacturing process with a level of requirement that is even higher than strictly legal.	There is evidence of compliance. Maximum valuation in the case of having DCOR.	10 (n=100)
1.3	Specific personnel dedicated to environmental issues	Technician and/or department in the company dedicated, partially or exclusively, with specific competences, to environmental issues.	There is evidence of compliance.	10 (n=100)
1.4	Supplier quality management	Percentage of supplier companies with quality management systems compliant with UNE-EN ISO 9001 certified by accredited organism.	1. Business objective 2. data from previous year Trend: Growing	7 In situ Prestressed 17
1.5	Quality management of contractors and suppliers	Percentage of contractors and suppliers that have a quality management system UNE-EN ISO 9001, certified by an accredited organism, with respect to the total (% CC).	CC Value (%).	10 (n=%CC)
1.6	Civil liability insurance I	Civil liability insurance, with a minimum coverage of € 600,000.	Has insurance	10 (n=100)
1.7	Civil liability insurance II	Civil liability insurance, with a C coverage, expressed in euros, greater than 6 P, where P is the annual production in concrete aggregates expressed in tons. The minimum coverage must be 600,000 euros and if as a result of the 6P product the coverage value of 1,200,000 euros is exceeded, it is allowed to maintain that value as a maximum.	Has insurance	10 (n=100)
1.8	Civil liability insurance III	Liability insurance, with coverage equal to or greater than 3 million euros.	Has insurance	10 (n=100)

Table A2.A.1.1

2. ECONOMIC INDICATORS				
Num.	Indicator	Definition/Parameter	Objectives	Assessment system
2.1	Annual Production I	Total production of each final product, produced annually (tons or cubic meters). For the workshop, the annual production shall not be measured in tons or cubic meters, it shall be measured in Hours * = (Hours $_{Engineering}$ + Hours $_{Assembly}$) / Hours $_{Workshop}$.	1. Business objective 2. Data from the previous year Trend: growing	7
2.2	Annual Production II	Total annual invoicing (Prod). It is compared with the value of the billing target included in the annual budget (Pres).	1. Prod ≥ 0,9 Pres 2. 0,9 Pres>Prod ≥ 0,75 Pres 3. 0,75 Pres>Prod ≥0,5 Pres 4. Prod < 0,5 Pres	13
2.3	Gross operating profit (EBITDA)	Gross operating profit EBITDA (Earnings Before Interests, Taxes, Depreciation and Amortization) related to the reference NIF. The EBITDA should be the business result before interest, taxes and productive amortization.	1. Business objective 2. Data from the previous year Trend: increasing	7
2.4	Index or profit margin	EBITDA / Total sales related to the reference NIF.	1. Business objective 2. Data from the previous year Trend: increasing	7
2.5	Production profitability	Production rate (m3) per fixed worker (PTF) of each concrete production center. It is understood that it is by installation and referred only to personnel dedicated exclusively to production.	1. PTF >12.500 2. 12500>PTF>10000 3. 10000>PTF>7500 4. PTF<7500	13
2.6	Salary increase	Salary increase (%) with respect to the CPI or GDP, understood as the increase in percentage of the total remuneration of employees in money or in kind. The real salary increase is compared with the increase in the CPI or the GDP of the year analysed. For its valuation, the CPI or GDP will be chosen and it will be maintained over time.	Increase in the CPI or GDP.	5
2.7	Minimum / average salary ratio I	Relationship between the minimum / gross average salary defined by the organization and the minimum interprofessional salary (SMI). Parameters (2): 1. Relationship between the minimum gross salary of the organization and the minimum interprofessional salary (SMI) 2. Relationship between the average gross salary of the organization and the minimum interprofessional salary (SMI) minimum interprofessional (SMI)	Objective for each parameter: Data from the previous year Trend: increasing	2
2.8	Minimum / average salary ratio II	Relationship between the gross minimum salary of the organization, defined as the average gross salary received by the group of employees with the lowest professional	1. RS ≥ 1,30 2. 1,30 > RS ≥ 1,20 3. 1,20 >RS ≥ 1,10 4. RS < 1,10	3

		qualifications, and the minimum inter-professional salary (SMI) legally established before being supplemented by the different sectoral, provincial agreements or regional, collective or company, which legally apply (RS = minimum gross salary / SMI).		
2.9	Added value	Added value generated during the year (euros) that shall be obtained from the profit and loss account. For this, the personnel expenses will be added to the pre-tax result.	1. Business objective 2. Data from the previous year Trend: increasing	7
2.10	Investments R&D&i I	Total value in euros of all R&D&i investments made by the organization, with respect to the value of production (including subsidies). In the value of the investment, only the investment in R&D&i should be recorded and not the expense associated with the amortization of fixed assets.	Data from the previous year Trend: increasing	5
2.11	Investments I R&D&i II	Ratio of investment in R&D&i with respect to annual net sales.	1. Business objective 2. Data from the previous year Trend: increasing	7
2.12	Investments R&D&i III	In the field of construction, the minimum investment in R&D&i is equivalent to 0.1% of the billing amount.	There is evidence of compliance.	10 (n=100)
2.13	management system R&D&i	R&D&i management system in accordance with UNE 166002.	It has a valid certificate issued by an accredited body.	10 (n=100)
2.14	Num. of projects R&D&i completed	Number of R&D&i projects completed throughout the year.	Data from the previous year Trend: increasing	5
2.15	Other investments (prod/quality/ environmental improvements)	Total value in euros of the investments executed in Production / Product quality / environmental improvement. Compliance with the budget (Pres) is measured in relation to the execution of the same (Prod).	1. Prod ≥ 0,9 Pres 2. 0,9 Pres>Prod ≥0,75 Pres 3. 0,75 Pres>Prod ≥0,5 Pres 4. Prod < 0,5 Pres	13
2.16	Investments in the environment	Amount of environmental investments with respect to benefits (investments / benefits)	1. Business objective 2. Data from the previous year Trend: increasing	7
2.17	Labor productivity	Number of workers per line (NTL) considering only the own personnel that is directly assigned to production activities (quarry, production, maintenance, expedition, quality, prevention, environment).	1. NTL<90 2. 90 ≤ NTL ≤180 3. NTL > 180 For factories with two lines, the numerical cutting criteria (90 and 180) shall be increased by 50% and for factories with three	16

			lines by an additional 50%.	
2.18	Energy productivity	Evaluation of productivity regarding the efficient use of energy through energy audits and the implementation of energy efficiency measures in the facilities.	1. It has a valid certificate in accordance with UNE-EN ISO 50001 issued by an accredited body. 2. Having carried out an energy audit in accordance with Real Decreto 56/2016 or the relevant parts of the UNE-EN 16247 regulations. 3. None of the above measures has been established	16
2.19	Materials Productivity	Use of natural raw materials ($t_{MMPPnat}$) per tonne of clinker of origin with which the cements ($t_{clínker}$) have been manufactured. In the case that there is more than one origin, it shall be weighted by production. It shall be expressed in dry tons. Indicator of productivity regarding the efficient use of natural resources, defined as TMTC = $t_{MMPPnat}/t_{clínker}$	1.TMTC <1,60 2.1,60≤ TMTC <1,70 3. TMTC ≥1,70	16
2.20	Water productivity	Water consumption (C) of the concrete manufacturing plant per cubic meter manufactured (l/m^3).	1. C≤ 235 2. 235 < C ≤ 250 3. 250 < C <265 4. C≥ 265	13

Table A2.A.1.2

3. ENVIRONMENTAL INDICATORS				
Num.	Indicator	Definition/Parameter	Objectives	Assessment system
3.1	Environmental management systems I	Environmental management systems in accordance with UNE-EN ISO 14001.	It has a valid certificate issued by an accredited body.	10 (n=100)
3.2	Environmental management systems II	For steel and processed steel (only active reinforcements): Parameters (2): 1. Systems compliant with UNE-EN ISO 14001. 2. Sustainability Management System according to UNE 36901.	Objective for each parameter: Parameter 1 It has a valid certificate issued by an accredited body. Parameter 2	10 (n=50)

			It has a valid certificate	
3.3	Environmental management systems III	For aggregates: Parameters (2): 1. Systems compliant with UNE-EN ISO 14001. 2. Sustainable Mining Management System according to UNE 22480 (aggregates).	Objective for each Parameter: 1. It has both current certificates issued by an accredited body. 2. Has one of the two certificates in force 3. You do not have any.	16
3.4	Environmental management systems IV	For the production of cement: Parameters (3): 1. Management System in accordance with the Community Eco-Management and Audit Regulation, EMAS. 2. Systems compliant with UNE-EN ISO 14001. 3. Does not have an environmental management system.	It has a valid certificate issued by an accredited body.	16
3.5	Environmental management systems V	Environmental management system in accordance with UNE-EN ISO 14001 for construction activities.	It has a valid certificate issued by an accredited body.	10 (n=100)
3.6	Energy management system	Management system in accordance with UNE-EN ISO 50001.	It has a valid certificate issued by an accredited body.	10 (n=100)
3.7	Relative Direct Emissions of GEI I	Relative emissions of GHG (CO_2 and other gases that may be relevant) in tons of CO_2 equivalent per ton of product. Direct emissions of greenhouse gases (GHGs) are called "scope 1" emissions in a GHG emissions inventory, according to the Greenhouse Gas Protocol criteria.	1. Business objective 2. Data from the previous year Trend: increasing	6
3.8	Relative Direct Emissions of GEI II	Favourable verified report of greenhouse gas emissions issued by an independent third party.	It has the report.	10 (n=100)
3.9	Relative indirect emissions of GEI I	Relative emissions of greenhouse gases, GHG, (CO_2 and other gases that may be relevant) in tons of CO_2 equivalent per ton of product, associated with the production of electrical and thermal energy purchased. Indirect emissions of greenhouse gases (GHGs) are called "scope 2" emissions in a GHG emissions inventory, according to the Greenhouse Gas Protocol criteria.	1. Business objective 2. Data from the previous year Trend: decreasing	6 Prestressed in situ 4
3.10	Relative indirect emissions of GEI II	Application of the European Emission Law Trade Regime or similar cap and trade system. In the case of cap and trade systems other than the European system, third-party verification will be required for the annual notification of emissions.	Its compliance is evidenced.	10 (n=100)
3.11	Environmental commitment I: Energy and GEI emissions	Commitment to improving performance in terms of energy and GHG emissions.	1. Definition of measurable objectives through indicators	1

			2. Existence of commitment	
3.12	Material consumption I	Total consumed materials (raw materials, auxiliaries and consumables) by annual production. For steel and processed steel (only active reinforcements) at least the following materials shall be taken into account: • Steelworks (scrap, cast iron, pre-reduced, ferroalloys, lime, coal, oils and greases) • Lamination (Billet, oils and greases) • Active reinforcements (wire rod, oils and greases) For the workshop, only the raw material transformed directly into its own facilities will be taken into account.	1. Business objective 2. Data from the previous year Trend: decreasing	6
3.13	Material consumption II	Ratio of consumable materials in the extraction and treatment of mineral resources or in research and geological exploration with respect to annual production.	1. Business objective 2. Data from the previous year Trend: decreasing	6
3.14	Waste valorization	Existence of a recycler for the recovery of concrete waste generated in the plant and its use in the manufacture of concrete or other use in the construction or manufacture of recycled aggregates from hardened concrete from the returns.	Evidence the existence of the recycler or verification of the treatment process of hardened concrete	10 (n=100)
3.15	Energy consumption I	Specific energy consumption per ton of final product produced (GJ / t) or total sales (GJ / TEP). For the workshop, the energy consumption can be categorized for four types of processes (cutting, assembly, welding and painting). Each activity is associated to a percentage of the total energy consumed (Consumption ratio Kwh / Ton of generated product or Kwh / Euros billed or Kwh / personal number or template in the factory).	1. Business objective 2. Data from the previous year Trend: decreasing	6 Prestressed in situ 4
3.16	Energy consumption II	Specific energy consumption (GJ / t). Parameters (2): 1. in the steelmaking process per tonne of billets produced. 2. in the rolling process per ton of final product produced (GJ / t).	Objective for each Parameter : 1. Objective: 1.1. Steel electric oven: - 2,7GJ / t (steel mill) - 1.8 GJ / t (rolling) 1.2. Wire rod steel integral route: - 1 GJ / t (steel mill) - 2.6 GJ / t (rolling)	8

			2. Data from the previous year Trend: decreasing	
3.17	Energy consumption III	Specific energy consumption (GJ / t) in the manufacturing process of the active reinforcements (wire rod drawing) per ton of final product produced.	1. Objective: 1,55 GJ/t 2. Data from the previous year Trend: decreasing	8
3.18	Energy consumption IV	Specific energy consumption (GJ / t) for stainless steel: Parameters (3): 1. in the steelmaking process per ton of product as cast. 2. In the process of hot rolling per ton of product as cast. 3. In the process of cold rolling, per ton of product as cast.	Objective for each Parameter : 1. Objective: - 4,2GJ/t (steel mill) - 3.0 GJ / t (hot rolling) - Objective of the installation (cold rolling) 2. Data from the previous year Trend: decreasing	8
3.19	Energy consumption V	Progressive decrease in unit energy consumption per worker compared to the previous year (CET).	1. CET ≥ 1,00 2. 1,00 > CET ≥ 0,95 3. 0,95 > CET ≥ 0,90 0,90 > CET	13
3.20	Use of renewable energies I	Percentage of renewable energy use, with respect to total energy consumption according to primary sources.	Data from the previous year Trend: increasing	9
3.21	Use of renewable energies II	Contribution of renewable energy to the energy combination of the electricity supply consumed by the installation, including the renewable sources that may exist in the facility's premises.	Value greater than or equal to 20%	10 (n=100)
3.22	Savings and energy efficiency	Parameters (2): 1. Percentage of energy savings achieved with respect to the reference year per unit of final product production. 2. Number of energy saving and efficiency projects completed throughout the year. The reference year that is adopted must remain fixed in time.	Objective for each Parameter : Data from the previous year Trend: increasing	2
3.23	Water consumption I	Annual consumption of water in the production center per tonne produced or per cubic meter produced.	1. Objective: - Business objective (general) - 0.8 m^3 / t (steel electric furnace) - 7 m^3 / t (steel wire rod integral route) - 1 m^3 / t (active reinforcements)	6

			2. Data from the previous year Trend: decreasing **Prestressed in situ** 1. Business objective 2. Data from the previous year Trend: decreasing	4
3.24	Water consumption II	Percentage of water consumption savings compared to a year taken as a reference, per unit of final product production (m^3/t o m^3/m^3).	Data from the previous year Trend: increasing	5
3.25	Water consumption III	Ratio of the annual net consumption of primary water with respect to the annual production of the organization. The calculation shall be made in accordance with the UNE 22470 standard.	1. Business objective 2. Data from the previous year Trend: increasing	6
3.26	Water consumption IV	Progressive decrease in unit water consumption per worker compared to the previous year (CAT).	1. CAT ≥ 1,002. 1,00 > CAT ≥ 0,95 3. 0,95 > CAT ≥ 0,90 4. 0,90 > CAT	13
3.27	Environmental commitment: Water	Commitment to improving water performance.	1. Definition of measurable objectives through indicators 2. Existence of commitment	1
3.28	Water saving and recycling project	Num. of water saving and reuse projects completed throughout the year.	Data from the previous year Trend: increasing	5
3.29	Project for the conservation or restoration of natural spaces	Parameters (2): 1. Amount (euros) projects conservation and restoration of natural areas, including the compensatory measures. 2. Number of conservation projects or restoration of natural areas completed during the year.	Objective for each Parameter : Data from the previous year Trend: increasing	9
3.30	Restoration project in extractive activities	Implementation of environmental integration and conservation projects, in which the implementation of activities related to the maintenance and care of the biological diversity of the factory environment or extractive installation is evaluated. In cement, the evaluation will be applied, at least, to the main quarry of the integral factory and / or in the area of influence of the productive activities. In other cases, the evaluation will necessarily refer to the clinker of origin with	1. Integration / conservation plans for species are available in relation to flora or fauna, introduction of native species, agricultural production, biodiversity studies, etc. 2. Restoration plans guaranteed in accordance with the mining law for mining operations linked to the installation	16

		which the cements have been manufactured.	3. No restoration plans are available for extractive activities.	
3.31	Emissions: Conventional pollutants (steel / converter furnace)	Concentration of emissions (mg/Nm^3). Parameters (12): 1. Particles 2. CO 3. NO_x 4. SO_x/SO_2 5. Mercury 6. Metals [As, Cd, Cr, Ni, Cu, Pb and Zn] 7. CIH 8. HF 9. COT 10. Benzene/Chlorinebenzene 11. HAP 12. Dioxins (PCDF) and Furans (PCDD) NOTE 7and 8	Objective (value) for each Parameter : **Stainless steel:** 1. Particles (5) 2. CO (150) 3. NO_x (50) 4. SO_x/SO_2 (30) 5. Mercury (0,05) 6. Metals (5) 7. CIH (5) 8. HF (1) 9. COT (10) 10. Benzene/Chlorinebenzene (0,5) 11. HAP (0,1) 12. Dioxins PCDF (0,1) and Furans PCDD (0,1) **Wire rod steel integral route:** 1. Particles (120) Trend: decreasing	10 (n=20) 10 (n=100)
3.32	Emissions: Conventional contaminants in steelmaking ovens (stainless steels)	Concentration of emissions (mg / Nm3) in focus included in steelmaking processes. Parameters (3): 1. Particles in electric furnaces, converters, continuous billet and roughing, grinders and oxyfuel grinders, oxicortes and shredder 2. NOx (nitrogen oxides) in electric furnaces and converters 3. CO (carbon monoxide) in electric furnaces and converters. NOTE 7 and 8	Objective (value) for each parameter in emission sources: 1. Particles in electric furnaces (5), converters (5), continuous billet and roughing (15), grinders and oxyfuel grinder (15), oxicortes and shredder (30) 2. NOx (nitrogen oxides) in electric ovens (30) and converters (30) 3. CO (carbon monoxide) in electric furnaces (150) and converters (150). Valuation cases: 1. 100% of the foci reaches the target 2. 60% of the foci reaches the target 3. Other cases Trend: decreasing	For each Parameter : 21

3.33	Other emissions: Conventional pollutants (steel mill)	Concentration of emissions (mg / Nm^3) Parameters (2): 1. Metals [Co, Te, Se, Sb, Mn, Sn, V]. 2. Polychlorinated biphenyls (PCB). NOTE 7 and 8.	Objective (value) for each Parameter : 1. Metals (5) 2. PCB (0,1) Trend: decreasing NOTE: This indicator does not apply to steel wire rod integral route	10 (n=50)
3.34	Emissions: Pollutants in conventional hot rolling (stainless steels)	Concentration of emissions (mg / Nm3) in foci included in steelmaking processes. Parameters (3): 1. Particles in roughing and finisher trains, and shot blasting machines. 2. NOx (nitrogen oxides) in oven heating roughing and oven plates. 3. HF (hydrogen fluoride) in pickling plates. NOTE 7 and 8	Objective (value) for each parameter in emission sources: 1. Particles in roughing and finisher trains (15), and shot blasting machines (200) 2. NOx in roughing heating furnace (320) and oven plates (200) 3. HF in pickling plates (2) Valuation cases for all parameters: 1. 100% of the foci reaches the target 2. 60% of the foci reaches the target 3. Other cases Trend: decreasing	For each Parameter : 21
3.35	Emissions: Conventional pollutants (lamination furnace)	Concentration of emissions (mg / Nm^3). Parameters (4): 1. Particles 2. CO (carbon monoxide). 3. NOx (nitrogen oxides). 4. SOx / SO2. NOTE 7 and 8	Objective (value) for each parameter: **Steel electric furnace:** 1. Particles (10). 2. CO (50) 3. NOx (250 if available regenerative burners, otherwise 600) 4. SOx / SO2 (35) Integrated steel wire rod route: 1. Opacity (1.5) 2. CO (500) 3. NOx (300) 4. SOx / SO2 (2400) Trend: decreasing	10 (n = 30)

3.36	Emissions: Conventional pollutants in cold rolling (stainless steels)	Concentration of emissions (mg / Nm3) in focus included in steelmaking processes. Parameters (3): 1. Particles in shot blasting machines. 2. NO_x (nitrogen oxides) in annealing and pickling furnace. 3. HC (hydrocarbons) in rolling mills. NOTE 7 and 8	Target (value) for each Parameter in emission sources: 1. Particles in blasters (20) 2. NOx in annealing and pickling furnace (325) 3. HC Rolling mills (10) Cases of valuation for all Parameters: 1. 100% of the focus reach the target 2. 60% of the focus reach the target 3. Other cases Trend: decreasing	For each Parameter : 21
3.37	Other issues: Conventional Contaminants (lamination furnace)	Concentration of emissions (mg / Nm3). Parameters (6): 1. H_2S 2. Metals [As, Hg, Cd, Cr, Ni, Cu, Pb, Zn, Co, Te, Se, Sb, Mn, Sn, V] 3. CIH 4. HF 5. COT 6. Dioxins (PCDF) and furans (PCDD). NOTE 7 and 8	Objective (value) for each Parameter : 1. H_2S (50) 2. Metals (1.5) 3. CIH (5) 4. HF (1) 5. COT (5) 6. Dioxins PCDF (0.1) and furans PCDD (0.1) NOTE: This indicator does not apply to integrated steel wire rod route Trend: decreasing	10 (n=20)
3.38	Emissions: Conventional Contaminants (prestressing steel)	Concentration of emissions (mg / Nm^3). Parameters (5): 1. Particles 2. CO 3. NO_x 4. CIH 5. H_2SO_4 NOTE 7 and 8	Objective (value) for each Parameter : 1. Particles (10) 2. CO (100) 3. NO_x (250) 4. CIH (10) 5. H_2SO_4 (5)	10 (n=25)

3.39	Emissions: Conventional pollutants in auxiliary processes (stainless steels)	Concentration of emissions (mg / Nm^3) in focus included in steelmaking. Parameters (3): 1. Particles in acid recovery plant. 2. NO_x (nitrogen oxides) in catalytic and boiler towers. 3. HF (hydrogen fluoride) complex in catalytic tower. NOTE 7 and 8	Target (value) for each Parameter in emission sources: 1. Particles in acid recovery plant (20). 2. NO_x catalytic tower (200) and boilers (200). 3. HF in catalytic tower (3) Cases of valuation for all Parameters: 1. 100% of the focus reach the target 2. 60% of the focus reach the target 3. Other cases Trend: decreasing	For each Parameter : 21
3.40	Emissions: NO_x and particulates	Concentration of emissions (mg / Nm^3) regarding the clinker furnace (necessarily the origin clinker furnace which have been manufactured cements). The measures shall relate to the conditions in the Integrated Environmental Authorization as an annual figure. Parameters (2): 1. NO_x (nitrogen oxides). 2. Particulates.	Target For each Parameter : NO_x emissions: 1. ≤ 500 2. > 500 Particulate emissions: 1. ≤ 20 2. > 20 For cement type CAC, its specific limits will be considered.	18
3.41	Noise values	Corrected noise value throughout the evaluation period. Parameters (3): 1. Morning (Lx,d) 2. Afternoon (Lx,t) 3. Evening (Lx,n) NOTE 7 and 8	Objective for each Parameter : Noise value is lower than the legal limit by at least 5 db. The legal limits of application shall be those established in the authorization or in the local regulations applicable to the installation. When there are no limits applicable to the afternoon period,	10 (n=40) 40 points shall be deducted for each Parameter with punctual overcoming of the legal limit during the evaluation period

			those corresponding to the morning period shall be considered. Trend: decreasing	
3.42	Dischargers of water: Industrial waste I	Discharges by pour point. Parameters (2): 1. Discharge of (m^3/year) 2. Oils and fats (mg/l) NOTE 7 and 8	Objective for each Parameter : Business objective Trend: decreasing	10 (n=100)
3.43	Water discharges: Industrial waste II	Discharges by pour point for steel: Parameters (21): 1. Discharge flow (m3 / year) 2. pH (units) 3. Conductivity (uS / cm) 4. Temperature (increase ºC) of the receiving medium 5. Solids in suspension (mg / l) 6. BOD5 (mg / l) 7. COD (mg / l) 8. Oils and fats (mg / l) 9. Ammonia (mg / l) 10. Metals [Al, Ace, Cd, Cu, Mn, Hg, Pb] (mg / l) 11. Fe (mg / l) 12. Zn (mg / l) 13. Ni (mg / l) 14. Total Cr (mg / l) 15. Cyanide (mg / l) 16. Fluorides (mg / l) 17. Sulphides (mg / l) 18. AOX (mg / l) 19. Total P (mg / l) 20. Neither total (mg / l) 21. Ag (mg / l) NOTE 7 and 8	Objective (value) for each Parameter : **Steel electric furnace:** 1. Discharge flow (company target) 2. pH (6-9) 3. Conductivity (<4,000) 4. Tª (1,5) 5. Suspension solids (20) 6. BOD5 (30) 7. COD (100) 8. Oils and fats (5) 9. Ammonia (15) 10. Metals [Al, Ace, Cd, Cu, Mn, Hg, Pb] (12) 11. Faith (5) 12. Zn (2) 13. Ni (0,5) 14. Total Cr (0.5) 15. Cyanide (1.0) 16. Fluorides (1,5) 17. Sulphides (2,5) 18. AOX (0.5) 19. Total P (10) 20. Not total (15) 21. Ag (0.1)	10 (n=10)

			Wire rod steel integral route: 1. Discharge flow (company objective) 2. pH (6-9) 3. Conductivity (<1,000) 4. Tª (1,5) 5. Suspension solids (80) 6. BOD5 (20) 7. COD (60) 8. Oils and fats (5) 9. Ammonia (15) 10. Faith (5) 11. Zn (2) 12. Ni (0,5) 13. Total Cr (0.5) 14. F (1,7) Trend: decreasing	
3.44	Dischargers of water: Industrial waste III	Discharges per pour point for prestressing steel: Parameters (10): 1. COD (mg / l) 2. Fe (mg / l) 3. Zn (mg / l) 4. Total Cr (mg / l) 5. Ni (mg / l) 6. Total N (mg / l) 7. Total P (mg / l) 8. Sulphates (mg / l) 9. Sulphides (mg / l) 10. Oils and fats (mg / l) NOTE 7 and 8	Objective (value) for each Parameter : 1. COD (100) 2. Faith (5) 3. Zn (2) 4. Total Cr (0.2) 5. Ni (0,5) 6. Total N (0.2) 7. Total P (10) 8. Sulphates (1,000) 9. Sulphides (2,5) 10. Oils and fats (5) Trend: decreasing	10 (n=10)
3.45	Dischargers of water: Industrial waste IV (stainless steels)	Discharges per pour point for stainless steel: Parameters (14): 1. Discharge flow (m^3 / year) 2. pH (units) 3. Solids in suspension (kg / year) 4. COT (kg / year) 5. Oils and fats (kg / year) 6. Fluorides (kg / year) 7. Ammonium (kg / year) 8. Not total (kg / year) 9. Nitrates (kg / year) 10. Total Cr (kg / year) 11. Total P (kg / year) 12. Zn (kg / year) 13. Ni (kg / year) 14. Cu (kg / year)	Objective (value) for each Parameter : 1. Discharge flow (company target) 2. pH (6-9) 3. Solids in suspension (57,600) 4. COT (41,400) 5. Oils and fats (14,500) 6. Fluorides (14,000) 7. Ammonium (70,000) 8. Not total (995,000)	10 (n=10)

		NOTE 7 and 8	9. Nitrates (4,000,000) 10. Total Cr (360) 11. Total P (1,320) 12. Zn (360) 13. Ni (975) 14. Cu (60) Trend: decreasing	
3.46	Other industrial sewage discharges	Discharges by pour point: Parameters (19): 1. Suspended solids (SS) (mg / l) 2. Ba (mg / l) 3. B (mg / l) 4. Cr III (mg / l) 5. Sn (mg / l) 6. Se (mg / l) 7. Mo (mg / l) 8. Phenols (mg / l) 9. Chlorides (mg / l) 10. Sulphites (mg / l) 11. Detergents (mg / l) 12. Trihalomethanes (THM) 13. Benzene-toluene-ethylbenzene-xylene (BTEX) (mg / l) 14. Polycyclic aromatic hydrocarbons (PAH) (mg / l) 15. Total hydrocarbons (TPH) 16. Total organic carbon (TOC) (mg / l) 17. Nitrates (mg / l) 18. Free residual chlorine (mg / l) 19. Toxicity to Daphnia Magna (equitox / m3 units) NOTE 7 and 8	Objective (value) for each Parameter : 1. SS (0.5) 2. Ba (2) 3. B (0.6) 4. Cr III (2) 5. Sn (2) 6. Se (0.01) 7. Mo (1) 8. Phenols (0.4) 9. Chlorides (800) 10. Sulphites (3) 11. Detergents (4) 12. THM (0.005) 13. BTEX (0.05) 14. PAH (0.01) 15. TPH (5) 16. COT (100) 17. Nitrates (30) 18. Free residual chlorine (2) 19. Toxicity (3) NOTA: This indicator does not apply to steel wire integral route Trend: decreasing	10 (n=10)
3.47	Discharge of water	Zero discharge or use of 100% of waste water from concrete production or cleaning of trucks.	There is evidence of compliance.	10 (n=100)
3.48	Waste generated	Parameters (2 ó 3): 1. Annual production of hazardous waste, per ton of final product 2. Annual production of non-hazardous industrial waste, per ton of final product 3. Num. of confirmed truck alarms with scrap contaminated with radioactive waste / 1000 trucks (Additional Parameter only for steel)	Objective for each Parameter : 1. Business objective 2. Data from the previous year Trend: decreasing	8
3.49	Environmental commitment: Waste generated	Commitment to improving performance in waste management.	1. Definition of measurable objectives through indicators 2. Existence of commitment	1
3.50	Waste Management	Parameters (2):	Data from the previous year	2

		1. Waste destined to recycling or recovery per tonne of final product (t_{was} / $t_{final\ product}$) or total sales (t_{was} / euros). 2. Waste destined to energy recovery per ton of final product (t_{was} / $t_{final\ product}$) or total sales (t_{was} / euros).	Trend: increasing	
3.51	Waste Management (concrete)	Procedure for management of special or dangerous waste generated by the plant or by the maintenance companies, as well as by the mobile machinery where appropriate, for example: - Written procedure of the treatment given to all waste leaving the plant. - Management of raft sludge; test tubes, in the case that the laboratory is in the plant, distinguishing if they have facing sulphur or polished / cubic; workshop waste. - Existence of classified containers (scrap, paper, containers, dangerous). - Documentary verification of reception in landfills and / or, of withdrawal of containers.	There is evidence of compliance.	10 (n=100)
3.52	Waste management (aggregates) I	Waste destined to recycling or recovery per ton of final product (t_{was} / $t_{final\ product}$).	1. Business objective 2. Data from the previous year Trend: increasing	1
3.53	Waste management (aggregates) II	Special or hazardous waste management system, for example: - Written procedure of the treatment given to all the waste that leaves the plant. - Existence of classified containers (scrap, paper, containers, dangerous). - Documentary verification of reception in landfills. - Documentary check of container withdrawal.	There is evidence of compliance.	10 (n=100)
3.54	Environmental risk assessment	Analysis or Evaluation of environmental risks of the production center according to the UNE 150008 standard. The analysis may have been carried out to meet with the requirements of Law 26/2007 on Environmental Responsibility and its related regulations.	1. ARA is available according to which it is specified that financial, insurance or guarantee guarantee is not necessary, as defined in Law 26/07 on environmental responsibility 2. ARA is available and insurance or guarantee is available to cover the environmental risks of	16

			the installation according to the manufacturer's evaluation. 3. ARA is not available for the installation.	
3.55	Use of alternative fuels	Replacement rate (TS) obtained as the percentage sum of the alternative fuels used in the installation with respect to conventional fuels (in terms of energy). Alternative fuels are those officially reported by the facility as such for statistical purposes. The replacement rate shall be calculated on an annual basis.	1. TS ≥25% 2. 15%≤TS<25% 3. 5%≤TS <15% 4. TS<5%	19
3.56	Incidents in the environment	Number of annual environmental incidents that occurred with respect to turnover (for example, emissions or discharges out of limits, spills, losses or escapes of waste, uncontrolled events with environmental damage, environmental non-conformities, etc.) In case that several exceedances of a legal limit are recorded throughout the year, they should be considered as different incidents.	Invalid incidents or lower than data from the previous year Trend: decreasing	10 (n=100)
3.57	Use of dangerous substances	Reduction of the dangerous substances consumption per tonne of final product ($t_{sust\ dangerous}$/ $t_{final\ product}$) such as: - Flammable and combustible liquids, except petroleum products - Gases compressed and liquefied under pressure in bottles and bottles, except natural gas - Petroleum products, except oils and fats - Natural gas - Corrosive liquids - Toxic products - Oils and fats - Drawing soaps	1. Business objective 2. Data from the previous year Trend: decreasing	6
3.58	Good management practices for hazardous substances	Good practices related to the management of dangerous substances implanted by the organization. Parameters (3): 1. Definition of good practices in the handling of dangerous substances (eg procedure, internal instruction) 2. Definition of emergency response due to the handling of dangerous substances 3. Realization of simulations that consider spill or leakages of dangerous substances.	Target for all parameters: There is evidence of compliance.	10 (n=40)
3.59	Good environmental management practices	Good practices related to environmental management implanted by the organization. Parameters (3):	Target for all parameters: There is evidence of compliance.	10 (n=according to parameter)

		1. Existence, availability and distribution of a Manual of Good Environmental Practices (n = 50) 2. Communication and internal diffusion in the organization (n = 25) 3. Communication and external diffusion to contractors, suppliers, etc. (n = 25)		
3.60	Affectation to soils	Grade of affectation to soils [surface (m^2) and volume (m^3) of polluted soils]. The non-existence of polluted soils should be justified by evidences in written documents, A preliminary report is considered valid in which it is affirmed that there is no pollution, provided that there is no request for additional information or for conducting a soil investigation by the Administration.	1. Null value 2. Data from the previous year	6
3.61	Remediation actions	Parameters (2): 1. Cumulative number of remediation actions since the realization of the characterization of soil. 2. Surface (m^2) and volume (m^3) accumulated of remediated soils. The non-existence of polluted soils should be justified by evidences in written documents. A preliminary report is considered valid in which it is affirmed that there is no pollution, provided that there is no request for additional information or for conducting a soil investigation by the Administration.	Objective for each Parameter : Overcoming the previous year Trend: increasing	10 (n=50)
3.62	Environmental improvement projects	Number of environmental improvement projects completed during the year, other than those indicated in 3.29.	Overcome the data from the previous year Trend: increasing	10 (n=100)
3.63	Environmental management of contractors	Percentage of contractor companies that are subject to environmental management systems UNE-EN ISO 14001.	1. Business objective 2. Data from the previous year Trend: increasing	7
3.64	Environmental management of contractors and suppliers	Number of contractors and suppliers that have an environmental management system UNE-EN ISO 14001, certified by an accredited company, between the total number of contractors and suppliers, in percentage (CR).	Value of CR (%).	10 (n=%CR)
3.65	Environmental management of suppliers	Percentage of supplier companies that have environmental management systems UNE-EN ISO 14001.	1. Business objective 2. Data from the previous year Trend: increasing	7 Prestressed in situ 17
3.66	Diffuse emissions: generation of	Adoption of specific and verifiable measures for reducing the generation of dust in storage (such as fairing or irrigation)	There is evidence of the system and technical justification of	10 (n=100)

	dust in storage and vials	taking into account that in the case of wet aggregate the same protection is not necessary protection.	the suitability of the solution adopted.	
3.67	Diffuse emissions: generation of dust	Adoption of specific and verifiable measures to reduce the generation of dust in concrete plants: — Ribbed fairing — Scale fairing — Dust capturing systems in material transfer areas — Captator and fairing in cargo nozzle without mixer	There is evidence of the adoption of all measures.	10 (n=100)
3.68	Use of recycled paper	Recycled paper (RP) as a percentage of paper purchased. RP is considered to be those that have a minimum percentage of 50% recycled fiber after consumption for uncoated paper and at least 30% for coated paper, always being processed papers without chlorine or its TFC derivatives.	1. RP ≥ 33% 2. 33% > RP> 20% 3. 20% ≥ RP > 10% 4. RP ≤ 10%	14
3.69	Paper consumption	Annual paper consumption reduction (APCR) as a percentage of the paper used the previous year.	1. APCR >25% 2. 25% ≥ APCR > 10% 2. 10% ≥ APCR > 5% 3. APCR ≤ 5%	14
3.70	Exploitation of slag	Exploitation of at least 50% of the slags produced in the manufacture of steel products.	A valid certificate is included which includes the use of 50% of slag among the evaluated requirements, issued by an accredited certification body.	10 (n=100)
3.71	Delimitation of facilities	Existence of physical delimitation in the entire contour of the concrete plant plot, with non-provisional systems.	There is evidence of the delimitation	10 (n=100)
3.72	Permanent storage facility	Existence of, at least, a permanent installation where the organization should arrange to store the constituent material of the Prestressed System "in situ", providing it with the technical services sufficient for calibration, conservation and maintenance of equipment, tools and auxiliary means for the installation of said system on worksite	Get an Opening Municipal License for the corresponding activity. The contour of the plot in which it is located should be delimited in its entirety with non-provisional systems.	10 (n=100)

Table A2.A.1.3

4. SOCIAL INDICATORS				
Num.	Indicator	Definition/Parameters	Objectives	Assessment system
4.1	Stability in employment I	Percentage of permanent employment over total direct employment	1. Business objective or 100% 2. Data from the previous year	7

4.2	Stability in employment II	Number of jobs with an permanent contract in relation to the total number of direct jobs, as a percentage (% PE)	Value of PE (%)	10 (n=%PE)
4.3	Direct and indirect employment	Parameters (2): 1. Direct employment: Total number of workers in the organization (equivalent jobs) [= a / b] where: (a) Total hours worked by direct employment. It is obtained through the data of the total hours worked of the entire staff (Source: Personnel Department, social security contributions). (b) Annual average of hours worked in full-time jobs. The data of annual hours of agreement (for example 1,670 h) multiplied by the number of employees is used. 2. Indirect employment: Total number of workers that provide services in the organization contracted by third parties, either by own or auxiliary activity (equivalent jobs) [= a * / b] where: (a *) Total hours worked by indirect employment. It is obtained through the data of the total hours worked by the contract staff (Source: Personnel Department, social security contributions)	Objective for each Parameter : 1. Business objective 2. Data from the previous year Trend: increasing	1
4.4	Direct employment	Total number of workers in the organization (equivalent jobs estimated as the quotient between the total hours worked and the annual average of hours worked in full-time jobs) with respect to the turnover.	Data from the previous year Growing tendency	5
4.5	Permanent employment with respect to direct	Relationship between the number of undefined jobs and the total number of direct jobs, referred to the own factory staff of cement or clinker, directly related to production activities (quarry, production, maintenance, shipping, quality, safety and environment). $\text{PEDE}\ (\%) = \frac{\text{N}^{\text{o}}_{\text{permanent employment}}}{\text{N}^{\text{o}}_{\text{total direct employment}}} * 100$	1. PEDE> 80% 2. 70%<PEDE≤80% 3. PEDE≤70	16

4.6	Training cost	Training costs with respect to the total wage bill. The wage bill is defined as the remuneration of employees in money or in kind, that an establishment or industry pays to an employee as consideration for the work it performs, plus the value of social contributions to be paid by the employer to the systems of compulsory social security, or to private social insurance systems.	1. Business objective 2. Data from the previous year Trend: increasing	7 Prestressed in situ 17
4.7	Training actions I	Parameters (2): 1. Num. of training actions carried out during the year. 2. Training hours with respect to the total staff.	Objective for each Parameter : 1. Business objective 2. Data from the previous year Trend: increasing	7 Prestressed in situ 17
4.8	Training actions II	Total hours of training with respect to the total number of workers in the organization (equivalent jobs estimated as the quotient between the total hours worked and the annual average of hours worked in full-time jobs.)	Data from the previous year. Trend: increasing	5
4.9	Freedom of association and collective agreements	Availability of policies, practices and procedures to facilitate the representation of workers. Parameters (3): 1. Rules or procedures that ensure that workers can join trade unions without fear of reprisals, applicable in particular to selection and promotion of personnel, file of information and personal data and decisions on dismissals or transfers 2. Collective agreement in force 3. Mechanisms of communication with workers' representatives	Objective for all Parameters: There is the mentioned policy, standard or procedure.	10 (n=40)
4.10	Occupational risk management systems I	Occupational risk management system according to OHSAS 18001 or ISO 45001.	It has a valid certificate issued by an accredited body.	10 (n=100)
4.11	Occupational risk management systems II	Occupational risk management system in the productive center	1. Having a valid certificate in accordance with ISO 45001 issued by an accredited entity. 2. There is an occupational risk management system for the company / group audited in the last financial year. 3. There is no audited or certified occupational risk management system.	16

4.12	Occupational risk management systems III	Occupational risk management system according to OHSAS 18001 or ISO 45001.	It has a valid certificate.	10 (n=100)
4.13	Accident indicators of own personnel I	Parameters (4): 1. Frequency rate (I_f) 2. Incidence rate (I_i) 3. Gravity rate (I_g) 4. Frequency rate (mortals) ($I_{f\,(mortales)}$)) Where: $I_f = \frac{N^o_{\text{total accidents with work leave}}}{N^o_{\text{total man hours worked}}} * 10^6$ $I_i = \frac{N^o_{\text{total accidents with work leave}}}{N^o_{\text{total people exposed}}} * 10^5$ $I_g = \frac{N^o_{\text{total days lost through injury}}}{N^o_{\text{total man hours worked}}} * 10^3$ $I_{f\,(mortales)} = \frac{N^o_{\text{total fatal accidents in working days}}}{N^o_{\text{total man hours worked}}} * 10^8$ The term "man hours" is understood as the sum of real working hours of own personnel, discounting any absence from work due to leave, vacation, sick leave or accident, etc.	Objective for each Parameter : 1. Business objective or null value. 2. Data from the previous year **Construction** Data from the previous year Trend: decreasing	8 10 (n=25)
4.14	Accident indicators of own personnel in concrete plants	Value of the average index of the company in the last 3 years (I_m) with respect to the index of the sector in the last sector report (I_s). Parameters (3): 1. Frequency rate (I_f) 2. Incidence rate (I_i) 3. Gravity rate (I_g)	Objective for each Parameter : 1. $I_m \leq 50\%\ I_s$ 2. $75\%\ I_s \geq I_m > 50\%\ I_s$ 3. $I_s \geq I_m > 75\%\ I_s$ 4. $I_m > I_s$	13
4.15	Accident rates of contracted personnel I	Parameters (4): 1. Frequency rate (I_f) 2. Incidence rate (I_i) 3. Gravity rate (I_g) 4. Frequency rate (mortals) ($I_{f\,(mortales)}$))	Objective for each Parameter : 1. Business objective or null value. 2. Data from the previous year Trend: decreasing	8
4.16	Accident rates of contracted personnel II	Frequency rate (mortals)	Data from the previous year. Trend: decreasing	5
4.17	Specific prevention measures	Parameters (2): 1. Prevention actions: Number of actions to reduce occupational	Objective for each Parameter :	Par.1: General 2

		risks, initiated, in progress or completed during the year. 2. Training programs in health and safety: Hours of training, in matters of safety and health and occupational safety, carried out during the year including those given by the company to contract staff.	Parameter 1: Objective to choose among the following and that should be maintained over time: 1. Data from the previous year 2. Number of actions planned in the prevention plan Parameter 2: 1. Hours planned in the training plan. 2. Data from the previous year Trend: increasing	Pretensado in situ 5 Par.2: General 11 Prestressed in situ 17
4.18	Specific prevention actions with training that exceeds the legal minimum required	Occupational Risks Prevention Courses with a duration exceeding the legal minimum required during the year	1.- Named courses planned in the training plan 2.- Data from the previous year Trend: increasing	17
4.19	Occupational health and safety rates	Parameters (3): 1. Death incidence rate: $$IIF = \frac{\text{Num. fatal accidents} * 1.000}{\text{Num. workers}}$$ 2. Incidence rate of accidents with temporary disability: $$IIACIT = \frac{\text{Num. accidents with temporal disability} * 1000}{\text{Num. of workers}}$$ 3. Gravity Rate: $$IGACIT = \frac{\text{Num. days lost by temporal disability} * 1.000}{\text{Num. total hours worked}}$$ The number of workers shall include their own employees, including full-time, part-time and temporary employees (the latter two, estimated as full-time equivalents). It includes employees of all companies where there is a management and companies control with which a technical or management agreement has been signed. The indicators may be calculated at the company level or at the installation level.	Objective for each Parameter : Parameter 1: 1.IIF=0 2. - 3.IIF > 0 Parameter 2: 1. IIACIT <25 2. 25 ≤ IIACIT < 50 3. IIACIT ≥ 50 Parameter 3: 1.IG < 0,80 2.0,80 ≤ IG < 1,0 3.IG ≥ 1,0	20
4.20	Good Government / Corporate Responsibility	Availability of policies, practices and good governance procedures. Parameters (3):	Objective for each Parameter :	10(n=33,4)

		1. Existence of a politics on good governance, but without definition of concrete actions. 2. Standards or procedures with criteria to avoid corruption in the domestic sphere (for example, regarding suppliers). 3. Standards or procedures with criteria to prevent corruption in the external environment (for example, with respect to clients, etc.)	There is the mentioned policy, standard or procedure. Trend: increasing	
4.21	Good Government and Corporate Social Responsibility	Realization of the indicated activities: Parameters (8): 1. There is a code of ethics or conduct that indicates the norms and general guidelines that mark the principles of corporate action and this is transmitted to all interest groups 2. Having an ethics committee or commission. 3. Define ethical norms or action procedures in the processes of purchase and selection of suppliers 4. Define ethical standards or procedures for action related to clients 5. Tools to preserve the privacy of the client, protection and treatment of personal data and confidential information 6. Adhesion to initiatives that promote ethical behaviour (United Nations Global Compact) 7. Development of improvement systems for service excellence and to increase responsible management (for example: System of ethical and socially responsible management SGE 21. etc.) 8. Existence of concrete actions for gender diversity.	Objective for each Parameter : There is evidence of the activity implementation.	10 (n=20)
4.22	Integration or equality actions	Integration or promotion of equality activities, carried out during the year. Parameters (6): 1. Existence of a politics against discrimination but without definition of concrete actions. 2. Rules or procedures for hiring / promotion with criteria against discrimination sufficiently detailed. 3. Measures to improve conditions for women in	Objective for all the parameters: There is the mentioned politics, norm, procedure or measure.	10 (n=20)

		pregnancy or other groups with special needs. 4. Equality of men and women in jobs (existence of workers of both genders in all category / area combinations). 5. Hiring people with disabilities above the legally required minimum (when there is no fee set by state regulations, it must be at least 2%, for companies with more than 50 workers) 6. Agreements with public administrations.		
4.23	Social benefits	Non-obligatory social benefits adopted by the organization, including conciliation measures. Parameters (8): 1. Flexibility of working hours 2. Reduction of working hours for children or disabled people, beyond what is recognized by legislation or programs or agreements with nursery school. 3. Social dining room, restaurant cheques or other similar programs. 4. Transport to the workplace (as long as you can benefit from it, depending on your residence, at least half of the staff). 5. Cultural, sports or recreational activities for workers and their families. 6. Scholarships, loans or training subsidies for workers and their families in any field. 7. Insurance or health programs for workers and their families, with a reduced cost compared to the market price. 8. Assistance programs in case of serious family misfortune, including life insurance.	Objective for all the Parameters: There is the mentioned policy, standard, procedure or measure.	10 (n=20)
4.24	Sponsorships and cultural, sports and environmental projects	Parameters (3): 1. Cultural projects 2. Sport projects 3. Environmental projects For the three parameters, one of the following calculation methods shall be chosen, which should be maintained in time: a) Amount of contributions to projects carried out or sponsored by the company with respect to the value of production in monetary units or	Objectives for each Parameter : 1. Business objective 2. Data from the previous year **Prestressed in situ** 1. Business objective 2. Data from the previous year	12 22

		tons. (euros / euros or euros / t). b) Amount of completed projects with respect to the value of production in monetary units or tons. (euros / euros or euros / t).		
4.25	Collaboration with environmental agents.	There are collaborations with entities or local institutions or (town halls, sports clubs, etc.)	There is evidence of the existence of collaborations.	10(n=100)
4.26	Projects Social	Social projects such as for example: - Vocational training programs - Support for the disabled - Agreements with universities and research centers - Singular Chairs - Donations / social action - For the calculation of the parameter one of the following methods shall be chosen, which should be maintained in time: a) Amount of contributions to social projects carried out or sponsored by the company with respect to the value of production in monetary units or tons (euros / euros or euros / t). b) Number of completed social projects regarding the value of production in monetary units or tons (Num. projects / euros or Num. projects / t).	1. Business objective 2. Data from the previous year	7
4.27	Communication on Social Responsibility I	Mechanisms of communication with the interested parties of the organization or business group to which they belong, to inform about their social, economic and environmental performance. Parameters (4): 1. Publication of reports or social responsibility reports (n = 40) 2. Meetings with stakeholders (n = 20) 3. Communications related to products (n = 20) 4. Public surveys aimed at knowing the opinion of the stakeholders about the action of the organization (n = 20)	Objective for each Parameter : There is the mentioned communication mechanism. Trend: increasing	10 (n= according to parameter)

4.28	Communication on Social Responsibility II	It has a communication report with stakeholders.	It has the report	10 (n=100)
4.29	Activities in community	Realization of the activities indicated. Parameters (9): 1. Laboral foundations 2. Relations with universities 3. Writing sustainability reports, including at the group level 4. Participation in sectoral and promotional activities 5. Participation in standardization committees 6. Collaboration agreements with third sector entities (NGOs or Foundations) to develop joint projects 7. Social requirements for the selection of suppliers, favouring the hiring of local suppliers 8. Information on the social management in the communication of the company 9. Corporate volunteering promotion programs	Objective for each parameter: There is evidence of the implementation of the activity.	10 (n=20)
4.30	Behaviour with employees	Realization of the activities indicated. Parameters (7): 1. Initiatives in favour of conciliation between professional and personal life (flexibility of schedules, possibility of reduced working hours, teleworking, etc.) 2. Training programs and professional development according to needs and levels, with annual budget for training 3. Achievement evaluation programs 4. Communication channels to encourage participation and involvement of workers 5. Safety, Health and Welfare Programs 6. Work climate studies 7. Management of diversity (cultures, religions, origins, sex and race, among others) in the selection, training, development and remuneration of staff	Objective for each Parameter : There is evidence of the implementation of the activity.	10 (n=20)

4.31	Customer complaints	Number of customer complaints per ton of final product. Only those registered during the year and evaluated as pertinent, related to the quality of the product or commercial aspects shall be considered. Parameters (2): 1. Quality complaints 2. Commercial complaints	Objective for each Parameter : Null value or lower than Data from the previous year Trend: decreasing	10 (n=50)
4.32	Customer satisfaction I	Number of customer claims per million tons sold (R). Only those registered and evaluated as pertinent and related to the quality of the product and not to the quality of the service will be considered. The Assessment shall carry out by company.	1.- 0≤R≤30 2.- 30<R≤60 3.- R>60	16
4.33	Customer satisfaction II	Realization of the activities indicated. Parameters (5): 1. Customer satisfaction surveys 2. Evaluation of customer satisfaction by alternative means 3. CRM systems (Customer Relationship Management or Management based on the relationship with customers) 4. Courses, training and customer orientation 5. Existence of technical assistance services.	Objective for each Parameter : There is evidence of the implementation of the activity.	10 (n=20)
4.34	Customer satisfaction III	Realization of the activities indicated. Parameters (2): 1. Existence of customer satisfaction surveys 2. Average score of clients with a minimum value of 70%	Objective for each Parameter : There is evidence of the implementation of the activity.	10 (n=50)
4.35	Customer and third part satisfaction	Protocol for third party or customer complaints register, in relation to quality, environmental or social issues, and their treatment.	Having the protocol.	10(n=100)
4.36	Data protection audits	Carrying out data protection audits at least every two years assessing the result of the last audit.	According to the audit report: 1. No deviation. 2. Measures have been implemented in time to resolve at least 75% of the deviations	7
4.37	Local employment I	Employment associated with the contractors of the organization who come from the local environment and who work inside the facilities (estimated equivalent jobs such as the ratio between the total hours worked and the	Overcoming data from the previous year Trend: increasing	10 (n=100)

		annual average of hours worked in a job on full time.)		
4.38	Local employment II	Employment generated by the organization in the environment of 50 km around each of its headquarters, in proportion to the total number of employees (EML). In the case of construction companies, this indicator refers to the central headquarters where the company's central services are located	EML > 75% 75% ≥ EML > 65% 65% ≥ EML > 50% EML ≤ 50%	14
4.39	Local purchases I	Percentage of local purchases of goods and services. Parameters (3): 1. Percentage of local purchases of scrap (steel) 2. Percentage of local billet purchases (steel) 3. Percentage of local purchases of other goods and services (all agents)	Objective for each Parameter : **General** Overcoming of data from the previous year Trend: increasing **Prestressed in situ** 1. Data from the annual budget. 2.Data from the previous year Trend: increasing	2 17
4.40	Local purchases II	Purchase of raw materials for concrete manufacturing: Parameters (2): 1. Aggregates: less than 30 km from the plant 2. Cements: to one of the two installations closest to the plant.	Objective for each Parameter : There is evidence of compliance.	10 (n=50)
4.41	Purchases and local employment	Percentage of local supplies of the main constituent raw materials (own or foreign) of clinker and cement within a radius of 100 km, measured on the percentage of purchases of the facility in tons (R).	1.- R ≥ 60% 2.- 60% > R ≥ 40% 3.- R < 40%	16

Table A2.A.1.4

2. Criteria for assessing the indicators

The following table defines the valuation systems to obtain λ_ (j, l, m) depending on the system indicated for each case in column 5 "Valuation system" of the tables in the previous section.

VALUATION SYSTEM			
Num. system	$\lambda_{j,l,m}$	Num. system	$\lambda_{j,l,m}$

1	+100 If it reaches objective 1 +50 If it does not reach objective 1 but it exceeds objective 2 -50 50 If it does not reach objective 1, either objective 2	2	+100 If it exceeds objective 0 If it equals objective -50 If it is below objective
3	1. +100 2. +75 3. +25 4. + 0	4	+100 if objective 1 is not exceeded +50 if objective 1 is exceeded but does not exceed objective 2 0 if objective 1 is exceeded and goal 2 is exceeded When objective 1 = objective 2 will apply: +100 if objective 1 is not exceeded +50 if objective 1 is exceeded but not exceeded (1.35 objective 1) 0 if it exceeds (1.35, objective 1) Considering as objective 2 the best value of those obtained in previous years. In the case of production in regression (production budgeted for the year < actual production of the previous year) it may be accepted that objective 1 > objective 2 and the same assessment table may be applied for the case in which objective 1 = objective 2.
5	+100 If it exceeds objective +50 If it equals objective 0 If it is below objective	6	+100 If it reaches objective 1 +50 If it does not reach objective 1 but below objective 2 0 If it does not reach objective 1, either objective 2
7	+100 If it reaches objective 1 +50 If it does not reach objective 1 but it exceeds objective 2 0 If it does not reach objective 1, either objective 2	8	+100 If it reaches objective 1 +50 If it does not reach objective 1 but below objective 2 -50 If it does not achieve objective 1 nor lower objective 2
9	+100 If it reaches objective +50 if does not exceed objective 0 Other cases	10 (n)	+n If it reaches objective 0 Other cases
11	+100 If it reaches objective 1 and exceeds objective 2 +50 If it reaches objective 1 and equals objective 2 0 If it does not reach objective 1 but equals objective 2 -50 Other cases	12	+100 If it reaches objective 1 +50 If it does not reach objective 1 but exceeds objective 2 0 If it does not reach objective 1 but equals objective 2 -50 Other cases
13	1. + 100 2. + 75 3. + 25 4. + 0	14	1. + 100 2. + 50 3. + 25 4. + 0
15	For each parameter 1 and 2: 1. +50 2. +25 3. + 0	16	1. + 100 2. + 60 3. + 0
17	+100 If it reaches objective 1 +50 If it does not reach objective 1 but exceeds objective 2 0 If it does not reach objective 1 nor exceeds objective 2	18	For each parameter 1 and 2: 1. + 50 2. + 0

	When objective 1 = objective 2, it shall be applied: +100 If it reaches objective 1 +50 If it does not reach objective 1 but reaches or exceeds (0,65. objective 1) 0 If it does not reach (0,65 . objective 1) Considering as objective 2 the best value of those obtained in previous years		
19	1. +100 2. +75 3. +50 4. +25	20	For each parameter : 1. + 34 2. + 10 3. + 0
21	1. + 40 2. + 20 3. + 0	22	+100 If it reaches objective 1 +50 If it does not reach objective 1 but exceeds objective 2 0 If it does not reach objective 1 but equals objective 2 -50 Other cases When objective 1 = objective 2, it shall be applied: +100 If it reaches objective 1 +50 If it does not reach objective 1 but reaches or exceeds (0,65 . objective 1) 0 If it does not reach (0,65 . objective 1) Considering as objective 2 the best value of those obtained in previous years. In the case of production in regression (production budgeted for the year < actual production of the previous year) it may be accepted that objective 1 < objective 2 and the same assessment table may be applied for the case in which objective 1 = objective 2.

Table A2.A.2

In the event that the application of the above evaluation criteria entails values of $\lambda_{j,l,m} > 100$, a maximum valuation of $\lambda_{j,l,m} = 100$ shall be taken.

NOTE: In the case of existing several parameters, the valuation of each indicator is obtained as sum of the positive or negative valuation of each one of the parameters that it includes. The positive score for the indicator is limited to a maximum of 100 points. The score of the indicator is limited inferiorly to a minimum of 0 points.

Example: Indicator with 4 parameters P1, P2, P3 and P4.

The score obtained in each parameter is indicated in parentheses:

Case 1: P1 (100), P2 (+50), P3 (0), P4 (-50)

Score of indicator (PI) = Σ Score of indicator 4 parameters = 100 + 50 + 0 – 50 = 100

Final value of indicator PI = 100

Case 2: P1 (100), P2 (100), P3 (0), P4 (-50)

Score of indicator PI = Σ Score of indicator 4 Parameters = 100 + 100 + 0 – 50 = 150

Final value of indicator PI = 100

Case 3: P1 (+50), P2 (-50), P3 (0), P4 (-50)

Score of indicator = Σ Score of indicator 4 Parameters = 50 - 50 + 0 – 50 = - 50

Final value of indicator PI = 0

3. Selection of indicators applicable to each agent

Weight factor $\gamma_{j,l}$ and indicators ICAS (PROJECT, $j = 1$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production / productivity	0,5	2.2	-
	2	Profitability indicator	0,5	2.3, 2.4	-
	3	Investments	-	-	-
Environmental	1	Management systems	0,4	3.1	-
	2	GHG emissions			-
	3	Materials	-	-	-
	4	Energy	0,15	3.19	-
	5	Water	0,15	3.26	-
	6	Biodiversity	-	-	-
	7	Other emissions	-	-	-
	8	Waste	-	-	-
	9	Residues	0,15	3.49	-
	10	Other environmental aspects	0,15	3.68, 3.69	-
Social	1	Employment	0,2	4.1	4.3, 4.6, 4.7, 4.9
	2	Occupational health and safety	0,25	4.11	4.15, 4.17, 4.19
	3	Good Government, diversity, equality and social benefits	0,2	4.23	4.20, 4.22
	4	Community	0,1	4.29	-
	5	Customer satisfaction	0,15	4.34	4.31
	6	Shopping and local employment	0,1	4.38	

Table A2.A.3.1

Weight factor $\gamma_{j,l}$ and indicators ICAS (CONCRETE, $j = 2$)

Annex 2
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Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production/productivity	1	2.17, 2.18, 2.19	-
	2	Profitability indicators	-	-	-
	3	Investments	-	-	-
Environmental	1	Management systems	0,15	3.4	-
	2	GHG emissions	0,15	3.10	-
	3	Materials	0,14	3.55	-
	4	Energy	0,14	3.21	-
	5	Water	-	-	-
	6	Biodiversity	0,14	3.30	-
	7	Other emissions	0,14	3.40	-
	8	Waste	-	-	-
	9	Residues	-	-	-
	10	Other environmental aspects	0,14	3.54	-
Social	1	Employment	0,2	4.5	-
	2	Occupational health and safety	0,3	4.19, 4.11	-
	3	Good Government, diversity, equality and social benefits	0,2	4.20	-
	4	Community	0,2	4.29, 4.30	-
	5	Customer satisfaction	0,05	4.33	4.32
	6	Shopping and local employment	0,05	4.41	-

Table A2.A.3.2

Weight factor γ_{jl} and indicators ICAS (AGGREGATES, $j = 3$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	1.7
Economic	1	Production/productivity	0,50	2.2	2.1
	2	Profitability indicators	0,25	-	2.6, 2.7, 2.9
	3	Investments	0,25	-	2.11, 2.16
Environmental	1	Management systems	0,25	3.3	-
	2	GHG emissions	-	-	-
	3	Materials	0,15	3.13	-
	4	Energy	0,10	-	3.15, 3.20,
	5	Water	0,10	3.24	3.25
	6	Biodiversity	0,25	3.30	3.29, 3.54
	7	Other emissions	-	-	-
	8	Waste	-	-	-
	9	Residues	0,10	3.48	3.52 3.53
	10	Other environmental aspects	0,05	-	3.56, 3.58
Social	1	Employment	0,17	4.7, 4.9	4.1, 4.3, 4.6
	2	Occupational health and safety	0,17	4.11, 4.13, 4.17	4.15
	3	Good Government, diversity, equality and social benefits	0,17	4.20	4.22, 4.23
	4	Community	0,16	-	4.24, 4.25, 4.27, 4.29, 4.30
	5	Customer satisfaction	0,17	4.31	4.33
	6	Shopping and local employment	0,16	4.38	4.39

Table A2.A.3.3

Weight factor $\gamma_{j,l}$ and indicators ICAS (ADDITIVES, $j = 4$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production/productivity	0,33	2.1	-
	2	Profitable indicators	0,34	2.3, 2.4, 2.6	2.7, 2.9
	3	Investments	0,33	2.10	2.14, 2.15
Environmental	1	Management systems	0,12	3.1	
	2	GHG emissions	-	-	-
	3	Materials	0,11	3.12	-
	4	Energy	0,11	3.23	3.20, 3.22
	5	Water	0,11	3.24	3.28
	6	Biodiversity	0,11	3.29	-
	7	Other emissions	0,11	3.41	-
	8	Waste	0,11	3.42	-
	9	Residues	0,11	3.48	3.50
	10	Other environmental aspects	0,11	3.57	3.56, 3.58, 3.62
Social	1	Employment	0,17	4.1, 4.3, 4.6, 4.9	4.7
	2	Occupational health and safety	0,17	4.13, 4.15	4.10, 4.17
	3	Good Government, diversity, equality and social benefits	0,17	4.20	4.22, 4.23
	4	Community	0,17	4.24	4.26, 4.27, 4.29
	5	Customer satisfaction	0,16	4.31	4.33, 4.36
	6	Shopping and local employment	0,16	4.37, 4.40	

Table A2.A.3.4

Weight factor $\gamma_{j,l}$ and indicators ICAS (STEEL, $j = 5$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production/productivity	0,3	2.1	-
	2	Profitable indicators	0,5	2.3, 2.4	2.6, 2.7, 2.9
	3	Investments	0,2	2.10	2.14, 2.16
Environmental	1	Management systems	0,05	3.2	
	2	GHG emissions	0,25	3.7, 3.9	-
	3	Materials	0,05	3.12	-
	4	Energy	0,15	3.6, 3.16(1), 3.18(2)	3.20,3.22
	5	Water	0,15	3.23, 3.24	3.28
	6	Biodiversity	0,05	3.29	-
	7	Other emissions	0,1	3.31(1), 3.32(2), 3.34(2), 3.35(1), 3.36(2), 3.39(2), 3.41	3.33(1), 3.37(1)
	8	Waste	0,1	3.43(1), 3.45(2)	3.46(1)
	9	Residues	0,05	3.48, 3.70	3.50
	10	Other environmental aspects	0,05	3.57, 3.60, 3.63	3.56, 3.58, 3.61, 3.62, 3.65
Social	1	Employment	0,3	4.1, 4.3, 4.9	4.6, 4.7
	2	Occupational health and safety	0,3	4.10, 4.13, 4.15	4.17
	3	Good Government, diversity, equality and social benefits	0,25	4.20, 4.22, 4.23	-
	4	Community	0,05	4.24, 4.26	4.27, 4.29
	5	Customer satisfaction	0,05	4.31	4.33, 4.36
	6	Shopping and local employment	0,05	4.37, 4.39	-

(1) Does not apply to stainless steels.

(2) Only applies to stainless steels

Table A2.A.3.5

Weight factor $\gamma_{j,l}$ and indicators ICAS (CONCRETE, $j = 6$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.2, 1.3	1.1
Economic	1	Production/productivity	0,5	2.20	
	2	Profitable indicators	0,5	2.5	
	3	Investments			
Environmental	1	Management systems	0,1	3.1	
	2	GHG emissions			
	3	Materials	0,15	3.14	
	4	Energy			
	5	Water			
	6	Biodiversity			
	7	Other emissions			
	8	Waste	0,2	3.47	
	9	Residues	0,2	3.51	
	10	Other environmental aspects	0,35	3.66, 3.67, 3.71	
Social	1	Employment	0,2	4.3, 4.9	4.7
	2	Occupational health and safety	0,2	4.11, 4.14	
	3	Good Government, diversity, equality and social benefits	0,15	4.20	
	4	Community	0,15	4.29	4.25
	5	Customer satisfaction	0,15	4.35	4.36
	6	Shopping and local employment	0,15	4.40	

Table A2.A.3.6

Weight factor $\gamma_{j,l}$ and indicators ICAS (PRECAST CONCRETE, $j = 7$)					
Type of requirements	Criteria			Indicators	
	Num.	Name	Weight factor γ_{jl}	Obligatory	Voluntary
Performance	1	Quality	1	1.1	
Economic	1	Production/productivity	0,1	2.1	-
	2	Profitable indicators	0,6	2.3, 2.4	
	3	Investments	0,3	2.10	2.14
Environmental	1	Management systems	0,50	3.1	
	2	GHG emissions	-	-	-
	3	Materials	0,1	3.12	-
	4	Energy	0,05	3.15	3.20
	5	Water	0,05	3.24	
	6	Biodiversity	-	-	-
	7	Other emissions	0,05	3.41	-
	8	Waste	0,06	3.42	-
	9	Residues	0,12	3.48	3.50
	10	Other environmental aspects	0,07	3.57, 3.66	3.56
Social	1	Employment	0,25	4.1, 4.9	4.7
	2	Occupational health and safety	0,30	4.13	4.10, 4.17
	3	Good Government, diversity, equality and social benefits	0,15	4.22	4.20
	4	Community	0,05	4.24	-
	5	Customer satisfaction	0,20	4.31	4.36
	6	Shopping and local employment	0,05	4.38	-

Table A2.A.3.7

Annex 2
Index of contribution of the structure to sustainability

Weight factor $\gamma_{j,l}$ and indicators ICAS (STEEL PROCESSED, j=8)					
Requirements	Criteria			Indicators	
	Num.	Name	Weight factor $\gamma_{j,k,l}$	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production/productivity	0,3	2.1	-
	2	Profitable indicators	0,5	2.3, 2.4	2.6, 2.7, 2.9
	3	Investments	0,2	2.10	2.14, , 2.16
Environmental	1	Management systems	0,1/0,05 (1)	3.1, 3.2(1)	-
	2	GHG emissions (1)	0,25 (1)	3.7(1), 3.9(1)	-
	3	Materials	0,1 /0,05 (1)	3.12	-
	4	Energy	0,3/0,15 (1)	3.15, 3.17 (1)	3.6, 3.20,3.22
	5	Water	0,1/0,15(1)	3.23, 3.24(1)	3.28
	6	Biodiversity	0,05 (1)	3.29(1)	-
	7	Other emissions	0,1	3.38(1), 3.41	-
	8	Waste	0,1	3.42, 3.44(1)	-
	9	Residues	0,1/0,05 (1)	3.48	3.50
	10	Other environmental aspects	0,1/0,05 (1)	3.57, 3.60(1), 3.63	3.56, 3.58, 3.61(1), 3.62, 3.65
Social	1	Employment	0,3	4.1, 4.3	4.6, 4.7, 4.9
	2	Occupational health and safety	0,3	4.13, 4.15, 4.17	4.10
	3	Good Government, diversity, equality and social benefits	0,25	4.20	4.22, 4.23

	4	Community	0,05	4.29	4.24, 4.26, 4.27
	5	Customer satisfaction	0,05	4.31	4.33, 4.36
	6	Shopping and local employment	0,05	4.37, 4.39	-

(1) Only applies to prestressed steel

Table A2.A.3.8

Weight factor $\gamma_{j,l}$ and indicators ICAS (METALLIC STRUCTURES WORKSHOP, j=9)					
Requirements	Criteria			Indicators	
	Num.	Name	Weight factor $\gamma_{j,k,l}$	Obligatory	Voluntary
Performance	1	Quality	1	1.1	-
Economic	1	Production/productivity	0,3	2.1	-
	2	Profitable indicators	0,5	2.3, 2.4	2.6, 2.7, 2.9
	3	Investments	0,2	2.10	2.14, 2.16
Environmental	1	Management systems	0,1	3.1	-
	2	Materials	0,1	3.12	-
	3	Energy	0,3	3.15	3.6, 3.20,3.22
	4	Water	0,1	3.23	3.28
	5	Biodiversity	0,1	3.41	-
	6	Other emissions	0,1	3.42	-
	7	Waste	0,1	3.48	3.50
	8	Residues	0,1	3.57, 3.63	3.56, 3.58, 3.62, 3.65

Social	1	Other environmental aspects	0,3	4.1, 4.3	4.6, 4.7, 4.9
	2	Employment	0,3	4.13, 4.15, 4.17	4.10
	3	Occupational health and safety	0,25	4.20	4.22, 4.23
	4	Good Government, diversity, equality and social benefits	0,05	4.24, 4.26, 4.29	4.27
	5	Community	0,05	4.31, 4.36, 4.33	
	6	Customer satisfaction	0,05	4.37, 4.39	-

Table A2.A.3.9

(Weight factor $\gamma_{j,l}$ and indicators ICAS (PRESTRESSED, j=10)					
Requirements	Criteria			Indicators	
	Num.	Name	Weight factor $\gamma_{j,k,l}$	Obligatory	Voluntary
Performance	1	Quality	1	1.1,1.8	1.4
Economic	1	Production/productivity	0,3	2.2	-
	2	Profitable indicators	0,5	2.8	-
	3	Investments	0,2	2.15	-
Environmental	1	Management systems	0,24	3.1	3.65
	2	GHG emissions	0,34	3.9	-
	3	Materials	-	-	-
	4	Energy	0,16	3.15	-

	5	Water	0,16	3.23	-
	6	Biodiversity	-	-	-
	7	Other emissions	-	-	-
	8	Waste	-	-	-
	9	Residues	-	-	-
	10	Other environmental aspects	0,10	3.72	3.68
Social	1	Employment	0,35	4.6, 4.7	4.30
	2	Occupational health and safety	0,25	4.13, 4.17	4.18
	3	Good Government, diversity, equality and social benefits	0,20	4.20	-
	4	Community	0,05	4.22	4.24, 4.29
	5	Customer satisfaction	0,10	4.31, 4.33	-
	6	Shopping and local employment	0,05	4.39	-

Table A2.A.3.10

Weight factor $\gamma_{j,l}$ and indicators ICAS (CONSTRUCTION IN WORK, j=11)					
Requirements	Criteria			Indicators	
	Num.	Name	Weight factor $\gamma_{j,k,l}$	Obligatory	Voluntary
Performance	1	Quality	1	1.1, 1.6	1.5
Economic	1	Profitable indicators	0,7	2.6	2.7
	2	Investments	0,3	2.12, 2.13	

Environmental	1	Management systems	0,08	3.5	
	2	GHG emissions	0,34	3.8	-
	3	Materials	-		-
	4	Energy	0,16	3.11	
	5	Water	0,16	3.27	
	6	Biodiversity	-		
	7	Other emissions	-		
	8	Waste	-		
	9	Residues	0,16	3.49	
	10	Other environmental aspects	0,10		3.56, 3.59, 3.64
Social	1	Employment	0,35	4.8	4.2, 4.4
	2	Occupational health and safety	0,30	4.12, 4.13	4.16,4.17
	3	Good Government, diversity, equality and social benefits	0,25	4.21	4.22
	4	Community	0,10	4.28	4.24, 4.29
	5	Customer satisfaction	-		
	6	Shopping and local employment	-		

Table A2.A.3.11

APPENDIX B. Complementary contribution to sustainability

1. Definition of indicators related to the complementary contribution of the processes

NOTE 1: Officially recognized sustainability badges

The officially recognized badges should meet the requirements established in article 7 of Chapter 2 of this Code.

NOTE 2: Environmental product declarations

The program administrator issuing the environmental product declaration (DAP) should do so according to the construction products of Table A2.2 and have general instructions publicly available, in accordance with the UNE-EN ISO 14025: 2010 Standard.

The verifying organism should meet with the of the program administrator's general instructions issuing the environmental product declaration.

The verifying organism must be accredited according to the Standard UNE-EN ISO / IEC 17065: 2012 by the National Accreditation Entity (ENAC) or by another national body according to Regulation (EC) No. 765/2008 of the European Parliament and of the Council, of July 9, 2008. The scope of the accreditation should include the Rules of Product Category (RCP) that corresponds to you, of those indicated in this annex.

The environmental product declarations should be developed, verified and issued in accordance with the provisions of the Rules:

- UNE-EN ISO 14025:2010
- UNE-EN 15804:2012+A1:2014
- In case it has been published, the specific Product Category Rule prepared by the corresponding Product Technical Committee

PRODUCT	PRODUCT CATEGORY RULE
Cement	UNE EN 16908:
Hot-rolled non-alloy steel from electric furnace	UNE 36904-1
Concrete	UNE EN 16757
Precasted concrete	UNE EN 16757
Transformed steel	UNE 36904-2
Metal structures workshop	UNE 36904-2
Prestressing systems "in situ"	UNE 36904-2

NOTE:

As indicated in Annex 1 of this Code, the aforementioned regulations may be replaced by others used in any of the other Member States of the European Union, or that are part of the Agreement on the European Economic Area, and in those States that have a customs association agreement with the European Union, provided that they are shown to own the same technical specifications.

Table A2.B.1

In case of medium or sectorial environmental product declarations, only those products that have been included in the data inventory that supports the life cycle analysis of said declaration may be part of them.

The environmental statement should also contain the following information:

- Explicit reference to compliance with the reference standards and the SPCs indicated in this Structural Code, including the national annexes if they exist.
- Identification of the program administrator and the verifying organism, including the program administrator's contact details.
- Unique identification of the product
- Geographical scope of the DAP. In case of products manufactured outside of Spain, a transportation scenario should be included, at least one capital of the Spanish province.

3. PERFORMANCE INDICATORS				
Num.	Indicator	Definition/Parameters	Objectives	Valuation system
1.1	DCOR	Officially Recognized Quality Mark (DCOR) in accordance with article 18 of this Code.	It has DCOR	2 (n=100)
1.2	Conceptual analysis	The project has a structural design study, carried out before the beginning of the project, in order to identify its critical points.	It has the study Maximum rating if it has DCOR.	2 (n=100)
1.3	Project control	The project has been subject to self-control by the designer, documented and verifiable.	It has self-control Maximum rating if it has DCOR.	2 (n=100)
1.4	Execution control	The construction process is subject to intense execution control, in accordance with the provisions of this Code.	It has intense control. Maximum rating if it has DCOR.	2 (n=100)
1.5	Encouragement of the industrialization of the reinforcement I	The project contemplates a percentage of reinforcements with standardized forms (ARN), according to UNE 36831.	1. ARN > 90% 2. 90% ≥ ARN > 80% 3. 80% ≥ARN > 75% 4. ARN ≤ 75%	4
1.6	Encouragement of the industrialization of the reinforcement II	The non-resistant joints between reinforcements are made with non-resistant solder, instead of wired. It is evaluated by the percentage of the reinforcement supplied to the work as reinforced rebar (ARS).	1. ARS > 75% 2. 75% ≥ ARS > 50% 3. 50% ≥ ARS > 25% 4. ARS ≤ 25%	4
1.7	Statistical control guarantee certificate for steel products	Steel products for the manufacture of reinforcing steel, prestressed steel and steel structures that meet the following requirements related to their statistical control: 1. For bars and rolls of steel for reinforcing steel should meet: a) Statistical control that guarantees, for all casts, with a confidence level of 90%, that at least one proportion "p" of the product meets the corresponding nominal value (where p=0.95 for R_e and R_m; p=0.90 for A_{gt} and A_5) b) statistical control that guarantees that the estimated total standard deviation of the yield strength does not exceed 5.5% of the nominal value.	It has a valid certificate issued by an accredited organism. Maximum rating if it has DCOR.	2 (n=100)

		2. For other steel products for steel structures (profiles, sheets, coils and strips): statistical control to ensure that the estimated total standard deviation of the yield strength does not exceed 10% of the nominal value.		
1.8	Statistical control guarantee certificate for steel transforms	Steel products processed for the manufacture of reinforcing steels, prestressing steels , meshes and basic reinforcements and steel products for steel structures meet the following requirements regarding their statistical control: 1. For bars and rolls of steel for reinforcing steel (should meet with) and b)): a) Statistical control that guarantees, for all casts, with a confidence level of 90%, that at least one proportion "p" of the product meets the corresponding nominal value (where p=0.95 for R_e and R_m; p=0.90 for A_{gt} and A_5) b) statistical control that guarantees that the estimated total standard deviation of the yield strength does not exceed 5.5% of the nominal value. 2. For processed steel products for reinforcing steel, meshes and basic reinforcements: statistical control that guarantees that the estimated total standard deviation of the yield strength does not exceed 10% of the nominal value.	It has a valid certificate issued by an accredited organism. Maximum rating if it has DCOR.	2 (n=100)
1.9	Use of products with statistical control	100% of the steel products used for the manufacture of reinforced rebar and steel structures meet with the statistical control established in 1.7 and / or 1.8, as appropriate.	It has a valid certificate issued by an accredited organism. Maximum rating if it has DCOR.	2 (n=100)
1.10	Civil Liability Insurance I	Certificate of validity of the Civil Liability Insurance Policy for possible manufactured defective products, with a sufficient amount to cover the possible liabilities that could be incurred.	It has a valid certificate issued by an accredited organism. Maximum rating if it has DCOR.	2 (n=100)
1.11	Civil Liability Insurance II	Civil Liability Insurance Policy for possible defective products	It has a valid policy	2 (n=100)

		(cements) manufactured, with a minimum amount of 5,000,000 €.	Maximum rating if it has DCOR.	
1.12	Civil liability insurance for concrete plants	Existence of a civil liability insurance with a specific union clause and mixture with a C coverage, expressed in euros, greater than 12 P, where P is the annual production expressed in cubic meters of concrete. The minimum coverage should be 600,000 euros and if as a consequence of the 12P product the coverage value of 1,200,000 euros is exceeded, it is allowed to maintain that value as a maximum.	It has a valid policy Maximum rating if it has DCOR.	2 (n=100)

Table A2.B.1.1

4. ECONOMIC INDICATORS				
Num.	Indicator	Definition/Parameters	Objectives	Valuation system
2.1	Economic study of alternatives	The project includes an economic study of the structure, comparing at least 3 viable solutions.	It has the economic study. Maximum rating if it has DCOR.	2 (n=100)
2.2	Analysis of life cycle costs	The project includes a cost analysis study during the entire life cycle.	It has cost analysis. Maximum rating if it has DCOR.	2 (n=100)

Table A2.B.1.2

5. ENVIRONMENTAL INDICATORS				
Num.	Indicator	Definition/Parameters	Objectives	Valuation system
3.1	Scrap content in steel	The steel incorporates a certain amount of recycled material (percentage by weight of scrap = CCA): Percentage by weight of scrap compared to the total steel supply in the steelworks (scrap, pig iron, pre-reduced and ferroalloys). For long products manufactured by hot rolling: - bars and rolls of steel for reinforcing steel. - Wire rod for further processing into steel products for reinforcing steel. - Wire rod for further processing into steel products for reinforcing steel For long structural products manufactured by hot rolling:	It has the current certificate issued by an accredited organism that verifies the specified compliance for each product. CCA ≥ 80% 1. CCA ≥ 60% 2. CCA ≥20%	 2 (n=100) 1

		- Wire rod for its subsequent transformation into steel products for prestressed steel. For long structural products manufactured by hot rolling: - Wire rod for its subsequent transformation into steel products for prestressed steel. For flat structural products manufactured by hot or cold rolling (sheets for structural steel, coils and strips for further processing). For all stainless steel products: - long products made by hot rolling (bars and rolls of steel for reinforcing steel, wire rod for further processing, profiles for structural steel), - flat products manufactured by hot or cold rolling (sheets for structural steel, coils and strips for further processing).	CCA ≥ 20% CCA ≥ 60% Maximum rating if it has DCOR.	2 (n=100) 2 (n=100)
3.2	Product environmental declarations	The product has an environmental product declaration (DAP) prepared and verified in accordance with Note 2 of Appendix B.	The product has a DAP.	2 (n=100)
3.3	Use of concrete manufactured from recycled or recovered materials	The concrete used for the structure has been manufactured from aggregates that incorporate a certain amount of recycled material or recovered from other concretes from returns to the plant.	There is evidence of this practice.	2 (n=100)
3.4	Use of concrete manufactured from recycled materials	The concrete incorporates recycled water from the washing of the tanks, in accordance with the provisions of this Code.	There is evidence of this practice.	2 (n=100)
3.5	Use of standardize reinforcements	The project includes for the use of standardized reinforcements (electrowelded mesh or basic electro-welded reinforcement in latticework). It is evaluated according to the relation between the weight of standard reinforcement arranged in the project and the measurement of the reinforcements corresponding to flat elements of the structure: slabs, concrete floor slabs, etc. (MAL).	1. MAL > 50% 2. 50% ≥ MAL > 30% 3. 30% ≥ MAL > 10% 4. MAL ≤ 10%	3
3.6	Radiological control of steel	The steel manufacturer has implemented a monitoring and control system for radioactive material in the raw materials and during the production process in accordance with the Safety Guide for Radiological Control of Scrap Recovery and Recycling Activities of the Nuclear Safety Council, which allows ensure:	It has a valid certificate issued by an accredited organism. Maximum rating if it has DCOR.	2 (n=100)

		1. That the product is below the exemption limits established in Annex VII of the European Directive 2013/59 EURATOM of the Council, of 5/12/2013 2. That the possible radioactive materials (non-exempt) detected are properly managed.		
3.7	Life cycle analysis in the project	The project incorporates a life cycle analysis (LCA) of the structural solution adopted for the project.	It has ACV. Maximum rating if it has DCOR.	2 (n=100)
3.8	100-year lifespan of the Prestressing System	The Prestressed System "in situ" incorporates, as own of said System, Elements (Kits) according to a European Technical Evaluation based on the assumption of a Useful Life of said Prestressing System of 100 years.	It has the corresponding European Technical Assessment Maximum rating if it has DCOR.	2 (n=100)
3.9	Use of reduced coefficients for the weighting of materials	Percentage of projects including the use of the reduced weighting coefficients which are admitted in this Code with respect to the total of projects carried out (% CPR). It is considered that a project has used reduced weighting coefficients when in concrete elements at least 50% of the concrete and 50% of the reinforcing steel is applied, and in steel structural elements in 100% of the steel.	Value of CPR (%).	2 (n=% CPR)
3.10	Use of reduced reduction coefficients in the Prestressing System	The installation of the Prestressing System "in situ" incorporates the necessary conditions to introduce the prestressing force with the coefficients of Reduced reduction allowed in this Code, in order to achieve the maximum permissible strain of prestressing.	It has Officially Recognized Distinction (DCOR)	2 (n=100)
3.11	Reduction of emissions in the work I	The work has systems to prevent dust emission to surrounding areas, such as the use of sprinklers, chemical stabilizers, screens or other dust retention devices, etc.	Existence and use of the system Maximum rating if it has DCOR.	2 (n=100)
3.12	Reduction of emissions in the work II	Existence of cleaning systems to avoid dirt from adjacent roads pavement	Existence and use of the system Maximum rating if it has DCOR.	2 (n=100)
3.13	Reuse of excavation products	The constructor reuses the maximum amount of excavation products corresponding to the structure, minimizing the volume of waste sent to landfill	Reuse in the work itself, 100% of the excavation products corresponding to the structure. Maximum rating if it has DCOR.	2 (n=100)

3.14	Waste management on work	The constructor makes a reservation of space in the work to deposit and manage the waste of it. Said space, container or storage area should be indicated indicating type of waste it will contain.	Existence of a defined and used space during the work to manage the waste. Maximum rating if it has DCOR.	2 (n=100)
3.15	Waste management of control polluted by sulphur	The self-control of resistance corresponding to the assessed power plant, carried out by the company or by third parties, in the plant installation or in another, it is done with concrete test not confronted with sulphur: cylindrical polished or cubic.	100% of concrete test without need of facing	2 (n=100)
3.16	Process water management	The constructor has systems to gather, store and reuse of process water. This reuse may be set aside for other applications for work and not necessarily for the structure construction. In this case, the water must comply with technical requirements established for its use as a construction material.	Existence and continued use of this type of process water reuse systems. Maximum rating if it has DCOR.	2 (n=100)
3.17	Lifetime extension	The project includes a nominal lifetime which exceeds the minimums established in the standards in force. It is evaluated from the Parameter (VU) defined as the ratio between the increase in lifetime and the minimum value established by the standards in force according to the design annex of this Code. It does not apply in the case of temporary structures.	1. VU > 30% 2. 30% ≥ VU > 20% 3. 20% ≥ VU > 10% 4. VU ≤ 10% Maximum rating if it has DCOR.	3
3.18	Decrease of waste in reinforcing steel	Reinforcement comes from steel supplied in roll. It is determined from the percentage of reinforcement that meets this condition (ARO)	1. ARO > 95% 2. 95% ≥ ARO > 75% 3. 75% ≥ ARO > 50% 4. ARO ≤ 50%	3
3.19	Installation / construction distance	Sum of the partial distances between the productive installation of basic products, the precast center, the transformed products installation or workshop, and the work in which the products are delivered (km).	1. Dist < 800 2. 800 ≤ Dist < 1.000 3. 1.000 ≤ Dist < 1.500 4. Dist ≥ 1.500	4
3.20	Scrap content in processed products	Percentage of recycled material (CTT) (scrap) contained in processed products. This percentage is calculated as a weighted average from the values of scrap content in steel (CCA) of the basic products, which have been verified by an accredited organism according to indicator 3.1.	It has a valid certificate issued by an accredited organism that verifies compliance. 1. CCT ≥ 80% 2. 80%>CCT≥50% 3. 50%>CCT≥20% 4. 20%>CCT	4

Table A2.B.1.3

6. SOCIAL INDICATORS

Num.	Indicator	Definition/Parameters	Objectives	Valuation system
4.1	General interest of the work	The work is declared as being of general interest, by any competent Public Administration	Declaration of general interest work.	2 (n=100)
4.2	Human Resources. Training	Average number of workers, including subcontractors, who have received specific training regarding technical, quality, environmental or safety and health aspects, weighted by the proportion of working days in the work.	Value greater than 50%. Maximum rating if it has DCOR.	2 (n=100)
4.3	Personnel Training for Prestressing System installation	The specialized personnel assigned to the installation of the prestressing system shall be in possession of a document that recognizes their professional qualification, as Specialized Operator, Specialist Technician or Person in Charge of the Works, for said Installation of the Pressing System.	It has the required documentation. Maximum rating if it has DCOR.	2 (n=100)
4.4	Health and safety	Percentage of collective security elements and work teams in height, certified, used in the work contemplated in the following Parameters: Parameters (3): 1. Safety networks in accordance with Standard UNE-EN 1263-1. 2. Peripheral edge protection systems (handrails), in accordance with the UNE-EN 13374 Standard. 3. Scaffolding, in accordance with Standard UNE-EN 12810-1.	Objective for each Parameter : Percentage value (%). N: Number of Parameters for the indicator used in the work. Maximum rating if it has DCOR.	2 (n=%/N)
4.5	Information to the citizen	The work has an information system (for example, website, the citizen service office , service telephone , etc.) relative to the work characteristics, terms of execution, evolution of the work in time, economic and social implications, etc.	Existence and accessibility of the information system. Maximum rating if it has DCOR.	2 (n=100)

Table A2.B.1.4

2. Criteria for assessing the indicators

For each of the indicators m, defined for each criterion l and agent j, the following table defines the assessing criteria to obtain $\lambda_{j,l,m}$ depending on the system indicated for each case in column 5 "Valuation system" from the tables of the previous section.

VALUATION SYSTEM			
Num. system	$\lambda_{j,l,m}$	Num. system	$\lambda_{j,l,m}$
1	+100 If it reaches objective 1 +50 If it does not reach objective 1 but exceeds objective 2 0 If it does not reach objective 1 nor superior objective 2	2 (n)	+n If it reaches objective 0 Other cases
3	1. + 100 2. + 75 3. + 25 4. + 0	4	1. + 100 2. + 50 3. + 25 4. + 0

Table A2.B.2

In the event that the application of the above evaluation criteria entails values of $\lambda_{j,l,m} > 100$, a maximum valuation of $\lambda_{j,l,m} = 100$ (shall be taken (see Note of section 2 of the Appendix A)

3. Selection of indicators related to the complementary contribution according to the type of criteria

Weight factor $\gamma_{j,l}$ and indicators ICS (PROJECT, j = 1)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
	1	Officially Recognized Quality Badge (DCOR)	0,1	1.1
Performance	2	Conceptual analysis	0,3	1.2
	3	Project control	0,3	1.3
	4	Reinforcing industrialization	0,3	1.5, 1.6
Economic	1	Study of alternatives	0,5	2.1
	2	Analysis of life cycle costs	0,5	2.2
Environmental	1	Prescription of materials from recycling	0,15	3.3, 3.4
	2	Optimization of the reinforcing	0,15	3.5
	3	Life cycle analysis	0,3	3.7
	4	Minimization of resources	0,15	3.9
	5	Lifetime extension	0,25	3.17
Social	N/A			

Table A2.B.3.1

Weight factor $\gamma_{j,l}$ and indicators ICS (CEMENTO, j = 2)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,8	1.1
	2	Product control	0,2	1.11
Economic	N/A			
Environmental	1	Environmental product declaration	1	3.2
Social	N/A			

Table A2.B.3.2

Weight factor $\gamma_{j,l}$ and indicators ICS (AGGREGATES, ADITIVES j = 3 and 4)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,2	1.1
	2	Civil liability insurance.	0,8	1.10
Economic	N/A			
Environmental	1	Environmental product declaration	1,0	3.2
Social	N/A			

Table A2.B.3.3 and 4

Weight factor $\gamma_{j,l}$ and indicators ICS (STEEL, j=5)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,7	1.1
	2	Civil liability insurance.	0,15	1.10
	3	Statistic control	0,15	1.7
Economic	N/A			
Environmental	1	Recycled steel from scrap Radiological control	0,45	3.1
	2	Recycled steel from scrap Radiological control	0,45	3.6
	3	Environmental product declaration	0,1	3.2
Social	N/A			

Table A2.B.3.5

Weight factor $\gamma_{j,l}$ and indicators ICS (CONCRETE, j=6)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,35	1.1
	2	Civil liability insurance.	0,65	1.12
Economic	N/A			
Environmental	1	Environmental product declaration	0,4	3.2
	2	Use recycled material	0,3	3.3, 3.4
	3	Waste sulphur content	0,3	3.15
Social	N/A			

Table A2.B.3.6

Weight factor γ_{jl} and indicators ICS (CONCRETE PREFABRICATED, j = 7)										
Type of requirements	Criteria		A		B		C		D	
	Num	Name	Weight factor γ_{jl}	Indicators	Weight factor γ_{jl}	Indicators	Weight factor γ_{jl}	Indicators	Weight factor γ_{jl}	Indicators
Performance	1	(DCOR)	0,6	1.1	0,7	1.1	0,6	1.1	0,7	1.1
	2	Statistic control	0,15	1.9			0,15	1.9		
	3	Civil liability insurance.	0,25	1.10	0,3	1.10	0,25	1.10	0,3	1.10
Economic	N/A									
Environmental	1	DAP	0,4	3.2	0,53	3.2	0,53	3.2	0,57	3.2
	2	Use of recycled material	0,2	3.3, 3.4	0,26	3.3, 3.4			0,29	3.3, 3.4
	3	Minimization of resources	0,05	3.9	0,07	3.9	0,07	3.9	0,07	3.9
	4	Waste sulphur content	0,05	3.15	0,07	3.15				
	5	Waste reduction	0,05	3.18			0,07	3.18		
	6	Installation/work distance	0,05	3.19	0,07	3.19	0,07	3.19	0,07	3.19
	7	Scrap content in processed products	0,20	3.20			0,26	3.20		
Social	N/A									

Table A2.B.3.7

Depending on the processes that are included in the manufacturing of precast concrete products, four scenarios can be considered:

A. Prefabrication processes, concrete and rebar manufacturing.

B. Processes of prefabrication and concrete manufacturing.

C. Processes of prefabrication and rebar manufacturing.

D. Prefabrication processes only.

Weight factor $\gamma_{j,l}$ and indicators ICS (PROCESSED STEEL, j=8)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,7	1.1
	2	Civil liability insurance.	0,15	1.10
	3	Statistic control	0,15	1.8 1.9(2)
Economic	N/A			
Environmental	1	Waste reduction (1)	0/0,10(1)	3.18(1)
	2	Installation / work distance	0,45/0,40(1)	3.19
	3	Scrap content in processed products	0,45/0,40(1)	3.20
	4	Environmental product declaration	0,10	3.2
Social	N/A			

(1) It only applies to reinforcing steel
(2) It only applies to prestressed steel.

Table A2.B.3.8

Weight factor $\gamma_{j,l}$ and indicators ICS (METAL STRUCTURES WORKSHOP, j=9)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,7	1.1
	2	Civil liability insurance.	0,15	1.10
	3	Statistic control	0,15	1.9
Economic	N/A			
Environmental	1	Installation/work distance	0,45	3.19
	2	Scrap content	0,45	3.20
	3	Environmental product declaration	0,1	3.2
Social	N/A			

Table A2.B.3.9

Weight factor $\gamma_{j,l}$ and indicators ICS (PRESTRESSED, j=10)				
Type of requirements	Criteria			Indicators
	Num.	Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	1	1.1
Economic	N/A			
Environmental	1	Lifetime	0,60	3.8
	2	Minimization of resources	0,30	3.10
	3	Waste management on work	0,05	3.14
	4	Environmental product declaration	0,05	3.2
Social	1	Human Resources. Training	0,05	4.2
	2	Human Resources. Specific training	0,90	4.3
	3	Health and safety	0,05	4.4

Table A2.B.3.10

Weight factor $\gamma_{j,l}$ and indicators ICS (CONSTRUCTION ON SITE, $j = 11$)				
Type of requirements	Num.	Criteria		Indicators
		Name	Weight factor γ_{jl}	
Performance	1	Officially Recognized Quality Badge (DCOR)	0,2	1.1
	2	Execution control	0,8	1.4
Economic	N/A			
Environmental	1	Emissions reduction in work	0,30	3.11, 3.12
	2	Reuse of excavation products	0,25	3.13
	3	Waste management on work	0,25	3.14
	4	Rainwater management in the work	0,20	3.16
Social	1	Character of public interest work	0,17	4.1
	2	Human Resources. Training	0,33	4.2
	3	Health and safety	0,33	4.4
	4	Information to the citizen	0,17	4.5

Table A2.B.3.

Annex 3
Checklist for control of the design

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The quality control of the structure project will be carried out from the documents of the same and according to the scope of the commission made by the property. For each document, the checklist will be as follows, in a guiding way.

1 Memory and Calculation Annex

1.1 Geometric definition of the structure

1.2 Actions

1.2.1 Identification and consistency

a) Types of actions
   a.1) direct and indirect;
   a.2) fixed and variable;
   a.3) permanent, variable and accidental.

b) These agree with
   b.1) standards on actions corresponding to the type of structure in question;
   b.2) geotechnical report;
   b.3) specific documents on actions to be considered, accepted by the Owner.

1.2.2 Actions during the construction process

Check whether actions have been evaluated during the construction process by examining
a) incidence in force calculations; and
b) effect on sizing.

1.3 Structural proposal

Check whether the structural layout adopted guarantees:

a) overall structure stability;
b) stability of each one of its parts;
c) stability during the stages of the construction process;
d) the impact on the structural response and the stability of the non-structural elements where necessary (for example, building works subjected to seismic actions); and
e) a correct conception of the details in the case of structures subject to fatigue.

1.4 Structural models

Check whether

a) they are correct and consistent with sizing criteria with regard to final structure;
b) they are correct and consistent with sizing with regard to construction process stages;

c) the static constants of the cross sections are correct and faithfully represent reality; and
d) the modelled linkage and support system represents reality.

1.5 Calculation of forces

1.5.1 Combinations of actions

Check whether:

a) the action combinations considered are relevant; and
b) the action combinations not considered are irrelevant.

1.5.2 Weighting coefficients

Check whether:

a) partial safety coefficients of actions are adapted to those laid down by specific current regulations in force;
b) combination coefficients are adapted to those laid down in the specific regulations in force; and
c) they comply with conditions for reduction of partial material coefficients, where applicable

1.5.3 Calculations methods or computer programs used

Check whether the calculations programs or methods used

a) are correctly specified in accordance with the provisions of this Code; and
b) are approved as acceptable.

1.5.4 Data entry in programs for the calculation of forces

Check whether these agree with:

a) the structural proposal adopted;
b) the model adopted;
c) the geometry of the structure;
d) the suggested combination of significant actions

1.5.5 Outputs of results of calculation programs

Check whether the results are consistent with the models used and the actions adopted, having carried out an independent evaluation of forces on a significant sample of selected components in accordance with structural importance and representativeness criteria. The following aspects shall be officially noted in accordance with the level of control and element analysed (tables 55.1 and 96.1 of this Code):

a) sample selected;

b) selection criteria

c) check processes;

d) assumptions adopted; and

e) results obtained

1.5.6 Consideration of the construction process

It will be checked if the project defines a viable constructive process, if the efforts in the structure have been evaluated during the same, and if the criteria or requirements to be met by the auxiliary elements necessary for the execution are established so that the defined construction process is feasible.

In general, particularly in the case of structures executed with shoring installation (curved, porticoes, movable formwork, etc...) and especially in the case of building structures with execution processes with several simultaneously shoring system floors, a record will be made, according to the level of control and the element analysed (according to Tables 55.1 and 96.1 of this Code), of itself:

a) the resistant schemes and the loads transmitted to the structure during the bending or the construction process are evaluated;

b) the evaluations of resistant schemes and transmitted loads are correct;

c) the rigidity of the shoring or auxiliary means has influence in the obtaining of efforts in the definitive structure during the construction process;

d) the conclusions are correct;

e) it is necessary to carry out complementary studies, depending on certain conditioning factors imposed by the construction process.

1.6 Checking of limit states

1.6.1 Consistency between the results of the calculation and checking forces

Check the suitability of the forces adopted in limit state checks. Depending on the control level (tables 55.1 and 96.1 of this Code) take the sample corresponding to the structural components shown in this table.

1.6.2 Characteristics of materials and reduction factors

Check whether the characteristics of materials and their partial safety factors are correctly specified for:

a) concrete;

b) passive and active steel;

c) structural steel; and

d) connection and joints elements.

1.6.3 Dimensioning and checking

Examine whether the dimensioning of sections and elements and also checks on ultimate and serviceability limit states are in accordance with this Code. Depending on the control level (tables 55.1 and 96.1 of this Code), take the sample corresponding to the structural components shown in this table.

1.6.4 Durability

It will be checked if a specific strategy has been adopted to achieve adequate durability conditions, in particular if the specifications related to durability are met in relation to:

a) identification of the type of environment;

b) specifications for concrete (dosage, type of cement, nominal coatings, ..);

c) specifications for possible corrosion protection systems of active or passive reinforcements

d) specifications for the anticorrosive protection systems of structural steel elements and their joints, defining the class of exposure and the degree of durability required, in accordance with Article 86 of this Code;

e) forms, construction details, special protection measures and conditions to facilitate maintenance and inspection. In particular, in sections in the drawer, it will be verified if a system has been foreseen for access to its interior; Y

f) replacement of support devices. It will be verified that a possible substitution of support devices has been planned in the project, the reactions for the substitution are defined, the possible reinforcements have been defined to allow it, and the process to be carried out is defined.

1.6.5 Fire resistance

It will be verified in general that the project details, for each structural element, the corresponding regulatory requirement of resistance to fire and the justification for compliance, and in particular if the related specifications are met in terms of:

a) fire resistance times;

b) mechanical covers, thicknesses, coatings.

c) typology, dimensioning and justification of the necessary protections. Compatibility of these with the protection systems for durability.

d) additional studies required

1.6.6 Seismic resistance

Check whether specifications relating to seismic behaviour are met with regard to:

a) suitability of structural hypothesis;
b) seismic area;

c) construction class;
d) ductility:
e) ties;
f) existence of sufficient and adequate constructive details;
g) consideration of the effect of the earthquake on the response of the non-structural elements and their stability; and
h) other aspects.

1.6.7 Fatigue strength

In the case of structures subject to fatigue, it will be verified that the project includes the explicit verification of this Limit State, and in particular it will verify that:

a) the fatigue actions considered are correct;

b) the partial coefficients considered are adequate;

c) compliance with the Limit State is verified; and

d) in structural steel structures, the defined details and their category against fatigue, are in accordance with the verifications carried out.

1.6.8 Dimensioning of support devices and joints

It will be verified that the project defines the movements and reactions for the dimensioning of support devices and joints, and in the case that the stiffness of the supports has an influence on the calculation, that the dimensioning carried out and the assumptions adopted in the global calculation are adequate.

1.6.9 Consistency of dimensioning with the models

Check whether the dimensioning results are consistent with the models used by carrying out an independent evaluation of dimensioning by means of safety checks, strain checks and other relevant limit states, on a significant sample of components chosen in accordance with criteria of structural importance and representativeness. Depending on the inspection level (tables 55.1 and 96.1 of this Code), take a corresponding sample, identifying:

a) sample selected;

b) selection criteria;

c) check processes;

d) assumptions adopted; and

e) results obtained.

1.6.10 Impact in the construction process

It will be checked the effects on the dimensioning of the construction process have been evaluated in accordance with that described in section 1.5.6 of this annex.

.

1.6.11 Case of specific elements

If particular components are present, such as special supports, corbels or wall beams take a sample check to evaluate whether the dimensioning is correct. Depending on the inspection level (tables 55.1 and 96.1 of this Code), take the corresponding sample and note officially whether:

a) samples selected;

b) selection criteria;

c) verification processes and justification of their validity, particularly if the strut-and-tie method is used;

d) assumptions adopted; and

e) results obtained.

1.6.12 Consistency with geotechnical report

Check whether the foundation component dimensioning respects the conclusions in the geotechnical report with regard to:

a) typology of the foundation and the containment elements, as well as the geotechnical recommendations for the foundation project

b) the characteristics of aggressiveness of the land and water, and its influence on the qualities of concrete and structural steel where appropriate;

c) covers, over thickness;

d) the resistant, deformational and stability properties of the land;

e) geotechnical parameters of the terrain necessary for the calculation of the foundations; and

f) criteria for the control of the movements of isolated elements and differential movements.

1.7 Additional checks

In addition to the verifications set out in the previous sections, the following aspects may be verified in accordance with the content of this Code:

a) the content of the documentation justifying compliance with the requirements related to the environmental management of the execution, if the Project indicates its need by express desire of the property.

b) The content of the Project in relation to the strategy for the contribution of the structure to sustainability, in accordance with article 6 of this Code.

c) The existence of the annex of the Memory corresponding to the Plan and control program of the structure, and the conformity of its content in relation to that indicated in Article 19 of this Code.

d) The consideration in the Project of an Inspection and Maintenance Plan, and its conformity in relation to the content of article 23 of this Code.

e) The content of the Project regarding the justification of compliance with additional requirements to those considered in this Code, by express desire of the property, as the case may be.

It should also be verified that the project complies with the rest of legislation in force in other areas (such as health and safety, the environment, etc.).

2 Drawings

2.1 Consistency with calculation report

Check whether the force and dimensioning calculation results have been respected by checking a significant sample of elements selected in accordance with criteria of structural importance and representativeness. Depending on the inspection level (tables 55.1 and 96.1 of this Code), take a corresponding sample and note officially whether:

a) samples selected;

b) selection criteria;

c) check processes;

d) assumptions adopted; and

e) results obtained.

2.2 Consistency with other definition drawings of the work

Check whether the layout, squares and dimensions of the various structural components, openings affecting the structural behaviour of components and other conditioning factors that may affect the structure defined in non-structural drawings have been taken into consideration in these structural drawings and to define the structural model.

Depending on the control level (tables 55.1 and 96.1 of this Code), take a corresponding sample and note officially whether:

a) samples selected;

b) selection criteria;

c) check processes;

d) assumptions adopted; and

e) results obtained

2.3 Graphic documentation

In accordance with the level of control (tables 55.1 and 96.1 of this Code), the corresponding sample will be taken to all the structural elements included in the project, on which it will be stated:

a) sample selected;

b) selection criteria;

c) check processes;

d) assumptions adopted; and

e) results obtained.

Check by sampling in accordance with the inspection level (tables 55.1 and 96.1 of this Code):

a) whether a material table is included in which all its characteristics are fully defined, together with the partial safety coefficients of actions and resistances adopted, and their associated control levels;

b) whether coatings are defined in accordance with environmental exposure conditions and fire resistance;

c) whether the setting out dimensions and the squares and dimensions of the different structural elements are in accordance with the forecasts of the adopted structural model;

d) whether construction openings have been allowed for in the installations and whether these agree with the assumptions made when calculating forces and dimensions;

e) whether provisions for reinforcements in cross-sections and reinforcements diagrams have been defined by means of detailed quartering views that allow the steelwork to be processed and facilitate the positioning of reinforcements in the parts to make them viable;

f) whether the reinforcement overlaps and anchorages and their bending radiuses have been defined or whether clear criteria have been laid down for their definition;

g) whether the criteria for the prestressing of prestressing tendons are defined: tensile forces, anticipated tensile elongations, tightening steps, active and passive anchors, etc ...

h) whether the transitions of reinforcements in the nodes are defined and their constructive viability evaluated;

i) whether the elements and details of the metallic structure are fully defined, that allow the metallic workshop, the development of the workshop plans, the assembly plans and the cutting sheets. It must be verified that the plans define, at least:

- thicknesses and dimensions of all the sheets
- locations of sheet metal welds
- details of welds, transitions of thickness and dimensions, and access for welding, as well as the minimum fatigue requirements to be demanded at the time of execution and control.

- In butt welds, it must be verified if the welds are executed from two sides, if it is executed from one side with sane root, or if a backup sheet is used.
- In partial penetration welds, it must be verified that the partial penetration percentage is defined.
- In welds at an angle, check that the thickness of the throat is defined.

- elements of union and connection
- precambers
- specifications for the anticorrosive protection systems of structural steel elements and their joints, defining the class of exposure and the degree of durability required, in accordance with Article 86 of this Code

j) whether the support details of the prefabricated or composite parts are defined according to the assumed constraints in the structural model and their required stability conditions;

k) whether the geometric type conditions and other details that the contours of the pieces of lightening character have to meet are defined according to their influence on the definition of the resistant section of the composite pieces;

l) whether all the structural elements are defined, there are no gaps in the definition of them or lack of information on particular elements on the construction details (knots, transitions, gaps, breaks, supports, links, fixings ...);

m) whether the geotechnical characteristics for the design have been described;

n) whether the parameters and geotechnical requirements used for the project are described;

o) whether the supports and joints are defined, as well as if the criteria for the realization of a possible replacement of support devices are included;

p) whether the proposed construction process has been defined, where necessary; and

q) whether the criteria or requirements to be met by the auxiliary elements necessary for the execution of the structure are established, and if the possible conditions that the auxiliary means may have on the final structure are defined.

Comments

The origin of a large part of the project failures lies in the absence of constructive details, in the existence of incorrect details or standard details that are not applicable or difficult to extrapolate. It is therefore important that the technicians involved in both the project and the control of the structure project pay special attention to this aspect.

3 Technical specifications

In general, the object of the quality control of the Technical Specifications of the Project is to ensure that the materials, equipment, manufacturing procedures, implementation, testing, treatment, supply conditions, reception, storage, storage and handling of products, acceptance and rejection criteria, actions to be taken in case of non-conformities, etc. they are in accordance with the conditions of the work.

It must be verified that this document has been specified for the work in question, that it refers to the control standards and updated acceptance criteria, and that it includes a specific Control Plan for the work.

Where appropriate, the verification may be carried out, by sampling, in accordance with the following procedure, as a guide:

3.1 Consistency with calculation report, annexes and drawings

It shall be checked

a) whether the material and construction specifications have been met and also its associated reception control levels specified in the report, the calculation annex and drawings;

b) whether aspects have been specified such as wall backfill conditions that affect ground thrust, respecting the assumptions laid down in the report and the calculation annex; and

c) whether the essential aspects of the construction process affecting the structural models have been specified together with actions adopted in the force calculation and in the ultimate and serviceability limit checks.

3.2 Tolerances

A check shall be carried out to ensure that the dimensional tolerances have been specified or specifically referred to in order to adopt those given in this Code.

3.3 Consistency with the budget

It will be verified that the forms or criteria of measurement and payment have been defined for the different work units associated with the structure and that they are consistency with the description of the budget items.

4 Budget

In general, the control of the content of this Project document is intended to establish possible omissions and contradictions in the work units defined in the Measurements and Budget with respect to the Report, the Project Drawings and the Specific Technical Specifications, as well as how to verify the correct measurement of the different items. Likewise, depending on the scope of the assignment, aspects related to the configuration of prices can be analysed.

The above checks will be carried out in general on a statistically representative sample of the different items or with the scope requested by the Property.

By way of guidance you can check:

a) that the definitions of the items corresponding to the foundation and structure work units are sufficient, complete, correct and congruent with the rest of the Project documents.

b) that the Measurements of the different items correspond to those that are derived from the technical definition of the structure. For this, an independent verification can be carried out by sampling;

c) that the Project contains the corresponding Price Table and its justification and that the decomposition of the prices is reasonable and consistent with the decomposition of the items. Where appropriate, verification by sampling of the adequacy of the prices of the Budget to Bases of reference.

Annex 4

Documentation of supply and control of products received directly on site

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1 Documents prior to supply

The supplier must provide the relevant documentation as laid down in chapter 13 and 23 of this Structural Code and as detailed below.

1.1 General documents

1.1.1 Cements

The documentation to be provided will be that relating to the CE marking (declaration of benefits and CE marking) or the certificate of compliance with the regulatory requirements

1.1.2 Water

In the case of water not previously used or arising from the cleaning of the tanks in the concreting plants, the supplier of the concrete or prefabricated products, will provide the following documentation:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 29 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications and the date of issue of the report or test report.
- Report or test report, less than 6 months old, issued by a laboratory that includes the results of all the characteristics referred to in Article 29 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

1.1.3 Aggregates

Where applicable, the documentation required by the CE marking shall be provided.

In the event that the aggregates are in possession of an officially recognized quality mark, the documentation referred to in section 1.2 of this annex will be delivered.

In the case of self-consuming aggregates the following documentation will be delivered:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 30 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications, the dates of issuance of reports or test reports and guarantee that the statistical treatment is equivalent to that required in the CE Marking.
- Reports or test reports, issued by a laboratory that includes the results of all the characteristics referred to in Article 30 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

1.1.4 Admixtures

Where applicable, the declaration of benefits and the CE marking shall be provided.

For admixtures that do not have CE marking, the supplier will provide the following documentation:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 31 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications, the dates of issuance of reports or test reports and guarantee that the statistical treatment is equivalent to that required in the CE Marking.
- Reports or test reports, issued by a laboratory that includes the results of all the characteristics referred to in Article 31 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

1.1.5 Additions

Where applicable, the declaration of benefits and the CE marking shall be provided.

1.1.6 Concrete

In the event that the concrete has an officially recognized quality mark, it will be sufficient to present the documentation established in section 1.2 of this annex.

If the concrete does not have an officially recognized badge, the supplier of the concrete will provide the following documentation:

- Responsible statement, whose model is included in this section.
- Where appropriate, report or test report, issued by a laboratory that includes the results of the tests referred to in the declaration.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code, in the case that reports or test records are attached.

DECLARATION RESPONSIBLE FOR THE MANUFACTURER OF CONCRETE PREVIOUS TO SUPPLY A WORK

Data of the reporting person:

Name……Last name ……..NIF/CIF/NIE……..,

Makes this statement responsible as ……..……..

Concrete manufacturer data:

Central:

Location:

Municipality: Postal Code:

Type of road: Road name: Number:

Polygon: Km: Island: Sector: Plot:

I declare:

1. That as a manufacturer I will supply the work …….
   located in ……..…….
   the following typified concretes: T-R/C/TM/A……..…….
2. That I have the facilities in accordance with the specifications indicated in the Structural Code and in accordance with the current industrial regulations, regarding the control of the production of concrete manufactured at the plant, and may show, if necessary, the required documentation in the latter I can contemplate.
3. That the materials I will use will be in accordance with the specifications indicated in the Structural Code and that the documentation of identification of the component materials (origin, supplier, certifications, etc.) is available to the facultative management, if requested.
4. That the nominal dosage of the concrete that I will supply will comply with the following:
   - Minimum cement content (Kg/m3): ± tolerance value
   - Maximum water / cement ratio: ± tolerance value
   - Content of additions, if applicable (Kg/m3):
   - Amount of admixtures (% by weight of cement):
5. That in all cases the dosages in Table 43.2.1 are met.
6. That the concrete that I will supply will comply with the technical conditions established in the current structural Code, and in the contract or supply order.
7. That I have a documented quality assurance system.

8. That each supply will be accompanied by the corresponding delivery note or supply sheet, in accordance with the technical conditions established in the structural Code, in the execution project and in the order.
9. That for the concretes of XA, XS, XD, XF and XM environments; the waterproofness of the concrete has been verified, in accordance with the provisions of this Structural Code. To this end, a report or test report, less than six months old, is attached.
10. That for the concretes subjected to an exposure class XF2 and XF4, the content of occluded air has been checked according to what is indicated in this Structural Code. To this end, a report or test report, less than six months old, is attached.
11. That in case of having requested in the order any additional characteristic for the concrete or for any of its component materials, the necessary supporting documentation will be provided to prove its compliance.
12. That I will deliver to the facultative management the technical documentation that I am requested to justify any technical specification included in the responsible statement.
13. In the case of the XC3, XC4, XD, XS, XF, XA and XM environments, a 'Technical Data Sheet' of the concrete to be supplied will be available to the user, for each working formula, where additional information about the component materials and the nominal dosage, as indicated in the Structural Code. This technical sheet will be updated at all times and will have a unique reference to identify it in the delivery notes or distinguish it from others, in case there are several cards for the same type of concrete.
14. That whenever there is a change in the supplier of the component materials, it will be previously communicated.

Location and date: ……..

Signed:

CONTENT OF THE CONCRETE TECHNICAL DATA SHEET

(Necessary for environments XC3, XC4, XD, XS, XF, XA y XM)

Concrete manufacturer data:
Central :
Location:
Product : T-R/C/TM/A……..
Unique product reference:…… *(When a file contains different variants of the same product, each of them must have a clearly differentiated name.)*

Identification data of the materials:

- Cement: (Complete designation, supplier and origin.)
- Aggregate
  - Fine aggregate: (Complete designation, supplier and origin.)
  - Coarse aggregate: (Complete designation, supplier and origin.)
- Admixtures: (Complete designation, supplier and origin.)
- Water: Origin (Public network, well, recycled ...).
  (In the event that the water does not come from the potable water supply network, the results of the tests must be available to the user.)
- Additions: (Complete designation, type, origin and supplier)

The declaration of features of the materials that require it must be available to the user.

In the case of special services contemplated in this Code, the tests that verify their compliance must be available to the user. For example, the requirements of the aggregate in the XM exposure or of the cement in the case of potentially reactive aggregates.

Data of the nominal dosage (*) of the product:

- Nominal cement content (Kg / m3): ± tolerance value
- Nominal water / cement ratio: ± tolerance value
- Nominal content of additions, if applicable (Kg / m3): ± tolerance value
- Amount of admixture (% based on cement weight) (**): ± tolerance value
- Other optional information, if applicable.

(*) The "nominal" values refer to the values reflected in the theoretical dosage used in the plant.

(**) It may reflect a range of additive dosages that include possible variations in its dosage depending on environmental conditions.

Date and Signature of the responsible person in the plant of the nominal dosage:

Comments:

At the request of the user and in accordance with the supplier, the technical sheet may provide the information deemed appropriate. For example, the percentage of the fraction of aggregates or the water of their absorption.

1.1.7 Steel for passive reinforcements

When steel products for passive reinforcements must have CE marking, the declaration of performance and CE marking will be delivered.

In the case that steel products for concrete have an officially recognized quality mark, it will be sufficient to present the documentation of the quality label established in section 1.2. of this annex.

While the CE marking is not in force and if it does not have an officially recognized quality mark, the following documentation will be delivered:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 34 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications, the dates of issuance of reports or test reports and guarantee that the statistical treatment is equivalent to that required in the CE Marking.
- Reports or test reports, issued by a laboratory that includes the results of all the characteristics referred to in Article 34 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

For particularly susceptible weldable steel, certificates of fatigue and cyclic loading tests will also be delivered.

When the manufacturer guarantees the adherence characteristics by means of the beam test laid down in Section 33.2 of this Code, he shall issue an adherence homologation certificate, with an antiquity less than 36 months from the date of manufacture of the steel in, which will contain, as a minimum, the following:

- Identification of the laboratory that has carried out the tests of the beam.
- Identification of the manufacturer.
- Address of the factory.
- Commercial brand.
- Type of steel
- Sketch with the manufacturer's identification on the bars.
- Diameters of the bars.
- Surface geometry of the bars, including diameter, minimum height of corrugation, separation of corrugations and its tolerance, perimeter without corrugations and its tolerance, range of inclination of corrugations, for which compliance is certified of the adhesion tensions.
- The admissible limits of variation of the geometric characteristics of the shoulders for the supply case in the form of a straight bar, with an express indication that in the case of roll supplies, the corrugation height must be greater than that indicated in the certificate plus 0.1 mm in the case of diameters greater than 20 mm or more 0.05 mm in the rest of the cases.
- Number of the beam test report.
- Nominal diameters tested and series to which they represent.
- Sketch with the surface geometry of the bars.

- Date of signature of the certificate and reference number thereof.

1.1.8 Steel for active reinforcements

When steel products for active reinforcements must have CE marking, the declaration of performance and CE marking will be delivered.

In the case that steel products for concrete have an officially recognized quality mark, it will be sufficient to present the documentation of the quality label established in section 1.2. of this annex.

While the CE marking is not in force and if it does not have an officially recognized quality mark, the following documentation will be delivered:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 36 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications, the dates of issuance of reports or test reports and guarantee that the statistical treatment is equivalent to that required in the CE Marking.
- Reports or test reports, issued by a laboratory that includes the results of all the characteristics referred to in Article 36 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

1.1.9 Passive reinforcements

1.1.9.1 Standardized passive reinforcements

When steel products for standardized passive reinforcements must have CE marking, the declaration of performance and CE marking will be delivered.

In the case that electrowelded meshes and basic reinforcements electrowelded in lattice have an officially recognized quality mark, it will be sufficient to present the documentation of the quality label established in section 1.2. of this annex.

While the CE marking is not in force and if it does not have an officially recognized quality mark, the following documentation will be delivered:

- Declaration signed by a natural person with sufficient power of representation in which compliance with all the specifications referred to in Article 35 of this Code is ensured, which will include the identification of the laboratory that has carried out the tests that justify compliance with the specifications, the dates of issuance of reports or test reports and guarantee that the statistical treatment is equivalent to that required in the CE Marking.
- Reports or test reports, issued by a laboratory that includes the results of all the characteristics referred to in Article 35 of this Code.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.

1.1.9.2 Assembled reinforcement

In the case of that the assembled reinforcement has an officially recognized quality mark, it will be sufficient to present the documentation established in section 1.2.

If the assembled reinforcement does not have an officially recognized badge, the assembled reinforcement processor will provide the following documentation:

- Responsible statement, whose model is included in this section.
- Where appropriate, report or test report, issued by a laboratory that includes the results of the tests referred to in the declaration.
- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code, in the case that reports or test records are attached.
- Where appropriate, certificate of approval of welders and the welding process.
- Where applicable, certificate of adherence with an age less than 36 months, from the date of manufacture of the steel.
- Likewise, a copy of the documentation relating to steel for passive reinforcement will be delivered in accordance with section 1.1.7 of this annex.

DECLARATION RESPONSIBLE FOR THE MANUFACTURER OF ASSEMBLER PREVIOUS TO SUPPLY A WORK

Data of the reporting person:

Name……Last name ……..NIF/CIF/NIE……..,

Makes this statement responsible as ……..……..

Assembler manufacturer data:

Central:

Location:

Municipality: Postal Code:

Type of road: Road name: Number:

Polygon: Km: Island: Sector: Plot:

I declare :

1. That as a assembler I will supply the work .....
   located in ……
   the following passive reinforcement elaborated : .....
2. That I have the facilities in accordance with the specifications established in the Structural Code.
3. That I perform production control in accordance with the specifications established in the Structural Code.
4. That the steel products I will use will be in accordance with the specifications established in the Structural Code.
5. That the reinforcements that I will supply will comply with the technical conditions established in the current Structural Code and in the order.
6. That for the assembly of the processed rebar, processes of: ..... will be used.
7. That straightening processes will be used in the following diameters: ....
8. That I have a documented quality assurance system.
9. That each supply will be accompanied by the corresponding delivery note or supply sheet in accordance with the technical conditions established in the Structural Code and in the order.
10. That the steel products used to make the reinforcements (yes / no) have an officially recognized quality mark.
11. That I will deliver to the facultative management the technical documentation that I am requested to justify any technical specification included in the responsible declaration.

Location and date: ……..

Signed:

1.1.10 Elements and systems for applying prestressing

When the elements and application systems of prestressing have CE marking, the declaration of benefits and CE marking will be delivered.

In the case that the prestressing elements and systems have an officially recognized quality mark, it will be sufficient to present the documentation established in section 1.2. of this annex.

Provided that it does not have CE marking and if it does not have an officially recognized quality mark, the supplier must provide the following information:

- Declaration signed by a natural person with sufficient power of representation in which compliance with the specifications indicated below is guaranteed, as well as the identification of the laboratory that has carried out the tests that justify compliance with the specifications and the dates of issue of the reports or test reports

  Steel specifications

  - Type: bar, wire or cord
  - Maximum unit load
  - Nominal cross-section
  - Relaxation at 1000 hours for an initial tension equal to 70% of the guaranteed maximum unit load
  - Elasticity module

  Specifications of tendons

  - Type
  - Corrosion protection
  - Specifications of anchorages
  - Weight of the tendon
  - Maximum unit load
  - Curve friction coefficient (μ)
  - Parasite friction coefficient (k)
  - Minimum curve radius
  - Inside and outside diameter of the sheath, and thickness
  - Maximum separation between the supports of the sheath

  Specifications of anchorages

  - Type of anchorage
  - Minimum separation between mass centers, with indication of the average strength of the concrete

- Minimum separation between plates, with indication of the average strength of the concrete
- Penetration of wedge

1.1.11 Prefabricated components

Where applicable, the documentation required by the CE marking shall be forwarded (declaration of performance, CE marking label and instructions for use and safety). Where those prefabricated components in which it is declared that the materials specified in the manufacturing plan pursuant to the project have been used, and prepared in such a way that the manufacturing process complies with the manufacturing plan pursuant to the project (method 3 of those contemplated in the corresponding harmonized standard, the CE marking), shall include the following information:

- Properties of the materials used
- Geometric data of the element: dimensions, sections and tolerances
- Quality control plan of the manufacturing process
- Where applicable, factory production control certificate in accordance with article 62.1 of this Code issued by a certification body.

For those prefabricated components deemed to comply with the essential requirements by means of the indication of the element's geometric data and the properties of the component materials and the products used (method 1 of the corresponding harmonized standard, the CE marking) must include the following information:

- Geometric data of the element: dimensions, sections and tolerances
- Properties of materials and products used that are necessary both for calculating the bearing capacity and for other relevant properties of the component: durability, functionality, etc

For components whose properties are determined by Eurocodes (method 2 of the corresponding harmonized standard, the CE marking) will include the following information:

- Characteristic values of resistance and other properties of the cross section whereby it is possible to calculate the bearing capacity and the other relevant properties of the component
- Calculation values of the element properties established in the Eurocodes.

In the case that the prefabricated elements have an officially recognized quality mark, it will be sufficient to present the documentation established in section 1.2. of this annex.

For other products for which the CE marking is not in force, and if they do not have an officially recognized quality mark, the following documentation will be delivered:

- Declaration of the laboratory to comply with the requirements contemplated in section 17.2.2.1 of this Code.
- Where applicable, certificate of qualifications of the personnel carrying out non-resistant welding

- Where applicable, certificate of qualification recognition of welders and the welding process

Prior to supply, the following documentation relating to suppliers of materials used in the preparation of passive reinforcements shall be forwarded:

- Documentation corresponding to the CE marking or, where applicable, certificates of tests guaranteeing compliance with the specifications laid down in this Code.
- Where applicable, declarations of having an officially recognised quality mark.
- Where applicable certificate of adherence test

1.1.12 Steel products for steel structures

When steel products for steel structures must have CE marking, the declaration of performance and the CE marking will be delivered.

In the case that steel products for steel structures have an officially recognized quality mark, it will be sufficient to present the documentation established in section 1.2. of this annex.

1.2 Documentation of the officially recognized quality mark

In the case that a product or process referred to in this code has an officially recognized quality badge, a copy of the current certificate of the badge will be delivered, signed by an individual with sufficient capacity of the document that accredits it, where at least it will contain the next information:

- Identification of the certifying entity.
- Logo of the quality badge.
- Identification of the manufacturer.
- Scope of the certificate.
- Certificate number.
- Date of issue of the certificate.
- Period of validity of the certificate.

The possession of an officially recognized quality badge, in accordance with the provisions of Article 18 of this Code, reduces the documentation required in this annex.

2 Documents during the supply

With the delivery of any material or product, the supplier shall provide a supply sheet including, at least, the information detailed below specifically for each material or product.

2.1 Cements

The information to be included will be that required in the specific regulations in force, in particular as indicated in the current Instruction for the Reception of Cements.
In your case, be in possession of an officially recognized quality badge.

2.2 Aggregates

- Identification of the supplier.
- Number of the declaration of benefits, or, where appropriate, indication of self-consumption.
- Serial number of the supply sheet
- Name of the quarry
- Identification of the applicant
- Delivery date
- Quantity of the aggregate supplied
- Designation of the aggregate is specified in Article 30 of these Code
- In your case, be in possession of an officially recognized quality badge.
- Identification of the place of supply

2.3 Admixtures

- Identification of the supplier
- Number the declaration of benefits
- Serial number of the supply sheet
- Identification of the applicant
- Delivery date
- Quantity supplied
- Designation of the admixture as specified in Article 31 of this Code.
- In your case, be in possession of an officially recognized quality badge
- Identification of the place of supply

2.4 Additions

- Identification of the supplier
- Number of the declaration of benefits.
- Serial number of the supply sheet
- Identification of the applicant

- Delivery date
- Designation of the addition is specified in Article 32 of this Code.
- In your case, be in possession of an officially recognized quality badge.
- Quantity supplied
- Identification of the place of supply

2.5 Concrete

- Identification of the supplier
- Serial number of the supply sheet
- Name of the concrete plant
- Identification of the applicant
- Delivery date and time
- Quantity of concrete supplied
- Designation of concrete as specified in the Structural Code. In the case of designation by properties, it must always contain the compressive strength, the consistency, the maximum size of the aggregate and the type of environment to which it will be exposed. In the case of designation by dosage, it must always contain the cement dosage (in kg/m3), the consistency, the maximum size of the aggregate and the type of environment to which it will be exposed. In your case, be in possession of an officially recognized quality badge.

- Actual composition of the concrete, which shall include, at least,
  - In the environments XC3, XC4, XD, XS, XF, XA and XM, the reference included in section 13 of the responsible declaration contained in section 1.1.6 will be included of this annex.
  - type and content of cement,
  - water/cement ratio
  - addition content, where applicable
  - type and quantity of admixtures
  - Identification of cement, admixtures and additions used
  - Identification of the place of supply
  - Identification of the lorry transporting the concrete
  - Time limit for using the concrete

2.6 Steel for passive reinforcements

- Identification of the supplier
- When the CE marking number of the declaration of benefits (as of the date of entry into force) is valid or, if applicable, indication of self-consumption.

- Number of the adherence approval certificate, where applicable, as laid down in section 34.2 of this Code
- Serial number of the supply sheet
- Name of the factory
- Identification of the applicant
- Delivery date
- Quantity of steel supplied classified by diameter and type of steel
- Diameters supplied
- Designation of types of steel supplied
- Type of supply (bar or roll)
- In your case, be in possession of an officially recognized quality badge.
- Identification of the place of supply

2.7 Steel for active reinforcements

- Identification of the supplier
- When the CE marking is valid, the declaration of benefits number (from the date of entry into force)
- Number of CE marking certificate (as of the date of entry into force)
- Serial number of the supply sheet
- Name of the factory
- Identification of the applicant
- Delivery date
- Quantity of steel supplied classified by type
- Diameters supplied
- Designation of the wire, bar or cord
- In your case, be in possession of an officially recognized quality badge
- Identification of the place of supply

2.8 Passive reinforcements

- Identification of the supplier
- Number of the CE marking certificate (as of the date of entry into force) or, where applicable, indication of self-consumption
- Serial number of the supply sheet
- Name of the structural ironwork installations

- Identification of the applicant
- Delivery date and time
- Identification of the steel used
- Identification of the reinforcement
- In your case, be in possession of an officially recognized quality badge
- Identification of the place of supply

2.9 Prestressing systems

- Identification of the supplier
- Number of CE marking certificate (as of the date of entry into force), or where applicable, indication of self-consumption
- Serial number of the supply sheet
- Name of operator
- Identification of the applicant
- Delivery date and time
- Identification of materials used
- Designation of components supplied
- Quantity of components supplied classified by component
- In your case, be in possession of an officially recognized quality badge
- Identification of the place of supply

2.10 Precast components

- Identification of the supplier
- Number of CE marking certificate (as of the date of entry into force), or where applicable, indication of self-consumption
- Serial number of the supply sheet
- Name of prefabrication installation
- Identification of the applicant
- Delivery date and time
- Identification of materials used
- Designation of components supplied
- Quantity of components delivered
- In your case, be in possession of an officially recognized quality badge
- Identification of the place of supply

2.11 Steel products for steel structures

- Identification of the supplier.
- When the CE marking is valid, the declaration of benefits number.
- Serial number of the supply sheet.
- Name of the factory
- Identification of the applicant.
- Delivery date.
- Quantity of steel supplied classified by steel geometry and types.
- Dimensions of the profiles or sheets supplied.
- Designation of the types of steel supplied.
- In your case, be in possession of an officially recognized quality badge.
- Identification of the place of supply.

3 Documents after the supply. Certificate of final guarantee of supply

Suppliers of materials or products covered by this Code shall provide a final supply certificate, detailing all materials or products supplied.

The supply certificate must retain the necessary traceability of the materials or products certified.

The box below contains a model with the minimum information that the supply certificate must contain

Annex 4
Documentation of supply and control of products received directly on site

SUPPLY CERTIFICATE

Name of the supply company _____

Name and position of the person in charge of the supply :_____

Address:_____

Identification of the declarant
(name, address, telephone/fax number, identity document. (VAT number/Passport)

I hereby certify that:

The company_____

Identification of the declarant
(name, address, telephone/fax number, identity document (VAT number/Passport)

Has supplied _____

[Place of receipt of material or product]

the products below detailed

Date	*Delivery number*	*Material Identification*	*Quantity*	*DCOR*

In the period between the declaration of being in possession of an officially recognized quality mark and the last supply, the quality mark in question has neither been suspended nor withdrawn. *(where applicable)*

I hereby declare that I am responsible for the compliance of the above supply with the provisions laid down in the Code for Structural Concrete, adopted by Royal Decree of [date]

Place, date and signature

4 Record of samples taken

The record of samples of the materials or products covered by this Code shall contain at least the following information:

- identification of the product
- Date, time and place of the taking of the samples
- Identification and signature of the persons responsible present in sampling
- Identification of the material or product from which the samples or specimens are taken, as laid down in this Code
- Number of samples taken
- Size of sample
- Code of simple
- Inform if there is a specimen conservation area provided in article 57.3.2

Annex 5

Requirements for using calcium aluminate cement

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5 WORK EQUIPMENT AND TOOLS....4
6 PLACING OF THE CONCRETE....4
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1 Characteristics of calcium aluminate cement

Whereas Portland cements essentially get their hydraulic properties from the calcium silicates and tricalcium aluminate, calcium aluminate cement gets these properties from the monocalcium aluminate. The Al_2O_3 content of the latter, according to UNE EN 14647, must be between 35 and 58%, although its usual values are between 37 and 43%.

Calcium aluminate cement offers a series of special characteristics. Thus, while its setting time is virtually identical to that of Portland cement, it hardens much more quickly. As a result, mortar and concrete made with calcium aluminate cement reaches strength, after only a few hours, which is about the same as that obtained at 28 days with Portland cement.

This strength reduces over time due to a conversion process in which the hydration of the calcium aluminate cement at ambient temperature (<25°C) produces hexagonal hydrated calcium aluminates which are metastable. These therefore inevitably undergo a transformation (conversion) to the cubic form of hydrated calcium aluminate which is the only thermodynamically stable compound.

This conversion causes the porosity of concrete made with calcium aluminate cement to increase and therefore reduces its strength. This conversion can take just a few minutes or several years as the transformation rate depends on several factors, principally temperature.

The degree of this reduction in strength can vary. If the recommendations for correct use are followed and if a high cement dosage and a low water/cement ratio are used, the concrete can remain strong enough. However, the strength can reduce to excessively low values if the aforementioned recommendations are not followed.

The final strength reached after the conversion can be determined using the test described in UNE EN 14647.

Calcium aluminate cement in particular withstands better than Portland cement the action of pure water, sea water, sulphated water and gypsum-bearing soil and also the action of magnesium salts and diluted acids. However, concrete made with this is less resistant to the action of alkaline hydroxides.

In order to correctly use calcium aluminate cement in its various applications, the general rules which are valid for producing Portland cement mortar and concrete should be borne in mind. The specific instructions indicated below should also be followed.

2 Materials

Calcium aluminate cement shall meet the requirements laid down in the applicable specific regulations in order to be used in those cases indicated in section 8 – Applications of this Annex.

The aggregates shall comply with the general specifications given in this Code.

Aggregates containing releasable free alkalis must not be used and, in particular, the use of granite, shale, micaceous and feldspathic aggregates must be avoided.

Fine aggregates with a sand equivalent higher than 85%, according to Annex A UNE-EN 933-8, or those containing less than 5% by weight of particles smaller than 0,125 mm must be used.

The behaviour of admixtures with calcium aluminate cement is significantly different from that observed with Portland cement. Prior tests are therefore compulsory to establish the compatibility and appropriate dosage of each type of admixture.

3 Design

The characteristic strength of concrete made with calcium aluminate cement shall be taken as the minimum residual strength which may be reached after the cement has fully converted, bearing in mind the considerations set out in section 1. Its value shall be determined using the experimental procedure described in section A.7 of Informative Annex A UNE-EN 14647 In any event, the characteristic strength shall never exceed 40 N/mm^2.

Due to the lower pH and reduced alkaline reserve, reinforcements embedded in concrete made with calcium aluminate cement may be more exposed to corrosion. As a result and for reasons of general durability, the minimum covers which must be used are:

- In the non-aggressive exposure class (XO): 20 mm.
- In the normal exposure class (XC): 30 or 40 mm depending on the reinforcement diameter and stresses in the element.
- In the marine (XS), non-marine chlorides (XD) and aggressive chemical (XA) exposure classes: 40 mm.

The minimum cover shall be increased along the cover edge Δr indicated in section 43.4.1 of this Code in order to achieve the nominal cover defined in this section.

4 Batching

The following requirements shall be strictly observed:

- Water/cement ratios higher than 0,4 shall not be used. When calculating the mixing water, the water provided by the aggregates shall be taken into account.
- The minimum cement content shall be 400 kg/m^3.

5 Work equipment and tools

Any possible contact between the calcium aluminate cement and other Portland clinker-based cements or lime or gypsum shall be avoided, as also shall any accidental contamination of the calcium aluminate cement by these elements.

6 Placing of the concrete

For the placing of the concretes with calcium aluminate cement, it is recommended to use the same techniques as for concrete with portland cement (cast, projected, pumped, etc.). It is also recommended to use usual compaction methods, such as vibrating needles.

The use of recycled water for the manufacture of concrete with calcium aluminate cement is not allowed

When concreting in hot weather, the aggregates and water must not be directly exposed to sunlight.

When concreting in cold weather, the following precautions shall be taken:

- Frozen aggregates shall not be used.
- The temperature of the recently mixed concrete shall be sufficient to ensure that this remains above 0°C until setting and, as a result, the exothermal cement hydration reactions have begun.

7 Curing

In the case of pavements or slabs, initial curing of the concrete must be carried out immediately using curing products or the concrete must be protected with damp cloths. In the case of other structures or elements with a smaller surface area, once setting has ended, curing shall begin using continuous spraying or watering. This shall continue for at least the first 24 hours after the concrete is placed.

As with Portland cement, it is advisable to avoid premature drying of the cast concrete elements, particularly in hot and dry environments. A good practical recommendation is to keep the concrete elements covered and it is advisable to water them periodically during the first few days.

Unless a special study is carried out, heat curing must not be used.

8 Applications

In accordance with Article 28, the use of calcium aluminate cement in concrete must be specially studied in each case, setting out the reasons for its use and strictly observing the specifications contained in this Annex.

Calcium aluminate cement is best for:

- Urgent and rapid repairs.
- Concrete in chemically aggressive media.
- Concreting in cold weather.

It may be used when justified:

- Structures and elements precast using plain concrete or non-structural reinforced concrete.
- Certain cases of plain concrete foundations.
- Sprayed concrete.

Calcium aluminate cement is not recommended for:

- Structural reinforced concrete.
- Large volumes of plain or reinforced concrete.

Calcium aluminate cement is prohibited for:

- Prestressed concrete in all cases, according to Article 28 of this Structural Code.

With regard to the exposure classes, concrete produced in accordance with the specifications of this Annex will behave appropriately in:

- Non-aggressive environments	XO
- Marine environments	XS
- Slightly aggressive chemical environments	XA1
- Moderately aggressive chemical environments	XA2

Comments

Although it is not the subject of this Code, concrete with CAC can be used to manufacture:

- Refractory concrete.
- Cement-treated substrates for roads.
- Soil stabilisation.

Annex 6

Recommendations for selecting the type of cement to be used in structural concrete

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4 SELECTING THE TYPE OF CEMENT ACCORDING TO THE CONCRETING CIRCUMSTANCES 6

5 SELECTING THE TYPE OF CEMENT ACCORDING TO THE EXPOSURE CLASS 7

1 Introduction

The current Guidelines on the acceptance of cement generally regulate the conditions which cement must meet in order to be used. This recommendations Annex is only included in order to facilitate the selection, by the Designer or Technical Management, of the type of cement to be used in each case.

The type of cement must be selected bearing in mind at least the following criteria:

a) application of the concrete, in accordance with section 2 of this Annex;

b) concreting circumstances, in accordance with section 4 of this Annex;

c) environmental aggression conditions to which the concrete element will be subject, in accordance with section 5 of this Annex.

2 Selecting the type of cement according to the concrete application

The recommended cements according to their application are indicated in Table A6.2.

Table A6.2. Types of cement according to the concrete application

APPLICATION	RECOMMENDED CEMENTS
Plain concrete	All common cements, except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T and CEM III/C. Cements for special uses ESP VI-1 (*)
Reinforced concrete	All common cements except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T, CEM III/C and CEM V/B.
Prestressed concrete including structural precast concrete	Common cements (**) of types CEM I, CEM II/A-D, CEM II/A-V, CEM II/A-P and CEM II/A-M (V-P) (***).
Reinforced concrete precast structural elements	Common cements (**) of types CEM I, CEM II/A, are highly recommended and common cement of type CEM IV/A, is recommended when this is determined by a specific experimental study.
Large volumes of plain or reinforced concrete	Common cements of types CEM III/B and CEM IV/B are highly recommended and common cements of types CEM II/B, CEM III/A, CEM IV/A and CEM V/A are recommended. Cements for special uses ESP VI-1 (*). The additional characteristic of low heat (LH) and very low heat (VLH) is highly recommended where applicable.
High-strength concrete	Common cements of type CEM I are highly recommended and common cements of types CEM II/A-D and CEM II/A 42,5 R are recommended. The other common cements of type CEM II/A may be recommended when this is determined by a specific experimental study.

Table A6.2. Types of cement according to the concrete application (continuation)

APPLICATION	RECOMMENDED CEMENTS
Concrete for urgent and rapid repairs	Common cements of types CEM I, CEM II/A-D and calcium aluminate cement (CAC).
Concrete for rapid formwork removal and stripping	Common cements (**) of types CEM I and CEM II.
Sprayed concrete	Common cements of types CEM I and CEM II/A.
Concrete with potentially reactive aggregates (****)	Common cements of types CEM III, CEM IV, CEM V, CEM II/A-D, CEM II/B-S and CEM II/B-V are highly recommended and common cements of types CEM II/B-P and CEM II/B-M are recommended.

(*) In the case of large volumes of plain concrete.
(**) Among the cements indicated, those with a high initial strength are preferable.
(***) The inclusion of cements CEM II/A-V, CEM II/A-P and CEM II/A-M (V-P) as being appropriate for the prestressed concrete application is coherent with the possibility, contemplated in this Code, of using fly ash in a quantity not exceeding 20% of the cement weight in the prestressed concrete.
(****) For this application, cements with a low alkaline content or those cited in the table are recommended.

3 Selecting the type of cement according to specific structural applications

3.1 Cements recommended for foundations

Table A6.3.1 indicates the cements recommended for use in the production of concrete intended for foundations.

Table A6.3.1. Cements recommended for use in foundations.

APPLICATION	RECOMMENDED CEMENTS
Plain concrete foundations	Common cements of type CEM IV/B are highly recommended and the other common cements are recommended, except for CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T and CEM III. In all cases the additional characteristic of low heat (LH) is recommended. The requirements for using the additional characteristic of sulphate resistance (SR o SRC)[1] or sea water resistance (MR) must be met where applicable.
Reinforced concrete foundations	Common cements of types CEM I and CEM II/A are highly recommended and the other common cements are recommended, except for CEM III/B, CEM III/C, CEM IV/B, CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T and CEM II/B-T. The requirements for using the additional characteristic of sulphate resistance (SR o SRC)[1] or sea water resistance (MR) must be met where applicable.

(1) In accordance with the current Cement Reception Instruction.

3.2 Cements recommended for port and maritime works

Table A6.3.2 indicates the cements recommended for use in the production of concrete intended for the construction of plain, reinforced or prestressed concrete structures forming part of port and maritime works.

Table A6.3.2. Cements recommended for use in port and maritime works.

APPLICATION	TYPE OF CONCRETE	RECOMMENDED CEMENTS
Port and maritime works	Plain	Common cements, except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T and CEM III/C.
	Reinforced	Common cements, except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T, CEM III/C and CEM V/B.
	Prestressed(**)	Common cements (*) of types CEM I, CEM II/A-D, CEM II/A-P, CEM II/A-V and CEM II/A-M (V-P).

(*) Among the cements indicated, those with a high initial strength are preferable.

(**) These cements are the only ones allowed according to Article 28 of the Structural Code in prestressed concrete.

The use of any particular type of cement, with the MR additional characteristic where necessary, shall depend on the concrete requirements, provided that there are no special circumstances advising against its use.

All SR and SRC cements are, in addition to resistant to sulphates, resistant to seawater. Therefore, when specifying the use of a seawater resistant cement, MR, an SR or SRC cement may be used instead.

3.3 Cements recommended for dams

Table A6.3.3 indicates the cements recommended for use in the production of concrete intended for the construction of dams.

Table A6.3.3. Cements recommended for use in dams.

APPLICATION	RECOMMENDED CEMENTS
Vibrated concrete dams	Common cements of types CEM II/A, CEM III/A, CEM III/B and CEM IV/A.
Compacted concrete dams	Common cements of types CEM III, CEM IV and CEM V. Cements for special uses ESP VI-1. Very low heat special cements of types VLH III, VLH IV and VLH V. Blastfurnace cements with a low initial strength L.

Type CEM I cements may also be used where an addition compatible with the design requirements is added to the concrete in a proper amount.

It is recommended that the cements used are in a low strength class (32,5) and also that the heat of hydration is particularly taken into account. As a result, the use of cements with the additional characteristic of low heat or very low heat is generally advisable.

3.4 Cements recommended for hydraulic works other than dams

Table A6.3.4 indicates the cements recommended for use in the production of concrete intended for the construction of water transport structures which do not form part of the main body of dams.

Table A6.3.4. Cements recommended for hydraulic works other than dams

APPLICATION	TYPE OF CONCRETE	RECOMMENDED CEMENTS
Concrete pipes, channels and other hydraulic applications	Plain	Common cements, except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T and CEM III/C. Cements for special uses ESP VI-1 (*)
	Reinforced	Common cements, except for types CEM II/A-Q, CEM II/B-Q, CEM II/A-W, CEM II/B-W, CEM II/A-T, CEM II/B-T, CEM III/C and CEM V/B.
	Prestressed	Common cements of types CEM I, CEM II/A-D, CEM II/A-V, CEM II/A-P and CEM II/A-M (V-P).

(*) In coatings of large channels with sliding formwork machines.

4 Selecting the type of cement according to the concreting circumstances

The cements recommended according to the placing conditions are indicated in Table A6.4.

Table A6.4. Types of cement according to the concreting circumstances

CONCRETING CIRCUMSTANCES	RECOMMENDED CEMENTS
Concreting in cold weather (*) (**)	Common cements of types CEM I, CEM II/A and CEM IV/A. The use of high or medium resistant class cements (52.5 and 42.5) is recommended.
Concreting in dry and windy environments and, in general, in conditions which accelerate the drying of the concrete (**)	Common cements of types CEM I and CEM II/A.
Strong sunlight and concreting in hot weather (**)	Common cements of types CEM II, CEM III/A, CEM IV/A and CEM V/A.

(*) In these circumstances, the additional characteristic of low heat (LH) should not be used.

(**) In these circumstances, the appropriate measures specified in the corresponding regulations and, where applicable, in the Guidelines on Structural Code must be taken during the execution or placing process.

5 Selecting the type of cement according to the exposure class

The cements recommended according to the exposure class of the environment in which the structural element will be located are indicated in Table A6.5.

Table A6.5. Types of cement according to the exposure class.

EXPOSURE CLASS	TYPE OF PROCESS (aggression due to)	RECOMMENDED CEMENTS
XO	None	All those recommended according to the application.
XC	Corrosion of reinforcements other than as a result of chlorides	CEM I, any CEM II (preferably CEM II/A), CEM III/A and CEM IV/A.
XS (*)	Corrosion of reinforcements by marine chlorides	Cements of types CEM II/S, CEM II/V (preferably CEM II/B-V), CEM II/P (preferably CEM II/B-P), CEM II/A-D, CEM III, CEM IV (preferably CEM IV/A) and CEM V/A are highly recommended.
XD	Corrosion of reinforcements by non-marine chlorides	Preferably CEM I and CEM II/A and also the same ones as for exposure class XS.
XA (**)	Concrete attacked by sulphates	The same ones as for exposure class XS.
XA	Leaching of concrete due to pure or acid water or water containing	Common cements of types CEM II/P, CEM II/V, CEM II/A-D, CEM II/S, CEM III, CEM IV and CEM V.
-	Alkali-aggregate reactivity	Cements with a low alkaline content (***) (sodium and potassium oxides) in which $(Na_2O)eq = Na_2O\ (\%) + 0'658\ K_2O\ (\%) < 0'60$.

(*) In this exposure class, the requirements for using the additional characteristic of sea water resistance (MR) must be met as established.

(**) In this exposure class, the requirements for using the additional characteristic of sulphate resistance (SR), where the specific class is XA2 or XA3, must be met as established in this Code. In cases where the element is in contact with sea water, the requirements for using the additional characteristic of sea water resistance (MR) must be met.

(***) The cements cited in Table A6.2 for concretes containing potentially reactive aggregates (which would require cements with a low alkaline content) are also recommended.

It is expressly forbidden to store in the same silo or the mixture of cements of different types, strength classes or manufacturers in the manufacture of concrete, since the traceability and guarantees of the product would be lost.

Annex 7

Recommendations for using fiber reinforced concrete

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1 Scope

The specifications and requirements included in the main articles of this Code relate to concretes which do not incorporate fibres in their mass. As a result, some additional and specific recommendations must be given for cases where fibres are used in concrete, given that these may alter some of its properties, in order to improve certain types of performance, whether in the fresh state, at an early age or when hardened. The following are expressly outside the scope of this Annex:

- Concretes produced using fibres other than those indicated in this Annex as acceptable for use in concrete.
- Concretes in which the distribution and/or orientation of the fibres is intentionally forced.

Concretes with a dosage of fibres higher than 1,5% by volume must be the subject of a specific study

For the purposes of this Annex, fibre-reinforced concrete (FRC) is defined as concrete which includes in its composition discrete short fibres which are randomly distributed in its mass. The provisions generally apply to all types of fibre, although it should be borne in mind that the existing fundamental knowledge base relates to steel fibres which is reflected to a certain extent in that knowledge.

This concrete can be used for structural and non-structural purposes. Using fibres in concrete has a structural purpose where their contribution is taken into account in the calculations of any of the ultimate or serviceability limit states and where they partially or totally replace the reinforcement in certain applications. It shall be considered that fibres have no structural function when they are included in the concrete for other purposes, such as improving fire resistance or controlling cracking.

Fibres may be added to plain, reinforced or prestressed concrete and this may be done by using any of the various systems for incorporating fibres in concrete which are approved practice. Where there is no such approved practice, the system used must be explained. The preparation of concretes with fibres with character, in a fresh state, of self-compacting, is contemplated

This Annex mentions certain national and international standards which relate to the subject of this Annex and which may serve as support or reference.

Each drawing of the structure must include a concrete classification table which shall indicate the additional conditions to be met by concrete with fibres, as set out in Article 33 of this Code.

The classification proposed in this Annex reflects the basic specifications which are required when fibres have a structural purpose. In addition to the properties which are implicit in the concrete classification according to section 6.1.1 of this Annex, the Specific Technical Specifications must include those additional characteristics required of concrete with fibres and also the test methods for verifying these characteristics and the values which must be met by these characteristics. In all cases, a proposed dosage must be indicated with the following details:

- Dosage of fibres in kg/m3
- Type, dimensions (length, effective diameter, slenderness), shape and tensile strength of the fibre (in N/mm2), in the case of fibres with a structural purpose.

However, the effectiveness of the various fibres available on the market can be very variable and the conditions of availability of the product or the site conditions may recommend a modification of some of the characteristics specified in the specifications, whether in relation to the type, dimensions and therefore the dosage of fibres needed to obtain the same properties. As a result, when concrete is designated by its properties, the dosage indicated in the Specific Project Technical Specifications must be understood as a guideline. Before starting the concreting, the supplier shall propose a site-specific dosage and shall perform the prior tests in accordance with section 8.2.2 of this Code. In light of the results, the Project Management shall accept the proposed dosage or request new proposals.

In the following, the complements to the various articles of the Code are detailed, necessary to be able to carry out and take into account the incorporation of fibres into concrete.

2 Design bases

2.1 Actions

2.1.1 Characteristic values of actions

2.1.1.1 Characteristic values of permanent actions

The density and usual dosages of fibres shall not alter the characteristic specific gravity values of concrete with fibres compared to those of concrete without these.

2.2 Materials and geometry

2.2.1 Materials

2.2.1.1 Partial safety factors for materials

For the Ultimate Limit States and for the Service Limit States, the same partial security coefficients given in Annexes 19 and 21 are maintained.

3 Structural analysis

3.1 Structural analysis

The incorporation of fibres modifies the non-linear behaviour of the structural concrete, especially in traction, a state in which the cracked sections also contribute to resist tractions. This resistant collaboration can be taken into account using some of the constitutive diagrams presented in section 6.1.1.3 of this Annex.

In addition, given the ductility introduced by the presence of fibres, the principles for applying the linear analysis method with limited redistribution and the plastic calculation methods are regarded as valid, when the requirements for applying these, as specified in Chapter 5 of Annexes 19 and 21, are met.

The plastic or ultimate moments shall be determined in accordance with section 6.1.1 of this annex and, for solid slabs, it shall be considered that the fracture lines have sufficient rotational capacity if the depth of the neutral fibre in the Ultimate Limit State (ULS) of simple bending is less than 0,3 d. (or 0.25 h in sections of concrete reinforced exclusively with fibres).

The use of structural fibres may increase the width of the compression struts; this can be taken into account in the strut and tie rod models. As a result, the combination of conventional reinforcement and fibres may form an alternative for reducing the amount of conventional reinforcement in D regions where there is a high density of reinforcement preventing the correct concreting of the element.

4 Technological properties of materials

4.1 Materials

Fibres. Definitions:

Fibres are short elements with a small cross-section which are incorporated in the mass of the concrete in order to give it certain specific properties.

In general, those fibres which provide greater fracture energy to plain concrete can be classed as structural fibres (in the case of structural fibres, their contribution can be taken into account when calculating the response of the concrete section). Those fibres which, without taking this energy into account in the calculation, improve certain properties such as, for example, control of shrinkage cracking, increase of fire resistance, abrasion, impact and others, can be classed as non-structural fibres.

The geometric characteristics of fibres (Length (lf), Equivalent diameter (df), Slenderness (λ)) shall be established in accordance with UNE-EN 14889-1, UNE-EN 14889-2 and UNE 83516. Furthermore, depending on their nature, fibres shall be classed as:

- Steel fibres
- Polymer fibres
- Glass fibres resistant to alkalis.

The effectiveness of the fibres can be assessed by means of the residual tensile strength by bending corresponding to crack openings of 0.5 and 2.5 mm, obtained according to the UNE-EN 14651. Alternatively, the author of the project or the optional direction may indicate the use of UNE 83515 standard (Barcelona test with circumferential displacement control or piston displacement) in order to reduce dispersion and test time or the UNE 83510 standard.

Although a minimum fibres content is not specified, when using fibres with structural function it is not recommended to use dosages lower than 0.25% by volume of the concrete (equivalent to 20 kg/m3 of steel fibres or 2.5 kg/m3 of polymer fibres).

The upper limit of the fibres content is set at 1.5% by volume of the concrete. The use of very high dosages requires a considerable modification of the granular structure of the concrete. For these cases it is recommended to consult specialized bibliography.

Steel fibres

These fibres must comply with UNE-EN 14889-1 and, depending on the manufacturing process, are classed as:

Group I: cold drawn wires.

Group II: strip-cut

Group III: melt extracted

Group IV: cold formed.

Group V: sawed steel blocks.

The shape of the fibre has an important effect on the bond characteristics of the fibre with the concrete and may be very varied: straight, undulated, corrugated, shaped with different-shaped ends, etc.

When the fibres are supplied with a coating (for example zinc), the type and quantity thereof, expressed in g/cm^2, must be declared.

It is recommended that the length of the fibre (lf), is at least twice the size of the largest aggregate. It is common to use lengths of 2,5 to 3 times the maximum aggregate size. In addition, the diameter of the pumping pipe means that the fibre length must be less than two-thirds of the pipe diameter. However, the fibre length must be sufficient to ensure the necessary bond with the matrix and to prevent pull-out occurring too easily.

Small-diameter fibres of equal length allow the number of these per unit weight to be increased and make the framework or mesh of denser fibres. The spacing between fibres is reduced when the fibre is finer, making this more efficient and allowing an improved redistribution of the load or stresses.

Polymer fibres

Plastic fibres are formed using an extruded and previously cut polymer material (polypropylene, high-density polyethylene, aramid, polyvinyl alcohol, acrylic, nylon, polyester). These may be uniformly added to the concrete, mortar or slurry. They are governed by the UNE-EN 14889-2 standard and, according to their physical form, they are classified as follows:

Class I: Micro fibres: <0.30 mm in diameter: a) mono-filamentous, and b) fibrinous.

Class II: Macro fibres:> 0.30 mm in diameter.

Macro-fibres may collaborate structurally provided that its length is between 20 mm and 60 mm, and that the length of the fibers is at least 3 times the minimum size of the aggregate.

Micro-fibres are used to reduce cracking due to plastic shrinkage of the concrete, particularly in pavements and floors, but they cannot assume any structural function. They are also used to improve fire resistance and, in this case, the number of fibres per kg should be very high.

In addition, due to their physical/chemical characteristics, micro-fibres are characterised by their fibre frequency which indicates the number of fibres present in 1 kg and which depends on the fibre length and particularly on its diameter.

Glass fibres resistant to alkalis

This type of fibres can be used provided that an adequate behaviour is guaranteed during the useful life of the structural element, in relation to the potential problems of deterioration of this type of fibres as a consequence of the alkalinity of the medium.

Fibreglass is commonly used for the manufacture of fibre reinforced mortar, known as GRC, whose composition includes only fine aggregate, usually silica sand, and not coarse aggregate.

Since HRF can undergo significant reductions in strength and toughness due to exposure to the environment, appropriate measures should be taken both on the fibre and on the cementitious matrix for protection.

It allows the use of mixtures of fibres of different nature and / or size, being called concretes reinforced with fibre mixtures. These combinations have proved effective in improving the performance of the concrete, obtaining synergy effects between the different fibre types combined. This combination is not recommended in the case of glass fibres.

4.1.1 Concretes

4.1.1.1 Composition

When the fibres used are metallic, the total chloride ion contributed by the components shall not exceed 0,4% of the cement weight.

4.1.1.2 Quality conditions

When fibres are used, the quality conditions or characteristics required in terms of the concrete in the Specific Project Technical Specifications shall include the maximum length of the fibres.

When fibres have a structural function, the values of the residual characteristic tensile strength due to bending, $f_{R,1,k}$ and $f_{R3,k}$, as specified in section 6.1 of this Annex, shall be included.

When fibres with other functions are used, the methods for verifying the suitability of the fibres for this purpose shall be specified.

4.1.1.3 Mechanical characteristics

For the purposes of this Code, the flexural strength of concrete refers to the strength of the product unit or mix and is determined from the flexural fracture test results. At least three of these tests must be carried out on prismatic test pieces of a width equal to 150 mm, height equal to 150 mm. The distance between support points should be 500 mm, and the total length of the specimen between 550 and 700 mm, 28 days of age, manufactured, preserved and tested in accordance with UNE-EN 14651.

When the element to be designed has a depth less than 12,5 cm or when the concrete offers flexural hardening with a residual flexural strength f_{R1} higher than the tensile strength f_{ct}, it is recommended that the dimensions of the test piece and the preparation method are adapted to simulate the actual behaviour of the structure and that the test is carried out using unnotched test pieces.

For structural elements working as a slab, other alternative types of test may be used, provided that these are confirmed by a conclusive experimental campaign. When the deviation between the results for one product unit exceeds certain limits, the process followed must be verified in order to ensure that these results are representative.

In order to ensure that a product unit is uniform, the difference between the results for a group of three test pieces (difference between the highest and lowest results, divided by the mean value of the three), taken from the same mix, may not exceed 35%.

The criteria laid down in this Code for determining the value of the tensile strength, f_{ct}, using the results of the indirect tensile test are valid provided that these refer to the limit of proportionality.

For compressive stresses, the stress-strain diagram for concrete with fibres shall not be any different from that in the main articles as it may be considered that the addition of fibres does not significantly alter the behaviour of the concrete under compression.

The test proposed in UNE-EN 14651 provides the load-crack opening diagram for concrete (Figure A7.4.1). Using the load values corresponding to the limit of proportionality (F_L) and to the crack openings of 0,5 mm and 2,5 mm (F_1 and F_3 respectively), the flexural strength value ($f_{ct,fl}$)) and the corresponding residual flexural strength values, $f_{R,1}$ and $f_{R,3}$, can be determined.

The flexural strength and residual flexural strength values according to said standard UNE-EN 14651 are calculated by assuming a linear elastic distribution of stresses at the fracture point.

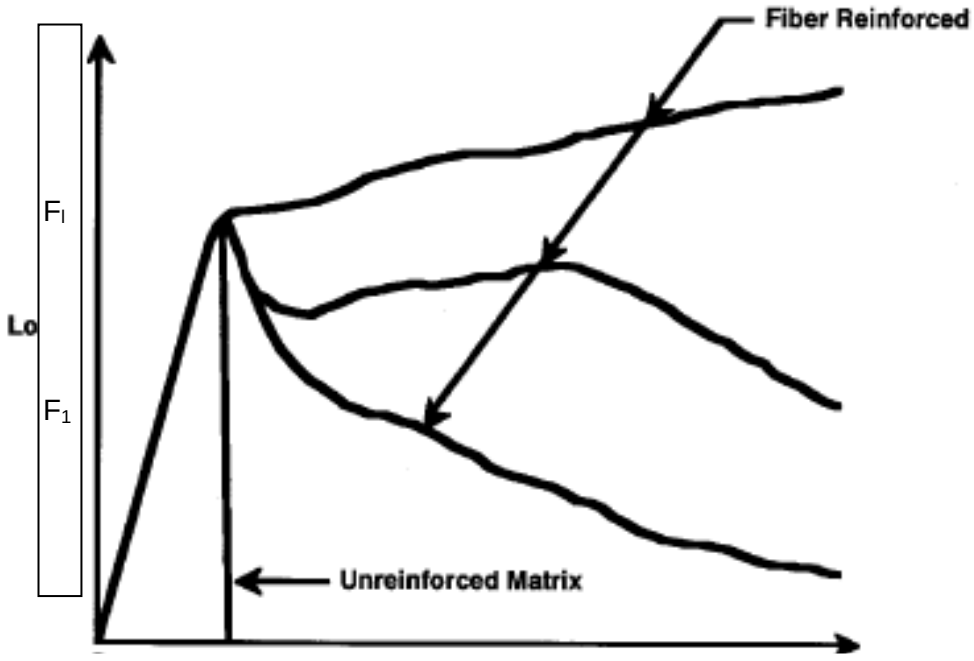


Figure A7.4.1. Typical load-crack opening diagram

Using these values, the tension calculation diagram can be determined as indicated in section 6.1.1 of this Annex. Other diagrams which directly define these constituent equations may also be used, provided that the results are endorsed by conclusive experimental campaigns and the specialised bibliography.

From these values, the tensile calculation diagram will be determined as indicated in section 6.1.1 of this annex. Also, other diagrams that define the constitutive equations can be incorporated directly as long as the results are supported by conclusive campaigns of experimental type and specialized bibliography.

Alternatively, the resistance to cracking, tenacity and residual tensile strength of fibre reinforced concrete can be used, properties obtained according to UNE-EN 14651. It is also possible to use the UNE 83515 standard to replace the UNE-EN 14651, previous calibration of the correlations between both tests for the concrete of work. The adoption of specimens with other shapes and dimensions is also admitted, as well as the simplification of the test procedure, as long as these modifications have been validated by means of experimental verification itself or based on the literature. The relative distance of a group of test pieces (difference between the highest result and the smallest, divided by the average value), taken from the same mix, can not exceed 35%.

As shown in Figure A7.4.2 of the test proposed in UNE 83515, the diagram that relates the applied load and the total circumferential displacement of the concrete (TCOD) is obtained. From the load values corresponding to the cracking load (P_f), the tensile

strength value (f_{ct}) can be estimated. Likewise, residual tensile strengths (f_{ctRx}) corresponding to a certain circumferential deformation (R_x) can be obtained.

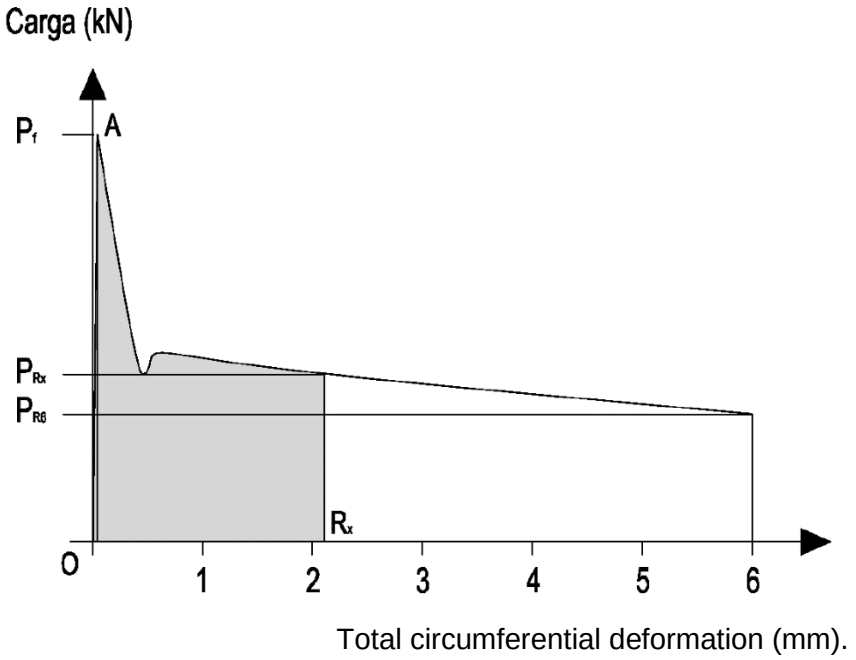


Figure A7.4.2. Load type diagram - total circumferential displacement (mm).

There is a specific bibliography that allows to correlate the results of the tests carried out with UNE-EN 14651 and UNE 83515, for concretes with different types of fibres. Likewise, experimental correlations can be established between both tests in order to use the UNE 83515 test -with control of the circumferential opening of the crack or vertical displacement of the actuator-. These correlations must be statistically representative and oriented to their use during quality control.

4.1.1.4 Minimum strength value

So that fibres can be regarded as having a structural function, the residual characteristic tensile strength due to bending $f_{R,1,k}$ shall not be less than 40% of the limit of proportionality and $f_{R,3,k}$ shall not be less than 20% of the limit of proportionality (see section 33.4 of this Code).

4.1.1.5 Workability of concrete

The use of fibres in concrete can cause a loss of workability, the magnitude of which will depend on the type and length of the fibre used and also on the quantity of fibres incorporated. This factor must particularly be taken into account when determining the consistency of concrete where the fibres are added on site.

In the case of concrete with fibres, it is recommended that the consistency of the concrete is not less than 9 cm of slump in the Abrams cone (although this depends on the type of application and placing system). In this case, the Abrams cone test is not particularly suitable and it is recommended that the consistency is tested in accordance with the tests proposed in UNE EN 12350-3.

In the case of concrete with fibres with self-compacting conditions with fibres, the provisions of Table 33.5 b of this Code apply.

5 Durability

5.1 Durability

5.1.1 Durability of concrete and reinforcements

5.1.1.1 Covers

The use of concrete reinforced with fibres with a structural function eliminates the need to use mesh reinforcement which this Code require to be placed in the middle of covers exceeding 50 mm.

5.1.1.2 Use of fibre-reinforced concrete

In general, fibre-reinforced concrete may be used in all exposure classes. In the general exposure classes XS2, XS3 and XD2 and in specific exposure class XF4, its use must be justified by means of experimental tests where carbon steel fibres are used. A viable alternative is to use stainless, galvanised or corrosion-resistant steel.

In the case of specific exposure classes due to chemical attack XA1, XA2 and XA3, steel and synthetic fibres may be used following a study proving the non-reactivity of the chemical agents with these materials (not including the concrete).

5.1.1.3 Resistance of the concrete to erosion

In general, the use of steel fibres improves the resistance to erosion.

6 Calculation

6.1 Material data for the design

6.1.1 Characteristics of concrete

6.1.1.1 Classification of concrete

Concretes shall be classified using the following format (which must be included in the design drawings and in the Specific Project Technical Specifications for the design):

T – R / f-R1-(R3/R1) / C / TM-TF / A

where:

- *T* Identifier which will be HMF for plain concrete, HAF for reinforced concrete and HPF for prestressed concrete
- R Specified characteristic compressive strength, in N/mm2
- f Identifier of the type of fibre which will be A in the case of steel fibres, P in the case of polymer fibres and V in the case of glass fibre. In the case of fibre mixtures, two or more indicative letters will be included.

R1,R3 Specified residual characteristic flexural strength $f_{R,1,k}$ and $f_{R,3,k,}$ in N/mm2

(R3/R1) Relation $f_{R,3,k}/f_{R,1,k}$.

C Initial letter of the type of consistency, or definition of self-compactability where appropriate, as defined in section 33.5. of this Code

TM Maximum aggregate size in millimetres, defined in section 30.3 of this Code

TF Maximum length of the fibre, in mm. In the case of fibre mixtures, two or more numbers will be included in the same order as f.

A Designation of the environment, in accordance with section 27.1 of this Code.

As regards the specified residual characteristic flexural strengths, it is recommended that the following series is used, provided that the minimum value required in section 33.4 of this Code is exceeded:

1,0 - 1,5 - 2,0 - 2,5 - 3,0 - 3,5 - 4,0 - 4,5 - 5,0

In this series, the figures indicate the specified residual characteristic flexural strengths of the concrete at 28 days, expressed in N/mm2.

Where the fibres have no structural function, the symbols R1 and R3 must be replaced by: "CR" in the case of fibres for shrinkage control, "RF" in the case of fibres for improving the fire resistance and "O" in other cases.

In the case of concretes designated by dosage, the following formula is recommended:

T - D – G/f/CF/C/TM/A

Where D means concrete designated by dosage, G is the cement content in kg/m3 of concrete and CF the fibre content in kg/m3 of concrete, prescribed by the petitioner. The rest of the parameters have the meaning indicated above. In this case, it must be ensured that the type, dimensions and characteristics of the fibres coincide with those indicated in the specific technical specifications.

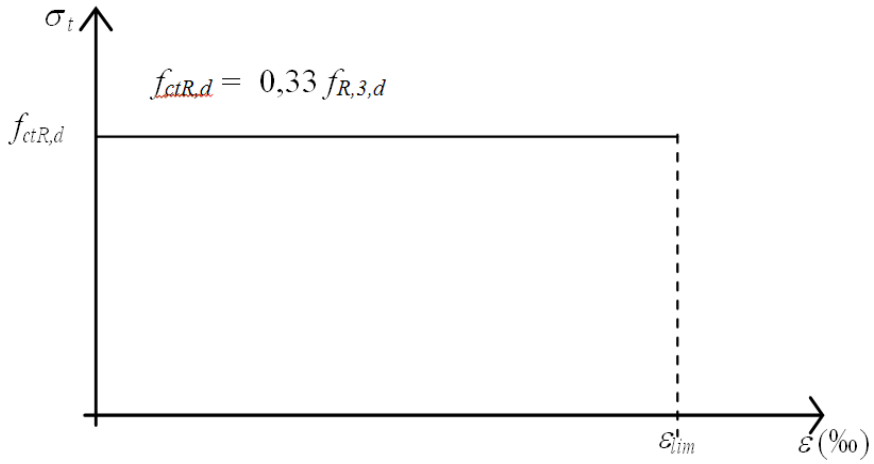
6.1.1.2 Design strength of concrete

The value of the corresponding characteristic design strength, $f_{R,1,k}$ and $f_{R,3,k}$, divided by a partial safety factor γ_c, which shall take the values indicated in Annexes 19 and 21, shall be regarded as the design residual flexural strengths of the concrete, $f_{R,1,d}$ and $f_{R,3,d}$. It is possible to work with residual tensile strengths, provided that the experimental validity of the approach is proven.

6.1.1.3 Design tensile stress-strain diagram of concrete with fibres

In order to calculate the sections subject to normal stresses in the Ultimate Limit States, one of the following diagrams shall be used:

- Rectangular diagram: In general, the diagram in Figure A.7.6.1, characterised by the design residual tensile strength, $f_{ctR,d}$, shall be used.



ε_{lim} = 20 ‰ for bending,
and 10 ‰ for tension

Figure A7.6.1. Rectangular calculation diagram

- Multilinear diagram: For applications requiring an adjusted calculation, the stress (σ)- strain (ε) diagram in Figure A.7.6.2 shall be used, defined by a design tensile strength f_{ctd} and design residual tensile strengths $f_{ctR1,d}$ and $f_{ctR3,d}$, associated with both strains ε_1 and ε_2 under post-peak conditions, where:

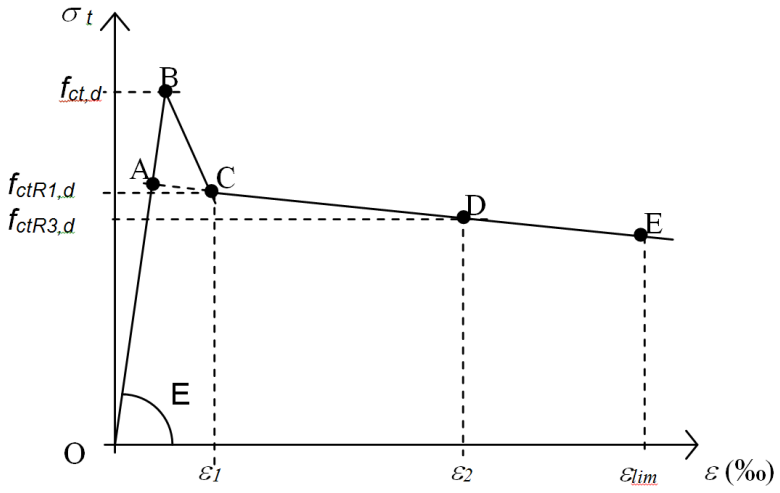


Figure A7.6.2. Multilinear calculation diagram

Where:

f_L Load corresponding to the limit of proportionality

$f_{ct,d}$ = 0,6 $f_{ct,fl,d}$

$f_{ctR1,d}$ = 0,45 $f_{R,1,d}$

$f_{ctR3,d}$ = k_1 (0,5 $f_{R,3,d}$ - 0,2 $f_{R,1,d}$)

k_1 = 1 for sections subject to bending and 0,7 for sections subject to tension

ε_1 = 0,1 + 1.000*$f_{ct,d}$ / $E_{c,0}$

ε_2 = 2,5/l_{cs}

ε_{lim} = 20 ‰ for sections subject to bending and 10‰ for sections subject to tension

l_{cs} Critical length (in metres) of the calculated element which may be determined using the expression:

l_{cs} = min (s_m, h - x)

where: x = depth of the neutral axis

h-x = distance from the neutral axis to the most highly tensioned end

s_m = mean distance between cracks. Unless justified data is available, the values in Table A.7.6.1 may be used for s_m.

Table A.7.6.1 Reference values for s_m

Elements without traditional reinforcement or with very little reinforcement and fibre concrete with a bending behaviour with softening ($f_{R,1} < f_L$ and $f_{R,2} < f_L$)	H (depth of the member)
Fibre-reinforced concrete, with $f_{R,3,d} < 2$ kN/mm^2	s_m calculated in accordance with Annex 19
Elements with fibre concrete with a bending behaviour with hardening ($f_{R,1} > f_L$ and/or $f_{R,2} > f_L$)	Shall be determined experimentally as indicated in section 4.1.1.3. of this Annex
Other cases	The specialised bibliography shall be consulted

Note: To simplify matters, elements with very little reinforcement shall be regarded as those in which the geometric quantity of traditional tension reinforcement is less than one per thousand.

The effect of the A-B-C peak may be important when a non-linear analysis is carried out, particularly for small strains. In other cases, the simplified bilinear diagram, formed of the straight lines corresponding to the elastic section O-A and the extension of the straight

line C-E to point A, and also considering a rigid behaviour with E = ∞, may be used for the fracture calculation.

Other calculation diagrams shall be accepted provided that the results obtained using these satisfactorily coincide with the results produced by the rectangular diagram indicated in Figure A.7.6.1. or are on the safe side.

The constitutive diagrams presented are general and any of these can also be used for the calculation in ELS by adapting the partial safety coefficients of the materials to the Limit State to be addressed.

Alternatively, the following formulation can be used:

CASE I: For the ELS design of materials with softening, the same diagram used for uniaxial tensile mass is proposed up to f_{ct}. In the residual branch (cracked regime) a bilinear diagram is applied (Figure a).

The residual branch (BC) is described analytically as:

$$\frac{\sigma - f_{ct}}{0.2 f_{ct} - f_{ct}} = \frac{\varepsilon - \varepsilon_p}{\varepsilon_Q - \varepsilon_p} \qquad \varepsilon_p \leq \varepsilon \leq \varepsilon_c$$

With $\varepsilon_Q = \frac{G_F}{l_{cs} f_{ct}} + \left(\varepsilon_p - \frac{0.8 f_{ct}}{Ec}\right)$

where G_F represents the fracture energy of the mass concrete.

CASE II: Material with hardening (Figure b), the residual branch (BD) is described analytically as:

$$\frac{\sigma - f_{ct}}{f_{Ftsd} - f_{ct}} = \frac{\varepsilon - \varepsilon_p}{\varepsilon_{SLS} - \varepsilon_p} \qquad \varepsilon_p \leq \varepsilon \leq \varepsilon_{SLS}$$

CASE III: Material with hardening (Figure c), the AD branch is defined according to:

$$\frac{\sigma - \sigma_{A'}}{f_{Ftsd} - \sigma_{A'}} = \frac{\varepsilon - \varepsilon_{A'}}{\varepsilon_{SLS} - \varepsilon_{A'}} \qquad \varepsilon_p \leq \varepsilon \leq \varepsilon_{SLS}$$

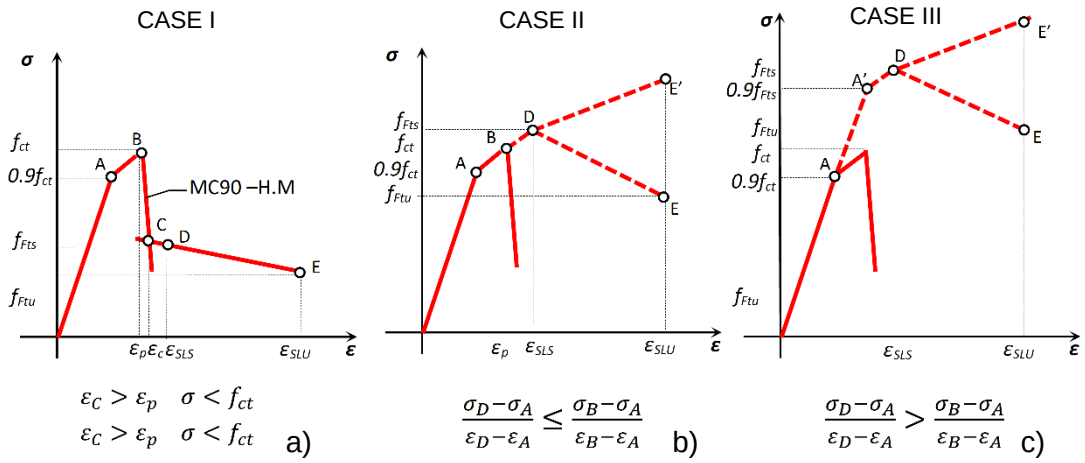


Figure A7.6.3.

The general expressions for the definition of the constitutive equation are:

$f_{ctm}=0,30(f_{ck})^{2/3}$

$f_{Fts}=0,45f_{R1}$

$f_{Ftu}=k\,[f_{Fts}-(w_u/CMOD_3)(f_{Fts}-0,5f_{R3}+0,2f_{R1})]$

$\varepsilon_{SLS}=CMOD_1/l_{cs}$

$\varepsilon_{SLU}=w_u/l_{cs}=\min(\varepsilon_{Fu}, 2,5/l_{cs}=2,5/y)$

ε_{Fu} = [20‰ softening; 10‰ hardening]

6.1.1.4 Orientation factor

In general, the design assumes that the distribution of fibres in the concrete is isotropic, that is, that the fibres are oriented uniformly throughout the volume. In order to consider different distributions that take place in structures, we introduce an orientation factor (K) that in the case of isotropic distribution takes a value K = 1.0. It is understood by orientation factor K:

$$K = \frac{n}{th} = n\frac{A_f}{V_f A}$$

Where n is the actual number of fibres in a section, *th* the theoretical number of fibres in the section, A_f the cross-sectional area of a fibre, V_f the volumetric fraction of fibres and A the area of the cross-section of concrete in the one that measures the value of K.

For favourable effects, a factor of K < 1.0 may be applied, provided that it is verified experimentally. For unfavourable effects, it will be necessary to determine and apply the K > 1.0 factor experimentally. When K < 1.0 is used in one direction, the value of K in the other direction should also be checked.

Specific tests may be carried out to determine the effect of the orientation of the fibres due to concreting and compaction in structures, using elements representative of the behaviour of concrete in the structures.

In the orientation and distribution of the fibres the effects of edge and wall of formwork, the form of the mold, the time and energy of vibration, and in the case of the self-compacting concretes the direction and distance of advance of the concrete have a remarkable influence.

6.1.1.5 Creep of concrete

When using synthetic fibres for structural purposes, the manufacturer must indicate the concrete's coefficient of creep, with the results being confirmed experimentally.

6.1.1.6 Poisson coefficient

The fibres individually or as a group must have a Poisson coefficient similar to that of concrete if the mesh effect is to be taken into account at structural level.

6.2 Ultimate Limit State calculations

6.2.1 Failure Limit State under normal forces

6.2.1.1 Basic assumptions

The ultimate loadbearing capacity of sections in which the fibres have a structural function shall be calculated using any of the diagrams defined in Annexes 19 and 21 as a calculation diagram for concrete under tension

6.2.1.2 Deformation domains

They are considered the same as for a structure with conventional concrete for concrete sections with mixed reinforcement, conventional reinforcement and fibres. For sections of concrete reinforced exclusively with fibres, the maximum deformation associated with pivot A (10‰) will be increased to ε_{lim} (see section 6.1.1.3 of this annex).

6.2.1.3 Concrete confinement effect

Fibres with a structural function provide a concrete confinement effect similar to that of transverse reinforcements. In order to quantify the confinement effect produced by the fibres, the specialised bibliography must be consulted.

6.2.1.4 Simple or compound bending

In those cases where fibres with a structural function are used, either alone or in combination with traditional reinforcement, the following limitation must be observed:

$$A_p\, f_{pd}\, \frac{d_p}{d_s} + A_s\, f_{yd} + \frac{z_f}{z}\, A_{ct}\, f_{ctR,d} \geq \frac{W_1}{z}\, f_{ctm} + \frac{P}{z}\left(\frac{W_1}{A} + e\right)$$

where:

$z_f \ A_{ct} \ f_{ctR,d}$	Contribution of the fibres
z_f	Lever arm for the tension in the concrete.
A_{ct}	Tensional area of the concrete.
$f_{ctR,d}$	Design residual tensile strength in the rectangular diagram.

In the case of rectangular sections with or without passive reinforcement, the following simplified expression may be used in which there is no need to determine the tensioned area of the concrete.

$$A_s \ f_{yd} + 0{,}4 A_c \ f_{ctR,d} \geq 0{,}04 \ A_c \ f_{cd}$$

This limitation is justified as a guarantee to prevent fragile fracture of the concrete. The action of the traditional reinforcements and the fibres is complementary in this respect and therefore the limitation constitutes a minimum fibre content requirement for elements without traditional reinforcements and the possibility of reducing, and even eliminating, the requirement for minimum traditional reinforcements in elements with a sufficient content of structural fibres.

This limitation does not apply for slabs resting on the ground. Likewise, in elements that work predominantly compressed and with reduced flexions in the service regime, this limitation does not apply either, should this be considered only if in some transitory phase there are bending states that can lead to the cracking of the structural element.

Alternatively to the proposed simplified expression, in an equivalent way and for any section geometry, the minimum reinforcement needs can be estimated by imposing that the Last Moment (M_u), considering the contribution of the fibres and the armature in the form of bars, if there should be, it must be equal to or greater than the Cracking Moment of the section (M_{fis}).

$$M_u \geq M_{fis}$$

For rectangular sections armed only with HRF, this condition will result in:

$b \cdot h^2/6 \cdot f_{R3d} \geq b \cdot h^2/6 \cdot f_{ctm.fl}$ and thus, $f_{R3d} \geq f_{ctm,fl}$.

6.2.1.5 Simple or compound tension

In the case of concrete sections subject to simple or compound tension which contain two main reinforcements and fibres, the following limitation must be observed:

$$A_p \ f_{pd} + A_s \ f_{yd} + A_c \ f_{\boldsymbol{ctR,d}} \geq 0{,}20 \ A_c \ f_{cd}$$

6.2.1.6 Geometric ratios (amount of reinforcement)

The values related to the minimum geometric ratios (established in Annex 19) that must which must be provided in all cases in the various types of structural element, depending on the steel used, may be reduced in the case of concrete with fibres by an equivalent mechanical quantity:

$$A_c \ f_{ctRm}$$

where A_c *and* f_{ctRm} are the area of the concrete cross section and the residual tensile strength of the concrete, respectively.

This reinforcement must be arranged in order to control the width of the cracks that form at short ages due to thermal phenomena due to hydration and retraction reactions, and not by actions of direct or indirect type. In this sense, although the control of this type of cracking is influenced by a multitude of factors (curing, thermal and hygrometric regime of the environment, solar action, among others), it is known that the use of the amount and type of suitable fibres leads to efficient control of cracking caused by these reasons. This limitation does not apply if the manufacturer and / or supplier of the fibres can guarantee, through real-scale tests or other tests, that their product is suitable for the control of this type of cracking, for the structural element to be executed and under the conditions real work.

6.2.2 Failure Limit State under shear

6.2.2.1 General considerations

The contribution of the fibres shall be taken into account in the loadbearing capacity of the tie rods.

6.2.2.2 Fibre-reinforced concrete members with and without shear reinforcement

Where there are bent longitudinal bars which are taken into account in the calculation as shear reinforcement, at least one-third of the shear strength must be provided by the contribution of the steel fibres or, where applicable, by the joint contribution of the steel fibres and vertical stirrups. In all cases, the minimum quantity of shear reinforcement is established and shall be provided as indicated in Annex 19.

The failure shear stress due to tension in the web is equivalent to:

$$V_{u2} = V_{cu} + V_{su} + V_{fu}$$

where:

V_{cu} Contribution of the concrete to the shear strength

V_{su} Contribution of the transverse reinforcement of the web to the shear strength

V_{fu} Contribution of the steel fibres to the shear strength

$V_{fu} = 0{,}7 \ \xi \ \tau_{fd} \ b_0 \ d$

where:

$\xi = 1 + \sqrt{\frac{200}{d}}$ with d in (mm) and $\xi \leq 2$

τ_{fd} Design value of the increment in shear strength due to the fibres, taking the value:

$\tau_{fd} = 0{,}5 \ f_{ctR,d}$ (N/mm^2)

In the case of T-sections, the contribution of the flanges may be taken into account through a multiplying coefficient k_f in the expression of V_{fu}. This coefficient may be determined using the following expression:

$$k_f = 1 + n \cdot \left[\frac{b_f}{b_0}\right] \cdot \left[\frac{h_f}{d}\right] \text{ con } k_f \leq 1{,}5$$

where:

h_f Height of the flanges in mm

b_f Width of the flanges in mm

b_0 Width of the web in mm

$n = \frac{b_f - b_w}{h_f} \leq 3$ y $n \leq \frac{3 \cdot b_w}{h_f}$

Comment:

In all the formulas related to tangential stresses (shear stress, punching), when speaking of the angle ϑ we must bear in mind that the value of it is somewhat different for concretes with fibres.

6.2.2.3 Transverse reinforcements

The minimum quantity of shear reinforcement, whether in the form of Steel Fibre-Reinforced Concrete and/or vertical stirrups, shall be provided where the following ratio is met:

$$V_{su} + V_{fu} \geq \frac{f_{ct,m}}{7{,}5} b_0 \, d$$

6.2.2.4 Longitudinal reinforcements

In the case of structures made of concrete reinforced with fibres with a structural function; (V_{su}+V_{fu}) must be used in the expressions in the main article in place of V_{su}.

6.2.2.5 Longitudinal shear between the flanges and web of a beam

It has been confirmed experimentally that fibres with a structural function can significantly contribute to the resistance of flange-web longitudinal shear stress. In order to take account of this contribution, conclusive experimental campaigns or endorsed scientific publications must be used.

6.2.3 Failure Limit State due to punching

6.2.3.1 Fibre-reinforced concrete slabs

Fibres can improve punching strength. An initial approach is to take account of their contribution by using a loadbearing stress in the critical surface equivalent to:

$$\tau_{fd} = 0{,}5 \, f_{ctR,d} \quad (\text{N/mm}^2)$$

However, this value may be significantly higher, but this must be proven experimentally if it is to be used.

6.2.4 Failure Limit State due to longitudinal shear stress in joints between concretes

6.2.4.1 Provisions in relation to reinforcements

It shall only be considered that the fibres contribute to the slip resistance in the case of joints which are strengthened transversely, where the dimensions of the keys are comparable to that of the fibre itself.

7 Execution

7.1 Execution

7.1.1 Reinforcement production, reinforcing and assembly processes

7.1.1.1 Anchorage of passive reinforcements. General

Fibres improve the anchorage characteristics where these are used together with passive and active reinforcements. This factor may be taken into account in the calculations in this article provided that this is confirmed by experimental tests which prove that this is the case.

7.1.2 Production and use of concrete

7.1.2.1 Production of concrete

7.1.2.1.1 Dosage of constituent materials

7.1.2.1.2 Water

The increase in the consistency due to the use of fibres must always be offset by the addition of water-reducing admixtures, without altering the specified water dosage

7.1.2.1.3 Fibres

The effectiveness of the various types of fibre can vary a great deal. As a result, it is recommended that the concrete is designated by its properties and that the type and dosage of fibres are defined in the prior tests.

The selection of the type and dosage of fibres will depend on their effectiveness and their influence on the consistency of the concrete. The maximum length will comply with the conditions stipulated in this Annex. The increase in slenderness of the fibres and the use of high dosages can increase their mechanical efficiency, but can also cause a reduction in the consistency and a greater risk of the formation of fibre balls which separate from the concrete (“hedgehogs").

The fibre dosage shall be determined by weight, using weighing machines and scales other than those used for aggregates. Where automatic dosing machines are used, these must be calibrated with the frequency determined by the manufacturer. The fibre weight tolerance shall be ±3 per 100.

7.1.2.2 Mixing equipment

The check that the mix produced by a fixed or mobile mixer is uniform must include the verification that the maximum difference tolerated between the fibre content results

determined according to UNE-EN 14721 and UNE-EN 14488-7:2007 from two samples taken from the concrete discharge (1/4 and 3/4 of the discharge) is less than 10%.

7.1.2.3 Mixing

Mixing is a critical phase in producing concrete with fibres due to the risk of tangling of the fibres, thus forming “hedgehogs”. This risk can be reduced by good dosage with a sufficient content of fine aggregate, but is increased by excessively long transport and particularly when the fibre content is high and these are very slender. The filling order may also be decisive. As a general rule, fibres must be added together with the aggregates, preferably with the coarse aggregate at the start of the mix. It is not advisable to make the fibres the first component of the mix.

In the case of steel fibres, when the concrete is to be transported over a long distance, the addition of fibres on site may be proposed. As a result, a sufficiently fluid concrete must be provided to facilitate the travel of the fibres to the bottom of the drum and an on-site dosing system must be provided which guarantees the accuracy indicated in section 51.2.3 of this Code. The fibres must be poured in slowly (between 20 and 60 kg per minute) with the drum rotating at its maximum speed until the uniform distribution of the fibres in the mass of concrete is guaranteed.

7.1.2.4 Supply of the concrete

The delivery note must contain the following data:

- Specification of the concrete: Designation in accordance with section 33.6. of this Code.
- Material, type, dimensions (length, characteristics of the section and equivalent diameter, slenderness) and characteristics of the shapes (shaped at the ends, undulated, etc.) of the fibres.
- Fibre content in kilograms per cubic metre (kg/m3) of concrete, with a tolerance of ±3%.

The list of the fibre characteristics may be replaced by a reference to their full commercial designation, supported by a data sheet previously accepted by the Technical Management and available in the site book.

7.1.2.5 Placing of concrete

7.1.2.5.1 Pouring and placing of concrete

Concrete must be poured and placed in such a way that no additional transport of the concrete on site is required. Interruptions in the concreting must be avoided as these could cause irregularities in the distribution of the fibres.

When the concrete is placed on site using a hopper, the diameter of the discharge outlet must be greater than 30 cm to facilitate pouring.

7.1.2.5.2 Compacting of concrete

Due to the fact that using fibres reduces the workability of concrete, greater compacting energy will be required. However, the response to vibration of concrete with fibres is better than that of a traditional concrete which is why, for the same slump in the Abrams cone, a shorter vibration time is required.

Compacting leads to a preferential orientation of the fibres. In general these tend to settle parallel to the surface resting against formwork, particularly if surface vibrators are used. This effect is only local but may be significant in thin elements.

The use of internal vibrators may generate zones with too much concrete and too few fibres in the zone where the vibrator has been placed, and also some orientation in the direction tangential to the external diameter of the vibrator.

8 Control

8.1 Control of the conformity of the product

8.1.1 Specific criteria for checking the conformity of the component materials of the concrete

8.1.1.1 Other concrete components

8.1.1.1.1 Specifications

Are those corresponding to Articles 31 and 32 of this Structural Code and the ones that the Project Technical Specifications could include.

8.1.1.1.2 Tests

Before to the start of the works the effect of fibres will be checked according to the tests referred in Annex 13 of this Code. Consequently, the trade marks, types and fibre doses being admissible. The continuity of the composition and the characteristics shall be guarantied by the corresponding Producer.

Along the period of execution of the work it shall be controlled that the fibres used are those accepted as in the previous paragraph.

The Work Management could require, if necessary, the checking of the properties exigible to the fibres

8.1.1.1.3 Acceptation or rejection criteria

Failure of any of the specifications will be a sufficient condition to qualify the fibre as ones not suitable for the concretes.

Any possible modification of the commercial mark, the type or the dosage of the fibres that is going to be used, with regard to what has been accepted in the tests prior to the beginning of the work, will imply their non-use until, after the accomplishment with these modifications of the tests foreseen in Annex 13 of this Code, Project Manager authorizes their acceptance and use in the work.

8.1.2 Control of the concrete

The control of the quality of the concrete of fibres will include that of the type and contents of fibres, and in the event of fibres with structural function, that of their residual strength according to the method that establishes the Project Technical Specifications

8.1.2.1 General criteria for the control of the conformity of the concrete

Where the fibres had a structural function, in addition to the tests specified in the articles, the flexural test of three specimens for each batch used for control, according to UNE-EN 14651, had to be done in order to determine the values of the residual strength $f_{R,1,m}$ y $f_{R,3,m}$ at 28 days of age. Alternatively, the project author or the facultative management can indicate the use of the UNE 83515 standard. In each batch the fibre content will also be determined according to UNE-EN 14721 or UNE-EN 14488-7.

When according to specifications in section 33.3 of the Structural Code, other types of alternative tests are selected for the control of the residual flexural strength of the concrete; these will have to be contrasted by a concluding experimental campaign. The Project Manager will determine previously the values of reference to obtain during the tests and the criteria of acceptance and rejection.

According to has been indicated in the part of materials of this Annex, Project Manager will be able to value, under his responsibility, the use of other procedures that facilitate the control. As it can be the case of the MDPT or multidirectional double punching test, performed on a cube of 15x15 x 15 cm for the control of the residual strength or the magnetic induction method for the control of the content of metallic fibres (and orientation). Finally, counts can be made to know the content and orientation of the fibres.

8.1.2.2 Carrying out of tests

In the case of concretes of fibres with consistency less below 9 cm of seat in the Abrams cone it is recommended to use other methods as the Consistometer Vb in agreement with EN 12350-3 or the inverted cone according to UNE 83503.

8.1.2.2.1 Tests on the strength of the concrete

Before the beginning of the concreting the accomplishment of previous tests or characteristic tests, which are respectively described in the Annex 13 of this Code, is necessary.
When there is experience, well documented and sufficient, so much in materials, included the type and trademark of the planned fibres, as in dosage and installations (for example the concrete mixing plants), only the test for control would be necessary.

8.1.2.2.2 Control of the strength of the concrete at 100%

The criteria of definition of lots will coincide with what has been specified in the articles.

The control of the residual flexural strength to flexotraction as UNE-EN 14651 or UNE 83515 will be carried out on 2 batches by lot. In these batches the control of the contents in fibres will be done as UNE-EN 14721 or UNE 14488-7.

When the result of the control of contents in fibres in one batche of the lot was inferior by 10% to the stipulated value, the control of residual flexural strength shall be extended

to all the batches on which samples are taken for determining the compressive resistance of the concrete.

The analysis of results and the estimators to use to obtain the corresponding characteristic values from the results of the tests will be the same that the ones included in the Articles for the resistance to compression.

8.1.2.2.3 Indirect control of the strength of the concrete

This type control does not apply to the concretes with fibres with structural function.

8.1.2.3 Decisions arising from the control

When in a lot of a work with strength control implemented, it happens $f_{R,j,est} \geq f_{R,j,k}$ such lot shall be accepted.

If were $f_{R,j,est} < f_{R,j,k}$,, for lack of an explicit forecast of the case in the Project Technical Specifications of the work and without prejudice of the planned contractual sanctions (to see this Code), it will be proceeded as it follows:

- If $f_{R,j,est} \geq 0{,}9\ f_{R,j,k}$,, the lot will be accepted.
- If $f_{R,j,est} < 0{,}9\ f_{R,j,k}$,, it will be proceeded to carry out, for decision of the Project Management or at the request of any of the parts, the studies or pertinent complementary tests.

If it would be detected some variation in the aspect, dimensions or shape of the fibres, the preliminary tests would be performed again.

8.1.2.4 Tests on additional information for the concrete

The extraction of core samples, carried out in accordance with Chapters 12, 13 and 14 of the Structural Code, leads to cylindrical specimens on those that can not be applied the tests of reference for the determination of the mechanical flexural characteristics of the concrete of fibres. Since this verification will not be able to be carried out, it can be replaced by other tests that allow estimating the resilience of the concrete such as the Barcelona test or alternatively the MDPT test, both under the double punching configuration.

8.2 Control of the construction

8.2.1 General criteria for the control of the construction

In the section 63.2 of this Code, the following construction units, specific of fibre concretes, shall be included:

- Type of fibres used alter the control of fibres contents
- Storage conditions for fibres
- Procedure to add fibres to the concrete mix

The maximum sizes of these inspection units shall be defined in the corresponding project, depending on the characteristics of the work.

8.2.2 Preliminary and characteristic tests of concrete

8.2.2.1 Preliminary tests

In concretes with fibres the preliminary tests take special importance for the definition of the fibres to use and their dosage.

When the fibres had structural function the preliminary tests will include the preparation of at least four series of specimens proceeding from different batches, of six specimens each for test at the 28 days of age, by every dosage that it is wanted to establish, and will be operated in agreement with UNE-EN 14651 to determine the average values of the residual flexure strength:

$$f_{R,1,m} \text{ y } f_{R,3,m}.$$

In order to define the values of resistance to be obtained in the preliminary tests, when the coefficient of variation of this test is unknown, only as an informative reference, it can be taken as:

$$f_{R,j,k} = 0{,}7\ f_{R,j,m}$$

while in the cases of elements requested to flexion that the coefficient of variation is known, the characteristic value of residual voltage can be calculated through:

$$f_{R,j,k} = \left(1 - \frac{0{,}85\,\alpha\, CV_{R,j}}{h^{0,32}\, l_{fis}^{\ 0,48}}\right) f_{R,j,m} \leq 0{,}85\ f_{R,j,m}$$

where:

- h is the height of the element in mm, which must always be assumed to be less than or equal to 300 mm;
- l_{fis} is the smaller of the different dimensions of the height or the minimum length of the broken lines formed, both in mm, assuming always values less than or equal to 2000 mm;
- $CV_{R,j}$ is the coefficient of variation of the flexural stress test of UNE-EN 14651 in so many per one, which must always be assumed to be greater than or equal to $0{,}115 \cdot \alpha'$;
- α' is the statistical coefficient related to the degree of uncertainty in the estimation of $CV_{R,j}$ as a function of the number of test pieces tested, as shown in Table A7.1;
- α is the parameter related to the confidence with respect to the value of $CV_{R,j}$, which can be assumed equal to 1 when the typical dispersion of the material is known in the UNE-EN 14651 test or equal α' if the dispersion is unknown, but experimental results are available.

- For beam elements, l_{fis} coincides with width (b) while for flat elements l_{fis} will be the minimum length of the main bending fissures, and that can be determined by plastic calculation criteria.
- In the case that the CV value is not known, CV = 25% can be assumed.

Table A7.1. Reference values for *α'*

Nº of test pieces tested	**3**	**4**	**5**	**6**	**8**	**10**	**20**	**30**	**∞**
α'	2,05	1,60	1,42	1,33	1,22	1,17	1,07	1,05	1,00

8.2.2.2 Characteristic tests for strength

When the fibres have structural function the tests will include, besides the ones specified in the Articles, the test of three specimens per batch in agreement with UNE-EN 14651 to determine the values of the residual flexural strength $f_{R,1,m}$ *y* $f_{R,3,m}$, at the 28 days of age. In every batch of this type will be determined also the contents in fibres UNE-EN 14721 or UNE-EN 14488-7.

The analysis of results and the estimators to use to obtain the corresponding characteristic values from the results of the tests will be the same ones referred in the Articles for the resistance to compression.

Annex 8

Recommendations for the use of lightweight concrete

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1 Introduction

The specifications and requirements laid down in the articles in this Code refer to the use of normal weight aggregates. It is therefore necessary to establish different or additional recommendations when lightweight aggregates are used to produce structural concretes.

A wide range of densities and mechanical properties may be obtained taking into account that the normal weight aggregate may be replaced by light weight aggregate in a partial manner, replacing only the coarse fraction of the aggregate or total, also replacing the sand by fine lightweight aggregate.

To distinguish lightweight concrete from conventional concrete, a subindicator “l” should be added to the stress-strain parameters of the concrete.

2 Scope

For the purposes of this Annex, structural light concrete (SLC) is defined as closed structure concrete with an apparent density measured under dry conditions up to constant weight is less than 2000 kg/m^3 but greater than 1200 kg/m^3 and containing a certain proportion of natural or artificial light aggregate. Cellular concretes are excluded whether cured in a standard manner or in an autoclave.

It is important to highlight that apparent density (or unit weight) in a fresh state is greater than that of normal aggregate concrete and depends on the light aggregate saturation level and the water content of the mixture.

3 Design bases

The bases laid down in this article of the Structural Code are applicable.

4 Structural analysis

4.1 Structural analysis

The principles and methods of calculation laid down in the articles of the Structural Code are applicable.

The thermal expansion coefficient of concrete with light aggregates depends on the characteristics of the aggregate used in its manufacture with a wide range between 4·10-6 and 14·10-6 °C-1. If no data is present and for structural analysis, an average value of 8·10-6 °C-1 may be adopted. In this regard, it is not necessary to consider existing differences between the steel in the reinforcement and the concrete with light aggregate.

5 Technological characteristics of materials

5.1 Materials

5.1.1 Aggregates

5.1.1.1 General

Light aggregates must have CE marking (subject to UNE-EN 13055-1).

There are many different types of light aggregates, both natural and artificial, designed to produce structural light concrete.

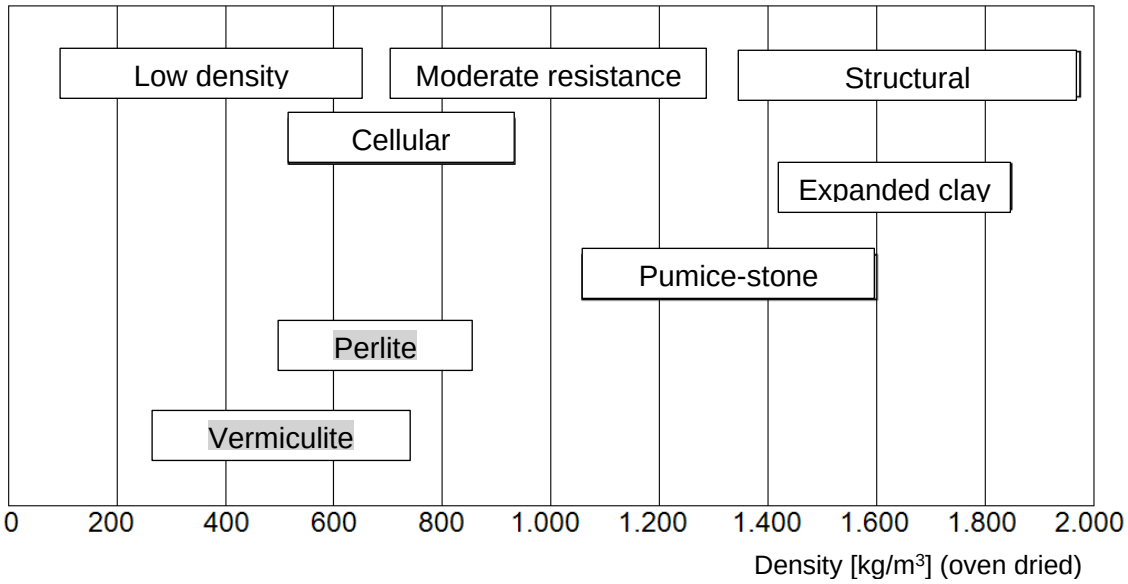


Figure A8.5.1.1. Density ranges and classification of light weight concretes.

Structural light concretes contain light aggregates that are situated at a high range on the scale and consist of clays, expanded slates or schists, pumice stone or may also take the form of synthetic aggregates, from raw materials such as fly ash.

Comments

The harmonized standard contained in this section, UNE-EN 13055-1, will be used in the latest version published in the Official Journal of the European Union (DOUE) (currently this standard is UNE-EN 13055-1: 2003 and UNE- EN 13055-1 / AC: 2004), while the standards of test methods referenced in this harmonized standard, should be applied in the version included in it.

5.1.1.2 Designation of aggregates

When designating aggregates by size, it should be taken into account that the size distribution of the aggregate will be expressed as a percentage by mass that passes a specified number of sieves, as indicated in the UNE-EN 13055-1 standard.

5.1.1.3 Maximum and minimum aggregate sizes

For the purposes of this Code, the maximum size D of a light aggregate is the minimum sieve size UNE EN 933-2 whereby more than 90% of the volume passes through (% of substandard higher than D 10%) when everything also passes through the double opening screen (% of substandard greater than 2 D equal to 0%). The minimum size of an aggregate is designated as the maximum sieve size UNE EN 933-2 whereby less than 15% by volume passes through (% substandard less than d less than 15%).

5.1.1.3.1 Specifications and tests

Lightweight aggregates do not display a history of an alkali-aggregate reaction and it will not therefore be necessary to evaluate the product for this type of attack.

5.1.1.4 Aggregate particle size grading

With regard to grading analysis, the normal procedure for screening and determining the weight of the retained fraction is insufficient because the difference sized fractions have different densities. If the aggregate is of normal weight and its density does not depend on its size, it is possible to convert weight to volume directly.

The same procedure applied to light aggregates provides incorrect information because the different fractions or sizes possess different densities. This may be taken into account when determining the density of each fraction and if the corresponding volume is calculated. With this proviso, it is possible to consider the same grading limits established for fine aggregates of normal weight.

5.1.1.5 Form of coarse aggregate

Because artificial or synthetic aggregates in the approximate shape of a sphere or ellipsoid are used in structural light concrete, the importance of the limits imposed on the shape coefficient and/or slab index shall be reduced.

5.1.1.6 Physical-mechanical requirements

Light aggregates are less strong than aggregates of normal weight, both under compression and when subject to the effects of wear by abrasion and crushing. In this situation, the wear resistance of coarse aggregate shall not be evaluated by the Los Angeles methods according to UNE-EN 1097-2, or limitation to the friability of light fine aggregate, evaluated in accordance with a micro-Deval test indicated in UNE 83115 EX, when necessary, the test method described in Annex A of the UNE-EN 13055 standard must be used.

The absorption capacity of light aggregates is normally high because their lower weight is achieved due to their porous structure. The limitation of water absorption values shall not be applied although ideally they shall be processed in order to present as closed a structure as possible, particularly if absorption is expressed as a % of the aggregate, because they are less dense. When necessary, the test method described in Annex C of the UNE-EN 1097-6 standard must be used.

Since absorption is normally high, to prevent this effect significantly altering the properties of fresh concrete (slump loss, for example), different prior concrete methods or treatments shall be adopted during the concrete production process.

With regard to the frost resistance and structural light concrete, the presence of incorporated air in the concrete helps to reduce deterioration in a similar manner to what occurs with concretes of normal weight. The concrete saturation level (and that of the aggregate) is a crucial factor, as is the appropriate level of strength. Evaluation of the aptitude of aggregates to magnesium sulphate solution treatment cycle in accordance with the method in UNE EN 1367-2 may not be applied, because the low intrinsic strength of light aggregate and its high absorption indicates a remote probability of compliance, when necessary, the test method described in Annex C of the UNE-EN 13055 standard must be used. In general, the aptitudes of concrete shall be evaluated under freezing and thawing cycles. High strength, inclusion of incorporated air, and a low level of saturation aggregate (and concrete) contribute to significantly improving behaviour.

5.1.2 Concretes

5.1.2.1 Composition

In structural light concretes, the influence of using light aggregate, mixture proportion, prior saturation level of light aggregate and even the type and variety of light aggregate have a direct influence on the properties of structural light concrete both in a fresh state and in a setting state. For this reason, the composition of concrete and the light aggregate pre-conditioning procedure shall be examined beforehand, without exceptions, to ensure that it is able to produce concretes whose mechanical, rheological and durability characteristics satisfy design needs.

5.1.2.2 Minimum strength value

Design strength f_{ck} *(see 33.4 of this Code)* shall not be less than *12* N/mm^2 in mass concrete, or 25 N/mm^2 in reinforced or prestressed concrete.

5.1.2.3 Concrete workability

The principles established in section 33.5 of this Code may be applied without the need for alteration. The characteristics of test methods UNE-EN 12 350-2 nevertheless mean that slump undervalues the aptitude of light concrete to be compacted.

Slump in a tapered cone is due to the strain of concrete under its own weight. The density of light concrete is less than that of conventional concrete and for this reason it offers greater workability for equivalent slumps.

For the same reason, it is not considered prudent to exceed the upper limits for fluid consistency even with the use of superfluidization additives.

6 Durability

6.1 Durability

6.1.1 Durability of the concrete and reinforcements

6.1.1.1 Concrete quality requirements

For equivalent strength levels, structural light concretes possess a mortar matrix that is usually stronger than that corresponding to a concrete of normal weight. For this reason, it is sufficient to indicate that the durability is assured by compliance with stress classes as indicated in section 43.2.1 of this Code. Obviously, requirements relating to the minimum cement content and maximum water/cement ratio shall naturally also be met.

6.1.1.2 Coverings

Minimum coatings for structural light concrete shall be 5 mm higher than that indicated in the article 44 of this Code.

6.1.1.3 Durability of concrete

Structural light concretes processed using light aggregates do not generally display good behaviour to erosion because the light aggregate is usually soft. With the exception of this situation, its behaviour is similar to that of conventional concrete of normal weight.

6.1.1.4 Mix proportioning requirements and concrete performance

The following requirements shall be met to achieve appropriate concrete durability:

a) General requirements

- Minimum cement concrete, according to 43.2.1 of this Code.
- Strength class according to section 43.2.1 of this Code.

The accurate determination of the water/cement ratio is not direct because light aggregates are partially presaturated with water and are capable of additional absorption. For this reason, the limit to the water/cement ratio is replaced with the strength class.

b) Additional requirements

It is not prudent to expose structural light concrete to wear by abrasion in a permanent situation. While in the concrete surface the aggregate particles are covered by mortar, light concretes are able to withstand erosion from eventual actions.

6.1.1.5 Limitations on water and cement content

Depending on the exposure classes to which the concrete will be subjected, defined in accordance with section 27.1 of this Code, the specifications set forth in section 43.2 of this Code, relating to the resistant class, discounting the water absorption of aggregates.

6.1.1.6 Erosion-resistance of concrete

It is not advisable to use structural light concrete with light aggregate for exposure class XM1, XM2 and XM3. This does not make structural light concrete able to withstand possible erosion but the wear mechanism is not controlled by the strength of aggregates as is the case with concrete of normal weight.

7 Design

7.1 Information concerning materials to be used in structures

7.1.1 Characteristics of concrete

The mechanical properties of concrete with light aggregates (ultimate strain, longitudinal strain modulus, tensile strength), for the same compressive strength depend to a large extent on the density, being higher as the dry density of light concrete increases.

The data and characteristics for the project of the concrete with light aggregates, as well as the tension-deformation diagrams applicable for the structural analysis and for the calculation of sections will be those indicated in section 11.3 of Annex 19 of this Code.

8 Execution

8.1 Construction, reinforcing and assembly processes for reinforcements

8.1.1 General criteria for structural ironwork processes

8.1.1.1 Bending

With the aim of avoiding excessive compression and scratching of concrete with light aggregates in the bar curvature area, folding of the bar to obtain hooks and bends in U, shall be carried out using mandrels of diameter no less than those indicated in table 49.3.4 of this Code, but multiplied by 1,5.

The remaining content of section 49.3.4 of this Code is applicable to concrete with light aggregates.

8.1.2 Reinforcement of structural ironwork

8.1.2.1 Distance between bars of passive reinforcements

8.1.2.1.1 Isolated bars

The maximum diameter of the bar to be used with SLC shall be Φ = 32 mm.

The remaining content of section 49.4.1 of this Code is applicable to concrete with light aggregates.

8.1.2.1.2 Groups of bars

In concrete with light aggregates the groups of bars will be constituted, at most, by two bars.

8.1.3 Specific criteria for anchorage and splicing of reinforcements

8.1.3.1 Anchorage of passive reinforcements

The basic length of SLC corrugated bar anchorage is as indicated in the section 49.5.1 of this Code multiplied by a factor [1/η_1],

where

$$\eta_1 = 0{,}40 + 0{,}60\frac{\rho}{2200}$$

and where ρ is the SLC dry density value ≤ 2000 (kg/m^3)

8.2 Elaboration and placing of concrete

8.2.1 Elaboration of concrete

8.2.1.1 Composition of component materials

In the case of SLC, conducting previous tests with the aim of checking that SLC meets the conditions laid down is the established procedure of accepting the required composition and approving the concrete construction procedure.

The high water absorption levels generally typical of light aggregates in the dry state makes it difficult to predetermine the true water/cement ratio corresponding to the required dose. If the status is saturated, which is not immediately achieved, a process of water transfer to the concrete paste that also alters the required water/cement ratio may arise from the cortex accessible to capillarity effects. In the first case, the workability of SLC will be reduced and in the second case its strength will be reduced.

The complexity of the problem gives rise to different procedures for constructing concrete that evade a standard regulation. The correct result of the planned composition is highly sensitive to small adjustments in the construction procedure. The previous tests are therefore established as a dose and construction procedure validation method, as a unique and indivisible process.

The remaining content of section 51.3.2.1 of this Code is applicable to concrete with light aggregates.

8.2.1.1.1 Aggregates

When working SLC, the aggregates may be composed by weight, volume or in a mixed manner so that the light aggregate is dosed by volume and the rest by weight.

The remaining content of section 51.3.2.3 of this Code is applicable to concrete with light aggregates.

8.2.1.2 Mixing of concrete

Mixing SLC takes longer, in general, than conventional concrete. This increase in mixing time is required for the moistening of the aggregates before adding the cement and blending the mixture after adding additives following the addition of total mixture water. This time is

required to prevent rapid absorption of water and additives by the light aggregate removes workability from the concrete mixture and efficacy from the action of its admixtures.

The low density of light aggregate may cause it to float at the beginning of the mixture, depending on the level of water saturation it possesses when it enters the mixing machine, which may determine effective use of the mixing machine.

The remaining content of section 51.3.3 of this Code is applicable to concrete with light aggregates.

8.2.2 Transport and supply of concrete

8.2.2.1 Transport of concrete

If the SLC is transported by pumping the influence of the pump pressure must be considered on the increase in water absorption by light aggregates and also the corresponding decrease when it ceases. In the first case, a loss of workability will arise and in the second case an excess water/cement ratio. In the first example, this will make the concrete difficult to place and, fundamentally, it's pumping operation and in the second case, a loss of strength will arise in the affected concrete and also a loss of compactness in internal structures. A change must therefore be made in the dose as a consequence.

The corresponding previous test on SLC after pumping constitutes the concrete validation procedure.

Transport in a concrete mixing truck makes it possible to correct the tendency for a drop in workability that arises in all cases during transport and also the tendency for light aggregates to segregate during the transport of more workable concretes by means of mixing before pouring.

The remaining content of section 51.4.1 of this Code is applicable to concrete with light aggregates.

8.2.3 Placing of concrete

8.2.3.1 Compaction of concrete

Compacting of SLC requires higher vibration energy than that required for normal concrete. As a consequence, compacting is carried out by reducing separation between consecutive vibrator conditions to 70% of that used for normal structural concrete.

The tendency for light aggregate to float grows with excessive vibration. The surface coating of the face wher the concrete is placed shall be produced by appropriate implements used to press the light aggregate and add it to the mixture so that it is covered by the grouting.

Annex 9

Recommendations for use of structural shotcrete

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1. INTRODUCTION

The projection is a concrete laying technique that combines, in a single action, the stages of placement and compaction, which is achieved by the projection of materials at high speed on a support by two systems: wet mix and dry mix. Although elements well executed by both systems may have structural responsibility, due to issues of quality of the work environment (especially in closed environments) and reduction of consumption of materials, the use of the wet mix is recommended. Although the present annex focuses on the last one, the design considerations included here also apply to elements executed by the dry mix, provided that measures are taken to ensure the water/cement ratio of the concrete and that compliance with the durability benefits required.

During wet execution, the fresh concrete is propelled to the spray nozzle by a pump system. In the nozzle, which supposes a strangulation of the pipe, air is added under pressure and, if necessary, additives before the material is projected onto the support. In this process two phenomena occur that have an impact on the resistant properties of the placed concrete: the rebound and the introduction of air into the mixture.

In order to establish production and control guidelines that are compatible with the specificities of the technique, it is necessary to distinguish between the terms starting concrete and shotcrete. The first one refers to the concrete supplied in the fresh state for the pumping and projection process, but which has not yet been submitted to said process. The second refers to the concrete placed after the pumping and projection process, which should resist the stresses of the structure and is influenced both by the rebound and by a greater porosity.

Due to the differences that may exist during the execution, it is necessary to distinguish between the shotcrete in the final structure and the shotcrete on the standardized trough in order to perform the quality control of the material.

In this annex, the complements to the various articles of this Code are detailed, necessary to be able to consider the structural application of the shotcrete.

2. SCOPE OF SPECIFIC APPLICATION RELATIVE TO CONCRETE STRUCTURES

The recommendations included in this annex are applicable to all structures and structural concrete elements that are indicated in this Code.

3. TECHNOLOGICAL PROPERTIES OF THE MATERIALS

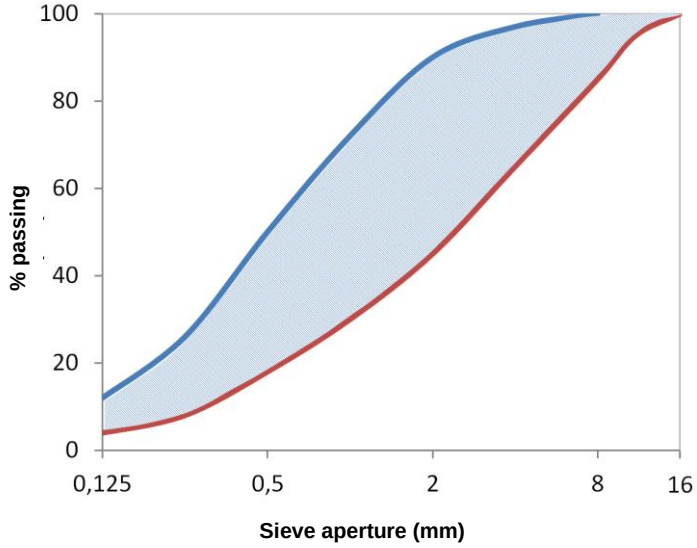
The main constituents of the shotcrete are cement, aggregates, water, additions and additives. For certain applications, the shotcrete may be reinforced with fibers or steel reinforcements. The general specifications of the materials are those indicated in this Code.

3.1 Cement

Type I or type II / A cements can be used in shotcrete. The use of type II / B or type III cements is also allowed, provided that the recommendations of Annex 6 are complied with and the viability from the point of view of their behaviour and safety is demonstrated by real-scale tests. It is necessary that the cement has good compatibility with the additives used to obtain a fast setting, promoting a rapid evolution of the initial resistance.

3.2 Aggregates

The workability, pumpability and properties in the hardened state of the shotcrete depend on the mineralogical composition and the granulometry of the aggregates. The maximum size of the aggregate should be less or equal than 12 mm. The granulometric distribution shall be within the spindle indicated in Figure A9.3.2.



Aperture (mm)	% passing through sieve
16	100
12	95 – 100
8	85 – 100
4	65 – 100
2	45 – 90
1	30 – 72
0,50	18 – 50
0,25	8 – 26
0,125	4 – 12

Figure A9.3.2 – Granulometry distribution of aggregate.

3.3 Additives

The main additives used in shotcrete are plasticizers / superplasticizers, setting stabilizers and setting accelerators. The combination of additives in the same shotcrete is allowed as long as they are compatible with each other and shall have CE marking in accordance with the UNE-EN 934-2 standard.

According to its chemical composition, the setting accelerators may be of three types: alkaline, either based on aluminates or on sodium silicates, or alkali-free, whose main compound is aluminium sulphate. In Table A9.3.3, the characteristics of the same are presented.

Table A9.3.3 – Accelerating setting additives.

Property	Alkaline (aluminates)	Alkaline (silicates)	Alkali-free
Dosing range (% on cement mass)	3 – 7	12 – 15	4 – 8
pH	13 – 14	12 – 13	2,5 – 6
Na_2O equivalent content (%)	19 – 20	8 – 10	< 1

The use of all types of accelerating setting additives indicated in Table A9.3.3 is allowed. For reasons of durability, resistance capacity and material consumption, elements with characteristic strength equal to or greater than 35 N/mm² that require the use of setting accelerators, shall be executed with alkali-free accelerators. They are also indicated for health and safety reasons, because, due to their pH around 3, the formation of alkaline mists and aerosols in the application environment is reduced and, therefore, the risk of damage to the skin, mucous membranes and eyes. In addition, these accelerators do not increase the amount of soluble ions in the concrete, which reduces the risk of efflorescence and alkali-aggregate reactions.

The optimum dosage of the accelerator and its compatibility with the other additives or the cement should be determined by previous tests. In the absence of another reference, the test procedure and the criteria described in section 7.2.3.7 of this annex shall be used, in addition to the subsequent real scale checks.

The self-curing additives may be used when the curing process by other methods is difficult to perform. Air-entraining additives may also be used in the starting concrete in order to facilitate the pumping process. This practice is especially interesting when the projection of mixtures with low consistency and without accelerators is carried out.

3.4 Additions

In the shotcrete the additions are used, replacing a part of the cement content, to improve some of its properties, such as workability, water retention, and density, strength and durability increase. Whenever viable, preference shall be given to the incorporation of silica fume for the consequent benefits obtained in terms of ease of pumping, durability and long-term resistance.

3.5 Concretes

In order to specify and classify the material, the differences between the original concrete and the shotcrete shall be taken into account. The first shall be the responsibility of the supplier of the concrete, while the second shall be the responsibility of the constructor in charge of executing the structure. For control purposes, when there is no specification in this regard, it shall be understood that the change of responsibilities occurs immediately before the entry of the starting concrete into the hopper of the projection equipment.

The specification and the typification of the concrete established in the project shall refer to the concrete already placed, being the responsibility of the constructor to ensure that

they are fulfilled. The supplier of the starting concrete shall not be responsible for the material placed, as long as it complies with the specifications defined for the starting concrete in the pre-validation stage or according to the constructor.

Once the dosage has been adjusted and the projection process has been checked, the supplier should inform the manufacturer beforehand of any change in the materials or the composition of the starting concrete. The lack of such prior information by the supplier of the concrete shall imply the assumption of responsibility for the incidents assessed after the execution and as a result of said changes.

The information of the change should be done from the first moment that occurs, communicating to the work management and reflected in the delivery notes.

3.5.1 Composition

The final composition of the shotcrete, close to the initial one, presents some differences introduced by the incorporation of compressed air, by the use of setting accelerators in the event that they are used and by the rebound. For a satisfactory pipeline transport, and projection it is recommended that the total fines content of the starting concrete passing through the UNE 0.063 sieve (including those from aggregate, cement and additions) be between 500 and 550 kg / m3. The builder shall take additional measures to ensure that the bounce does not exceed 15% on vertical surfaces and 20% on the roof.

Any structural fibre may be used in shotcrete, the most common being steel and polymer. The steel fibres should have CE marking in accordance with the UNE-EN 14889-1 standard and the polymeric according to the UNE-EN 14889-2 standard. The length of the fibres is determined by the diameters of the transport pipes and the projection nozzle, as well as by the maximum size of the aggregate and the possible formation of urchins. Lengths of 30 to 40 mm are usual, in the case of steel fibres and less than 65 mm in the case of polymer fibres, due to their greater flexibility.

3.5.2 Workability of concrete

The consistency of the starting concrete is conditioned by the pumpability requirements of the fresh material. This consistency may be assessed through the slump in the cone of Abrams in accordance with UNE-EN 12350-2 or by the extension of flow in the shaking table according to UNE-EN 12350-5. Whenever possible, preference shall be given to the realization of this last test due to its greater ability to discriminate variations that may affect the pumping and projection process.

The consistency ranges for each test are presented in table A9.3.5.2. The shotcretes without setting accelerators shall preferably have consistency S2, S3, E1, E2 or E3. Furthermore, shotcretes with setting accelerators shall preferably be of type S4, S5, E3 or E4. The observance of these ranges does not guarantee compliance with the pumpability conditions required for fresh concrete, which is why pre-tests should be carried out on site.

Table A9.3.5.2 – Consistency classes.

Test	Class	Range
Slump UNE-EN 12350-2	S1	between 10 mm and 40 mm
	S2	between 50 mm and 90 mm
	S3	between 100 mm and 150 mm
	S4	between 160 mm and 210 mm
	S5	higher than 220 mm
Flow extension UNE-EN 12350-5	E1	between 500 mm and 540 mm
	E2	between 550 mm and 590 mm
	E3	between 600 mm and 640 mm
	E4	between 650 mm and 700 mm

3.5.3 Identification of concretes

3.5.3.1 Starting concrete

The designation of the starting concrete may be done both by dosage and by properties. In the first case, the identification shall be done according to the following format:

T - D – G / f / CF / C / TM-TF / A

where:

- T Symbol which shall be HB for the starting concrete without fibre and HBF for the starting concrete with fibres.
- D Indicative of concrete specified by dosage.
- *f* In the case of using fibers, indicative of the type of fibers, which will be A in the case of steel fibers, P in the case of polymeric fibers and V in the case of glass fibers
- G It is the content of cement, in kg per m³ of concrete.
- CF It is the fibre content, in kg (up to the first decimal precision) per m³ of concrete.
- C It is the kind of consistency of the concrete according to the type of reference test selected
- TM Maximum aggregate size in mm, defined in section 30.3.
- TF In the case of using fibres, maximum fibre length, in mm.
- A Designation of the environment, according to the section 27.1.

It shall also include a table with the composition of the dosage, which shall indicate the materials used, as well as their respective quantities in kg per m³ of concrete.

In the case of designation of the starting concrete for properties, the same identification shall be used, changing the meaning of the acronym T and of the acronym C. The first one shall be HB for the starting concrete without fibre and HBF for the starting concrete with fibres. The second corresponds to the consistency class according to the type of reference test selected, as indicated in table A9.3.5.2 of this annex.

3.5.3.2. Shotcrete

The concretes projected and already placed on the surface shall be identified in accordance with the following format (which should be reflected in the project plans and in the Specific Technical Specifications of the project):

T – R / J / (f-R1-R3) / TM-TF / A

where:

- *T* Indicative that will be HMP in the case of mass shotcrete, HAP in the case of reinforced shotcrete, HPP in the case of prestressed shotcrete and HRP in the case of reinforced shotcrete with fibres only and projected. In the case that the reinforced shotcrete or the prestressed shotcrete shall also carry fibres, HAPF or HPPF shall be used respectively.
- *R* Specific characteristic resistance to compression, in N / mm² and referred to concrete once projected on the surface
- *J* Resistant class at a young age, established in accordance with section 7.2.3.2 of this annex.
- *f* In the case of using fibres, indicative of the type of fibres which shall be A in the case of steel fibres, P in the case of polymer fibres and V in the case of glass fibres.
- *R1,R3* In the case of using fibres, residual specific characteristic resistance to flexural stresses $f_{R,1,k}$ *and* $f_{R,3,k}$, in N / mm² and related to the concrete once projected on the surface or equivalent values obtained in an alternative test, such as indicates section 7.2.3.3 of this annex.
- *TM* Maximum aggregate size in mm, defined in section 30.3
- TF In the case of using fibres, maximum length of the fibre, in mm.
- *A* Designation of the environment, according to the section 27.1.

4. DURABILITY OF CONCRETE STRUCTURES

4.1 Nominal covering

In the case of reinforced or prestressed shotcrete, the minimum coverings defined in

the Code should be increased by:

10 mm	environments XD, XS y XA
5 mm	rest of environments.

This increase is due to the possible higher surface porosity of the concrete.

In the case of reinforced shotcrete with fibres, no covering condition is imposed. Guidelines other than those specified in this recommendation may be used when testing the behaviour of the material through specific tests.

4.2 Concrete carbonation

In shotcrete elements, the value of the falling coefficient c_{air} of table A12.3.1.b, in absence of more information, should be taken equal to 0.7.

5. DIMENSIONING AND CHECKING

For the structural analysis, dimensioning and checking of the shotcrete structures, the project author shall use annexes 19 and 21, depending on the case.

The incorporation of air into the mixture and the modification of the granular structure due to the differential rebound lead to a slight variation in the density and in the mechanical properties of the shotcrete in comparison with the initial one before the projection. This affects the equations used to estimate the mechanical properties and constituent diagrams included in the Code. All the properties related to the shotcrete shall be indicated in the present annex with the same symbols included in the Code for conventional concrete, adding the subscript "p".

5.1. Characteristic values of permanent actions

As a consequence of the on-site work system, the density of the shotcrete is usually lower than that of conventional concrete. For that reason, to calculate the weight of the structure itself, it is recommended to take the following defined densities according to the characteristic resistance of the shotcrete (f_{ckp}) after 28 days:

Shotcrete in bulk or with structural fibres

$f_{ckp} < 40$ N/mm^2	2.250 kg/m^3
$f_{ckp} \geq 40$ N/mm^2	2.300 kg/m^3

In the case of reinforced or pre-stressed shotcrete, 100 kg/m3 shall be added to the values indicated above.

5.2. Modulus of elasticity

The modulus of longitudinal secant elasticity of the shotcrete ($E_{cmp,j}$) at age j in N/mm^2,

is given by the equation:

$$E_{cmp,j} = \gamma_p \cdot \gamma_r \cdot 9500 \cdot \sqrt[3]{f_{cmp,j}}$$

when:

- $f_{cmp,j}$ It is the average compressive strength estimated for the shotcrete at age *j*.
- γ_p It is the porosity coefficient given by equation 2.
- p_s It is the porosity of the shotcrete at the age of 28 days, in percentage expressed as a decimal.
- γ_r It is the rebound coefficient calculated by equation 3.
- r It is the rebound of material when shotcrete is projected, in percentage expressed as a decimal.

$$\gamma_p = \frac{1-p_s}{0{,}92}$$

$$\gamma_r = 1 - r$$

This formulation is valid as long as the voltages, under service conditions, do not exceed the value of *0,40 $f_{cmp,j}$*. In these equations, the porosity of the shotcrete should be between 8% and 18%, while the rebound of the material during the projection should be between 5% and 15%. In the absence of data regarding porosity and rebound, the value of 0.76 may be adopted for the product $\gamma_p \cdot \gamma_r$.

Longitudinal modulus of elasticity of concrete has a marked dependence on the type of aggregate with which the concrete has been manufactured. The proposed expressions correspond to concretes manufactured with dense limestone aggregates. The same correction factors established in annexes 19 and 21 may be applied to these equations in the case of having aggregates of other natures.

If it is desired to obtain more precisely the value of the module for the specific type of aggregate to be used, experimental tests should be carried out to adapt the proposed expressions with correction coefficients depending on the nature of the aggregate. As with conventional concrete, these checks should also be carried out in those structures in which the deformations and their control are especially important, either because of their magnitude (as in the case of very stable structures) or because of their influence on the efforts and behaviour of the structure itself (as in the case of evolutionary or phased constructions).

5.3. Design tensile strength.

The mean tensile strength or characteristic and flexural strength of the shotcrete may be estimated with the same equations and considerations proposed in the Code, multiplying the resulting value by the coefficient (η_p) that takes into account the variations in density with respect to conventional concrete. This coefficient shall be calculated according to the following equation.

$$\eta_p = 0{,}4 + 0{,}6 * \frac{\rho_p}{2.400}$$

where ρ_p is the dry density of the shotcrete in kg/m^3, which shall not be considered greater than 2,400.

5.4. Stress-strain diagram of design

For shotcretes it is recommended to use the parabola-rectangle or rectangular diagrams shown below, which contemplate the risk of progressive reduction of the maximum strain when the dry density of the shotcrete decreases.

a) Parabolic-rectangular design diagram:

The same diagram of the articulation may be used, multiplying the ultimate bending strain (ε_{cu2}) by η_p obtained in section 5.3 of this annex.

b) Rectangular diagram:

The rectangular diagram of the articles is applicable, with constant tension $\sigma_{cp} = \eta(x) \cdot f_{cdp}$ and height of the compressed block $y = \lambda(x) \cdot h$. However, the ultimate strain obtained according to the Code shall be multiplied by η_p. In addition, the factor λ_p for obtaining $\lambda(x)$ shall be defined by the equation:

$$\lambda_p = 0{,}937 \cdot \eta_p - 0{,}737$$

5.5. Strain envelopes

In the definition of the strain envelopes, the reduction of ultimate bending strain in the concrete should be taken into account, in accordance with the criterion established in section 5.4 of this annex.

5.6. Limit State of Failure due to shear

5.6.1. Obtaining V_{u1p}

The shear stress of oblique compression of the soul shall be obtained from the articles, reducing by the factor υ_p given by the equation that follows. In it, the characteristic compressive strength of shotcrete (f_{ckp}) in N/mm² shall be used.

$$\upsilon_p = 0{,}5 \cdot \eta_p \cdot \left(1 - \frac{f_{ckp}}{250}\right)$$

5.6.2. Obtaining V_{u2p}

5.6.2.1. Members without any shear reinforcement

The shear force by tensile in the soul it shall be obtained as:

$$V_{u2p} = \left[\frac{0,18}{\gamma_c}\eta_p\xi\left(100\rho_p f_{cvp}\right)^{1/3} + 0,15\alpha_p\sigma'_{cdp}\right] b_0 d \geq \left[0,35 f_{ctdp} + 0,15\alpha_p\sigma'_{cdp}\right] b_0 d$$

5.6.2.2. Members with shear reinforcement

Contribution of the concrete to shear strength is obtained as:

$$V_{cup} = \left[\frac{0,18}{\gamma_c}\eta_p\xi\left(100\rho_p f_{cvp}\right)^{1/3} + 0,15\alpha_p\sigma'_{cdp}\right] b_0 d \geq \left[0,35 f_{ctdp} + 0,15\alpha_p\sigma'_{cdp}\right] b_0 d$$

5.7. Limit State of Failure due to torsion in linear elements

5.7.1. Obtaining T_{u1p}

The ultimate torsional force by oblique compression of the core shall be obtained from the articles, reducing by the factor υ_p given in section 5.6.1 of this annex.

5.8. Punching Limit State

Maximum tension resistance in the critical perimeter, is obtained as:

$$\tau_{rdp} = \frac{0,18}{\gamma_c}\eta_p\xi\left(100\rho_p f_{cvp}\right)^{1/3} + 0,1\sigma'_{cdp} \geq 0,4 f_{ctdp} + 0,1\sigma'_{cdp}$$

5.9. Anchorage and splicing of reinforcement steels.

The bond between bars and ribbed wire with the shotcrete may reach values similar to those achieved with concretes placed by conventional methods. However, this is a parameter that is heavily influenced by the laying technique, the diameter of the bar, the reinforcement density, the composition of the concrete, the accelerant content and, especially, the experience and skill of the operator, which plays a key role when it comes to achieving good benefits. To determine the net anchorage length, the following coefficients are considered for the calculation of the bonding stress with the shotcrete:

$$\tau_{bdp} = 2,25\ \eta_1\eta_2\ f_{ctd}$$

f_{ctdp} Design tensile strength of shotcrete, calculated in accordance with section 5.3 of this annex. For calculation purposes, a value higher than that associated with a concrete with

a characteristic resistance of 60 N/mm^2 shall not be adopted.

η_1 Factor related to bonding quality and the position of the bar during concreting
$\eta_1 = \eta_p$ for single bar in a single assembly plane and good bonding
$\eta_1 = 0,7$ for any other case

η_2 Coefficient related to the diameter of the bar:
$\eta_2 = 1$ for bars of diameter Ø ≤ 16
$\eta_2 = (116-Ø)/100$ for bars of diameter Ø > 16

6. EXECUTION OF CONCRETE STRUCTURES

6.1. Placing and curing concrete

6.1.1. General prescriptions

In the placing concrete, a main factor is the support on which it is projected, in which, prior to the projection, preparatory work should be carried out and additional measures may be taken to ensure the required final features, whether bonding between layers or the finish of the layer. The substrate may be any supporting element capable of resisting the impact of the shotcrete and having sufficient rigidity so that the material can be applied correctly and bond well to the substrate without the latter moving or vibrating excessively.

The application area shall be cleaned with an air-water mixture. It may be wet but without free water before the application of concrete. Shotcrete should not be used on substrates with temperatures below 2 °C or on those exposed to strong winds and rains without taking special measures.

6.2. Manufacture of concrete

6.2.1. Cement

The minimum amount of cement per cubic meter of concrete shall be 1.15 times that established in section 43.2.1. This is to compensate, to some extent, the part of cement that is lost in the rebound, apart from facilitating aspects of putting into work. In case that the projection is carried out by dry mix, the necessary measures shall be taken to ensure that the amount of water added to the nozzle and the resulting water/cement ratio does not exceed the limits established in the Code at any time within the limits defined in the project and in the validation stage described in section 7.2 of this annex.

6.2.2. Additives

Accelerators shall be stored avoiding frost and contamination. Each machine for the projection by wet mix shall incorporate an integrated dosing pump to dispense liquid additives with a minimum precision of ± 5% of the required dosage.

6.3. Transport and supply of concrete

6.3.1. Transport of concrete

Depending on the application and the open time necessary for the transport and operation of projection, the use of setting stabilizing additives is frequent, so that the limitation of time in the articles is not applicable. In this case, the indications of the supplier of the additive regarding the maximum stabilization time should be considered.

6.3.2. Supply of concrete

With regard to the supply of the starting concrete, the considerations made in the articles rule, allowing the specification by composition. This should be taken into account in the control and management of the construction.

6.4. Pouring and placement of concrete

Before starting the projection, project manager should approve the equipment and the operator. When the work starts, the nozzle shall be directed in another direction to that of the works until the mixture is correctly adjusted. Also, in case that during the projection the flow was intermittent, the operator should perform the same operation until said flow becomes constant again. Therefore, it is recommended to adequately protect the areas adjacent to the work to avoid splashes, stains and bounces.

Each shotcrete layer shall be carried out through several passes of the nozzle in the work area, using good practices and nozzle manipulation. Each pass is made with a trajectory in the form of an ellipse that moves in space, that is, it is not necessary to concentrate the projection in a point. The concrete shall leave the nozzle in a constant and uninterrupted flow, maintaining a distance to the support (between 0.5 and 1.5 m depending on the projection system and the equipment used) and an appropriate angle (close to 90º with respect to the substratum). When projecting behind the reinforcement the nozzle will remain close to the substrate and at an angle that ensures that the reinforcement is completely wrapped, preventing the rebound from accumulating behind it.

For vertical or almost vertical surfaces, the projection should start from the bottom. In areas where thick layers are applied, the upper surface shall maintain a slope of approximately 45º. For curved or vaulted upper surfaces, the concrete should preferably be projected from the sides to the top.

Sufficient time shall be respected for the concrete of one layer to set before applying the next. To obtain the prescribed concrete thickness it is preferable, from the technical point of view, to make several passes forming thin layers, although from the point of view of performance this process is not satisfactory, so it shall be necessary to find a balance in the work site itself.

The constructor shall ensure the projection of a layer with the minimum thickness established in the project. To simplify the thickness control, wherever possible, reference separators shall be installed at different points on the surface on which concrete is to be projected. The operator that controls the nozzle should cover the surface with material until the separators are not visible, seeking to generate a thickness as uniform as possible. All bounce material shall be removed from the work area and shall not be used for projection work. The elimination of the rebound shall be done with due respect to the risks of environmental pollution.

The projection machine and the auxiliary equipment shall have an adequate capacity for the applied volumes. In addition, the equipment shall be leak proof with respect to all materials, maintaining correct operation for the duration of work on the site. The projection equipment shall be able to feed the materials at an approximately constant rate and eject the shotcrete mixtures from the nozzle at speeds that allow adherence to the surface with minimal rebound and maximum adhesion and density.

The equipment shall be thoroughly cleaned at least once per work shift, or at shorter time intervals if additives are used to control hydration, to prevent waste accumulation.

Flexible or rigid hoses should follow a straight line or smooth curves. They shall also have a uniform diameter suitable for the mixture and the characteristics of the fibre (in the case of shotcrete with fibres) determined in the on-site tests, avoiding any dent or twist.

The equipment for wet mix projection shall be configured in accordance with the manufacturer's recommendations. The nozzle shall be designed for the addition of pressurized air to obtain speed and high compaction of the concrete. In the cases that are required, the nozzle shall present an entry for the incorporation of accelerating setting additives. Preferably, these additives should be mixed with the compressed air in the nozzle before being incorporated into the concrete. The nozzle should be long enough to take advantage of the pressure generated by the compressed air. The air for the equipment should be clean, dry and free of oil. The equipment shall be continuously supplied at a pressure no lower than the operating pressure and at the volume ratios specified by the manufacturer.

6.5. Projection for repair work.

For repair work in concrete, the requirements specified in the previous sections shall apply. In addition, the recommendations indicated below should be followed.

- Before starting the repair work, a test shall be carried out on an area of the surface to verify the quality of the surface and that the reinforcement is properly embedded.
- The concrete shall be applied up to the level of the adjacent concrete or until it meets the specified covering. If necessary, formwork shall be used to obtain the original form.
- If the space between reinforcing steel is less than 50 mm, special measures shall be taken, such as reducing the concrete coming out of the nozzle and reducing the distance between the nozzle and the substrate.

6.6. Execution of concrete in special climatic conditions

6.6.1. Concreting in cold weather.

The shotcrete shall be protected from sporadic frost until it has reached a compressive strength of at least 5 N/mm². If the freezing occurs cyclically at short ages, additional measures shall be taken to avoid affecting the durability of the placed material.

Before and during the execution of elements with the threat of collapse, the concrete that is projected should have a temperature of at least 10 ºC. In case that the temperature affects the behaviour of the material and the work, additional measures should be taken in the production center to increase the temperature of the starting concrete, either by using hot water, or by protecting the aggregates from frost, among other measures. In addition, the temperature of the air used for the projection should be taken into account, as well as that of the setting activating additives.

6.7. Curing of concrete

In the shotcrete, apart from the usual curing methods, internal curing additives may be used. If the curing agents are applied in areas where there shall be projection of more layers of concrete, tests shall be carried out to check the adhesion between layers. For this, the approved mixtures and work methods shall be used before using said agents in the work site.

The curing shall preferably begin during the 20 minutes following the end of each projection operation if accelerating setting additives are used and during the next one hour when such additives are not used. Curing shall be continuous for at least 7 days.

6.8. Post-concreting processes

6.8.1. Formwork removal, uncasing and removal of falsework

Given the very fast speed of resistance development of these concretes, the formwork removal, uncasing or removal of falsework times may be reduced. The period given in the comments of section 53.2 is only indicative as a value of maximums, being more representative the time in which the set of the structural element is stable and everything is projected.

6.8.2. Surface finishing

Use of accelerating additives make difficult any subsequent action of finishing on the concrete surface. Consequently, it should be studied in detail (even with previous experiences) about what should be the additive and the accelerant dosage to achieve the required finish.

Unless otherwise specified, finishing actions such as surface flush applied directly to the shotcrete layer shall be avoided. In case that a treatment by contact is required, this shall be done using trowels. No surface treatment shall take place until the previous layer has reached adequate strength. Immediately after finishing the final layer, a curing agent or other method shall be applied to protect the drying surface. Where a subsequent coating is necessary, the curing membranes shall be removed before application.

In the case of accumulations of aggregates, gravel nests or other defects, they should be eliminated. The area of the new projection shall not be less than 300 x 300 mm.

7. MANAGEMENT OF THE QUALITY OF THE PRODUCTS

7.1. Specific criteria for product control

7.1.1. Specific criteria for checking the conformity of products

The specifications for all materials shall comply with the provisions of Articles 28 to 33 of the Structural Code and the specific technical specifications. In the case of using fibres, the specifications established in Annex 7 shall also be followed.

7.1.2. Additives

In the case that setting accelerators are used, before beginning the work, the effect thereof shall be verified from tests with the cement used, as well as the rest of additives for the manufacture of the starting concrete. As a consequence of the above, the brands, types and dosing of the accelerators shall be selected in the work. The continuity of its composition and characteristics shall be guaranteed by the corresponding manufacturer.

During the execution of the work, it shall be ensured that the setting accelerators are approved according to the previous paragraph. The project manager, when it considers it necessary in the execution of the work, may require the verification of the required conditions to the setting accelerators. The dosage of validation of the setting accelerators shall be that which allows an adequate execution into work, as well as the correct development of mechanical resistances at all ages according to the concrete specification.

Failure to comply with any of the specifications shall be sufficient condition to qualify the accelerators as unsuitable for concrete. Any possible modification of the brand, type or dosage that shall be used, compared to what was accepted in the tests prior to the start of the work, shall imply its non-use, until after carrying out new validation tests the project manager authorize its acceptance and use in the work.

7.2. Control of the concrete

The characterization of the properties of the material may be carried out at three levels: on the starting concrete, on the concrete already projected in standardized troughs and on the concrete projected in the structure itself. When the extraction of the control or the execution of the test does not pose a risk to the person who executes it and does not cause unacceptable structural or aesthetic damage, the characterization may be carried out in the structure itself, and it is not necessary to repeat it in the trough. Otherwise, it shall be considered that the results derived from the characterization of the projected troughs are representative of the structure itself, although there may be differences that should be evaluated if incidents or non-conformities occur.

As regard to the control of concrete, it is necessary to distinguish two stages with different purposes: the previous validation and the systematic control. In the first of them, made before the start of the execution of the structure, the evaluation of the behaviour of the concrete and the verification of its conformity with the requirements established in the project shall be carried out. The equipment used in the tests shall be the same as the one used in the work and the materials shall be representative of those that shall be used. The projection shall be carried out by the operators in charge of carrying out the projection on work site, who should demonstrate their competence and ability to produce shotcrete, complying at all times with these recommendations. With the test mixture, sufficient panels of at least 1,000 x 1,000 mm shall be prepared for projection by robot and 600 x 600 mm for manual projection, following what is described in standard UNE-EN 14488-1, which shall be properly characterized. The age of extraction of the sample, the age of the test and the procedure of conservation and curing adopted in this stage shall be the same as those used during the execution of the work.

The procedure described in the previous paragraph shall be repeated taking into account the maximum and minimum values foreseen for the dosing of the accelerant and for the projection parameters (pressure of the pumps and compressed air) during the work. In this sense, it should be verified that the concretes obtained in these extreme situations meet the project requirements. Likewise, the characterization of the starting concrete used in the tests shall be carried out, in order to establish the requirements that the person responsible for the supply of the same should respect during the execution. As a final result of this stage, a validation report shall be prepared, which shall include the description of the validated dosages, the reference projection parameters, the results obtained and the criteria for the acceptance of the concretes.

In the second stage, carried out during the execution of the work, the systematic check of the requirements from the point of view of behaviour and durability established in the design and derived from the previous stage shall be carried out. Said verification shall be carried out both in the starting concrete and in the concrete already placed. It is important to ensure that the material object of the control tests is as representative as possible of the material found in the structure. For this reason, the characterization tests of the concrete already placed shall be carried out on a surface executed with a dosage of accelerant that is representative of the batch.

7.2.1. General criteria for the control of the conformity of a concrete

The criteria for the control of the starting concrete are the same established in the Code. The control of the quality of the shotcrete shall include, in addition to the control specified in the Code, that of its resistance at very young ages.

7.2.2. Sampling

In case that the classification of the starting concrete is carried out by properties, the taking of samples prior to the projection process shall be carried out as established in the Code. In case of shotcrete, the samples shall be obtained from panels previously projected in the same work following the procedure described in standard UNE-EN 14488-1 or in samples taken from the same concrete placed on site, which shall result in most representative results. The location of the point to be characterized in the structure should be proposed by the

contractor and approved by the project manager, being the accelerator dosage used in the projection of that representative point of the lot.

The extraction of samples from the projected panels or from the structure itself shall be carried out when the shotcrete has reached an average compressive strength of at least 15 N / mm², estimated in cylindrical samples. All samples taken shall be carved and prepared before the tests, and shall be referenced appropriately, marking the date and time of the projection. The curing and the conservation of the samples shall be carried out in a manner analogous to that applied on site. To ensure traceability, it is advisable to check the original concrete and the shotcrete on the same supply lots.

7.2.3. Testing

The main tests carried out are presented in Table A9.7.2.3, which may be informative or characteristic. The first ones provide basic information about the material or about the compatibility of some of its components, while the second ones are mandatory checks for the acceptance of the starting concrete or shotcrete. The project manager may incorporate other tests to those already indicated, as well as establish the obligatory nature of informative tests for the acceptance of the material.

Table A9.7.2.3 – Test classification. Tests detailed in sections in parentheses.

Type	Tests
Informative	Modified Vicat (7.2.3.7)
	Modulus Elasticity (7.2.3.4)
	Content of fibre (7.2.3.5)
Characteristic	Workability (7.2.3.1)
	Compressive strength (7.2.3.2)
	Residual flexural strength 1 (7.2.3.3)
	Projected thickness check (7.2.3.6)

Note 1: This test shall be considered mandatory only in reinforced concretes with fibres with structural responsibility.

Another relevant aspect in structural members of shotcrete is the definition of the moment in which the characterization is carried out. Given the importance of the evolution of resistance at a young age in the stability of the shotcrete member, it is recommended to carry out tests to directly or indirectly estimate the evolution of properties during the first 24 hours. Likewise, in order to obtain more reliable and representative results, it is recommended that the age of characterization of the mechanical properties be close to the moment in which the stresses in the structure should occur or there is a risk of instability. In general, if there is no different specification in the specifications or due to limitations of the test procedure, the 28-day reference age is defined as the reference age for the calculation of characteristic values.

In case the components of the starting concrete vary or there is a change in the process

of the work, it shall be necessary to experimentally verify their suitability before continuing with the execution of the work.

7.2.3.1. Tests of workability of concrete

The workability of the starting concrete shall be verified by determining the consistency of the fresh concrete by the slump-test in the Abrams cone in accordance with the UNE-EN 12350-2 standard or by the extension of flow in the shaking table in accordance with the UNE-EN 12350-5 standard. Preference shall be given to the realization of this last test because of its greater ability to discriminate variations that can affect the pumping and projection process, especially when fibre concrete is used. Unless specified otherwise, the verification of the workability of the concrete shall be carried out just before pouring into the hopper of the projection equipment.

7.2.3.2.Tests on the strength of the concrete

The evaluation of the strength up to 24 hours shall be carried out in accordance with the standard UNE-EN 14488-2, or through the penetration test (used until the concrete acquires a resistance equal to 1.0 N/mm²), or by the nail gun method (which is used to estimate the resistance up to 20.0 N/mm²).

Depending on the early evolution of the strength measured with the tests up to 24 hours, the shotcrete shall be classified as type J1, J2 or J3, according to figure A9.7.2.3.2. Class J1 concretes shall have an evolution of resistance between curves A and B, while those of class J2 shall have an evolution between curves B and C. Concrete J3 should have a strength higher than that indicated in curve C.

The compressive strength of shotcrete when the material already has a minimum resistance of 15 N / mm² is estimated according to the UNE-EN 123090-3 standard through the test of samples. The samples may be cubic or cylindrical, and the height/diameter ratio (h/d) must be equal to 1.0 for cubic samples and 2.0 for cylindrical samples. The use of different sample forms and different h/d ratios requires the use of conversion factors to compare the experimental results of compressive strength. It is recommended to establish a single form of the samples and to adapt the preparation of the samples so that the desired h/d ratio is maintained.

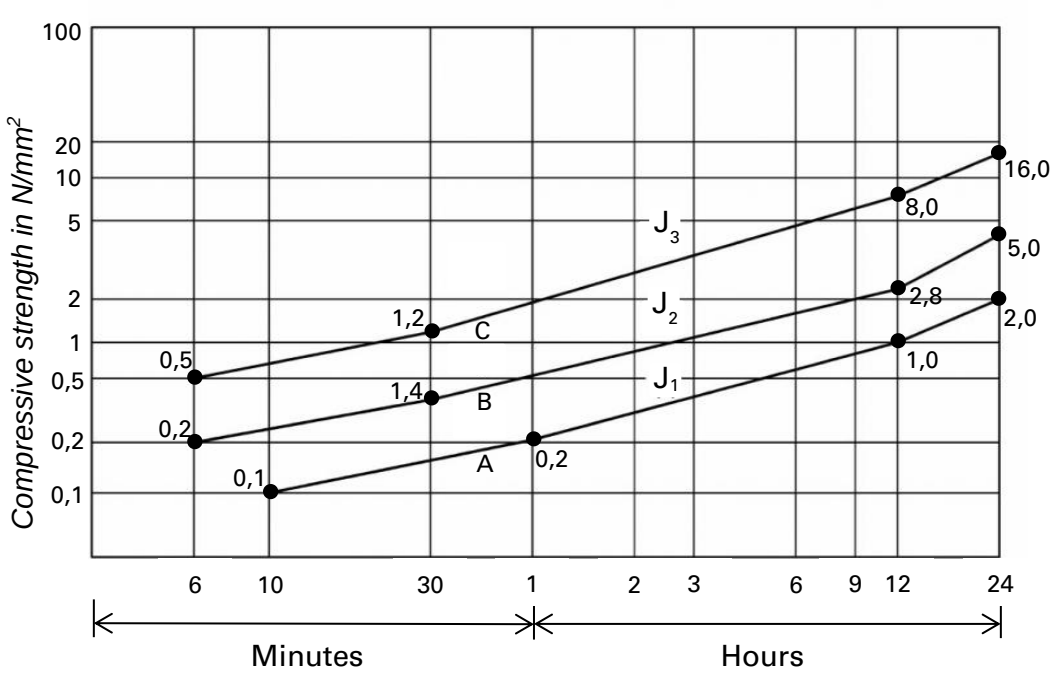


Figure A9.7.2.3.2 – Strength evolution requirements at a very young age

7.2.3.3. Bending strength and residual strength.

Often the shotcrete is subjected to bending stresses in service. Bending strength is an indirect measure of the tensile strength of concrete and is made on cut joists or panels obtained after projection. Likewise, the estimation of the residual strength of the shotcrete with fibres is mandatory when they have a structural responsibility. For this purpose, the flexural test should be used according to the UNE-EN 14651 standard, which allows to estimate the residual strength required for the design in the limit state of service and ultimate limit state. In this sense, the results obtained in the test of three points made in prisms of 150 x 150 x 600 mm with notch shall be taken as a reference.

Due to the characteristics of the production process, said test is not easy to apply for the systematic control of shotcrete with fibres. For that reason, alternative tests may be used. The determination of the equivalent residual values between the bending test according to the UNE-EN 14651 standard and the chosen alternative test shall be carried out by means of an experimental check prior to execution, as indicated in Annex 7.

In this check, panels of the same projection shall be produced for the extraction of the samples for both tests. In order to do it, panels that have at least 3.5 times the volume of the samples shall be used, avoiding extraction in areas affected by bouncing or edge effects. The projected thickness shall be sufficient to satisfy the minimum height of the sample required for each test. The samples shall be carved to regularize the faces of the specimens and eliminate the roughness of the projected surface. The age of extraction of the samples of the panels, the ages of testing and the procedures of conservation and curing shall be the same employees later in the stage of quality control. The results obtained for openings of analogous fissure for

both tests shall be used to estimate the equivalent residual loads, which shall be the reference for the systematic control of residual strength by the alternative test.

To simplify the extraction, characterization and systematic control, it is recommended that the residual strength is estimated indirectly by means of the Barcelona Method, described in standard UNE 83515. The openings of analogous fissures between said test and the flexural fraction shall be those defined in Annex 7. The procedure for defining equivalence of residual strength described above may also be used to estimate the tenacity of the material.

The estimation of the energy absorption capacity of flat cylinders reinforced with fibres shall be carried out according to the UNE-EN 14488-5 standard.

7.2.3.4. Modulus of elasticity

The estimate of the modulus of elasticity shall be made with samples according to the UNE-EN 83316 standard.

7.2.3.5. Fibre content

The fast evolution of the mechanical properties of shotcrete with setting accelerators makes it difficult to quantify the fibre content by traditional methods. The determination of said content shall be carried out in accordance with the provisions of the UNE 83607 standard. In the case of using metallic fibres, the use of the method described by the UNE-EN 14721 standard is recommended, which estimates the fibre content through an inductive method.

7.2.3.6. Tests to check the projected thickness

The verification of the projected thickness after the execution of the structure is mandatory and shall be carried out with topographical or equivalent methods. Said check shall be carried out in representative points distributed uniformly throughout the surface.

7.2.3.7. Modified Vicat test

As an indirect way to check the required dosing of the setting accelerator or the compatibility between the setting accelerators and the other selected additives and cement, the modified Vicat test shall be used, using the same equipment described in the UNE-EN 196-3 standard for the determination of the setting time. To carry out the test, the materials and equipment should be at the same temperature as the work site during the application of the material.

The test consists of actively mixing 300 g of cement with 84 g of water for 30 seconds until a homogeneous paste is obtained. Then, add the plasticizers / superplasticizers or retardants, mixing actively for 90 seconds. Then let it sit for 30 seconds and mix again for 90 seconds. Once that time is over, the setting accelerator is added quickly, continuously and distributed over the material while mixing vigorously for 15 seconds. The mixture is introduced into the standardized conical mold standard UNE-EN 196-3 supported on a base plate and, in less than 30 seconds from the mixture with the accelerator, the first reading is made. All the

measurements are carried out with the needle used to determine the start of setting, which is put in contact with the upper part of the sample and dropped on it.

The initial setting time is considered as the time when the needle stops touching the base plate. The final setting time is considered as that in which the needle penetrates less than 1 mm into the sample. Both are measured taking as reference the start of the addition of the setting accelerator. The test shall be repeated at least three times maintaining the same mixture composition and the average times obtained in the three measurements shall be used. Table A9.7.2.3.7 presents an approximate classification of the results.

Table A9.7.2.3.7 – Classification of the results of the Modified Vicat Test.

Setting	**Acceptable**	**Very good**
Star	$\leq$ 5 min	$\leq$ 2 min
End	$\leq$ 10 min	$\leq$ 5 min

In order to facilitate comparison of the efficiency of different accelerators, the times obtained may be compared for the same dosage previously defined according to the requirements of the design. Alternatively, the minimum required dosage of each accelerant may also be determined to achieve a behaviour considered acceptable or very good.

For applications with high risk of detachment of the projected material or in which strength is required at very young ages, it is recommended to look for the composition or dosage that confers a behaviour classified as Very Good. In contrast, applications in which there is no high risk of detachment may be executed with compositions or dosages that exhibit a behaviour classified as Acceptable. The execution of the modified Vicat test does not exempt the constructor from carrying out real-scale tests to confirm the compatibility and the results obtained.

Annex 10
Concretes for non-structural use

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1. Scope

This Code lay down specific regulations for Structural Mass Concrete (HM), Structural Reinforced Concrete (HA) and Structural Prestressed Concrete (HP). This Annex also defines the scope and specifications to which concretes for non structural use are subject.

- Blinding Concrete (HL): The purpose of this concrete is to prevent structural concrete drying during pouring and also possible contamination during the first hours of concreting.

This annex does not include concrete that has the purpose of configuring resistant material volumes. Examples include concretes for sidewalks, concretes for borders and concretes for filling.

2. Materials

2.1 Usable cements

The cements usable for these concrete types are common cements that comply with the current Cement Reception Instruction.

2.2 Aggregates

For the manufacture of concrete for non-structural use, rolled sands and gravels or sands and gravels from crushed rocks or appropriate steel industry slag may be used.

Up to 100% of recycled coarse aggregate may be used for the manufacture of non-structural cement, provided it complies with the specific classifications laid down in section 30.8 of this Code.

If the affected performance of granulated slag from combustion in power stations has been demonstrated in accordance with article 30 of this Code, they may be used as aggregates provided they comply with the specifications laid down in the section 30.9 for steelwork aggregates.

2.3 Admixtures

Concretes for non-structural use are characterised by their low cement content and it is therefore advisable to use water-reducing admixtures with the aim of reducing the porous structure of the concrete in its set state as far as possible.

2.4 Additions

Fly ash must have CE marking (subject to UNE-EN 450-1 standard) and the declaration of benefits (DdP) must meet the requirements established in section 32.1 of this Code.

In the case of fly ash co-combustion, the declaration of benefits must also meet the following requirements:

$(SiO_2+Al_2O_3+Fe_2O_3)$ (%) according to UNE-EN 196-2	≥ 70

Na_2O eq according to UNE-EN 196-2	≤ 5,0
MgO (%)according to UNE-EN 196-2	≤ 4,0
Content of reactive SiO_2 (%)	≤ 25
P_2O_5 (%) total according to ISO 2958-1	≤ 5
PO_4^{3-} soluble	≤100mg/Kg
Variation of the initial setting time (mixture 75/25) (min)	≤ 200 (1)

(1) The initial setting time of the 75/25 mixture (cement / fly ash) must not be more than twice the initial setting time of a paste made with 100% of the test cement.

The declaration of performance of the manufacturer shall indicate the initial setting time of the 75/25 mixture (mixture consisting of 75% of the test cement and 25% of fly ash), expressed in minutes.

The maximum number of additions, whether they are fly ash according to Article 32 of this Code, or co-combustion fly ash according to UNE-EN 450-1, shall not exceed 35% of the cement weight.

Ashes from different origins can not be used simultaneously in the same concrete.

Comments

The requirements established in this section will be determined in accordance with the standards set forth in the current standard UNE-EN 450-1 published in the Official Journal of the European Union (DOUE). Currently those standards are:

- UNE-EN 196-2:2005
- UNE-EN 196-2:2005
- UNE-EN 196-2:2005
- UNE-EN 197-2011
- ISO 29581-2:2010
- UNE-EN 450-1:2013

3. Characteristics of concretes for non-structural use (HL)

The only concrete usable for this application is designated as follows:

HL-150/C/TM

As indicated in the identification, the minimum cement dose shall be 150 kg/m^3.

It is advisable for the maximum aggregate size to be 30 mm with the aim of facilitating the workability of these concretes.

Annex 11

Preparation procedure by straightening of steel samples from coils, for mechanical characterisation

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4 PROCEDURE FOR THE PREPARATION OF SAMPLES BY STRAIGHTENING 4

1 Introduction

The purpose of this Annex is to lay down the conditions governing the preparation and straightening of samples extracted from supplies of corrugated steel coils which must be carried out prior to all of the mechanical characterisation tests set out in this Code.

2 Sampling

Samples shall be extracted directly from finished coils, ready for supply. Complete spires shall then be extracted from the coil.

Each time samples are taken, a total of three spires shall be obtained from each coil subject to inspection. From each spire, two equal samples shall be obtained, consisting of half spires.

From each spire, one of the samples (half spire) shall be used for the inspection laboratory tests and the other, duly identified with the corresponding seals, shall held in safekeeping by the manager of the facility at which sampling is carried out (steel fabrication plan, ironwork fabrication, construction site, etc.), where they shall be stored, without being deformed or handled, in order that they be accurate as re-test samples for a period of one month following the sampling date.

3 Equipment for the preparation of samples by straightening

The samples extracted from the coil shall undergo a straightening process using a suitable machine. This machine shall have a total of eight rollers of equal diameter (four drive rollers to move the steel along and four other free rollers), which may be manoeuvred into a vertical position in order to adjust the axis of the bar, and shall be staggered, as shown in Figure A11.3. Table A11.3 indicates the diameter of the rollers and the spacing between them.

Table A11.3. Geometric characteristics

Type of roller	Geometric characteristics			
	Roller diameter (mm)		Horizontal spacing between rollers (mm)	
	∅≤12	∅>12	∅≤12	∅>12
Drive or free	140 ± 2%	180 ± 2%	175 ± 2%	330 ± 2%

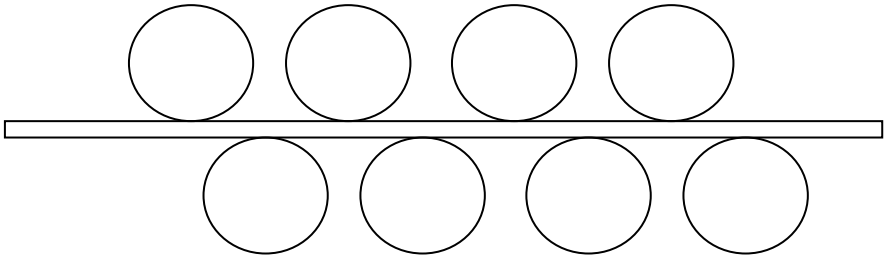


Figure A11.3. Layout of the rollers in the straightening machine

The straightening machine must keep a continuous record of the conditions under which the straightening is performed (position of the rollers, speed of the machine, etc.).

4 Procedure for the preparation of samples by straightening

Once the sample has been straightened, 35 cm shall be taken off each end. The effectiveness of the straightening shall then be checked, with any straightened half spires being rejected where, once the ends have been taken off, there is a greater than 5 mm/m deviation from straight alignment. The samples may then be cut for subsequent mechanical characterisation testing in accordance with the procedures laid down in this Code.

Annex 12

Estimation of the service life of concrete elements.

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1. Introduction

This annex, of informative nature, serves as an example of some of the models that the author of the project may use, under his responsibility and good judgment, for the estimation of the service life of the structures and / or concrete elements.

The purpose of this annex is to provide a tool to get the estimation of the residual service life of existing structures, as well as helping in the following cases:

- That the project author specifies a concrete with a stricter dosage than that indicated in the article (for example with a lower ratio of w/c or with a higher content of cement).
- In the case of structures in very aggressive environments where the articulated does not provide a fully defined durability strategy

In both cases this annex allows to estimate the possible reduction of the coatings set out in article 44 when the performance relative to the durability of the concrete is improved.

In no case may be used to reduce the coatings of tables 44.2.1.1.a and b in concretes with the strict dosages of table 43.2.1.a

Comments

The formulation of the models included in this annex is deterministic. However, these models do allow probabilistic calculations whenever the input parameters are adjusted according to their statistical distributions (real or estimated).

In most cases, the research and studies that support these models are in stage of development and maturation, and it is foreseeable that significant advances will be made in the coming years and broadening the knowledge about the processes of degradation that act on the concrete.

Given the importance of the consequences derived from an inadequate application of these tools, it is highly recommended to have the participation of an expert in the field.

2. Estimation of the service life of concrete elements

Generally, the service life of the concrete elements can be obtained according to the following expression:

$$t_{\text{est}} = t_{\text{inic}} + t_{\text{prop}}$$

where:

t_{inic}: corrosion initiation period, defined as the time elapsed to the damage is initiated according to that indicated in section 3, and

t_{prop}: propagation period, defined as the time from the start of the damage to the impermissible threshold is reached, according to that indicated in section 4

3. Models for the period of initiation in concrete elements

3.1 Carbonating of concrete

In the case of elements located in XC exposure classes, it should be fulfilled

$$t_{\text{inic}} = t_{\text{inic,desp}}$$

Being $t_{\text{inic,desp}}$,the period of time elapsed until corrosion starts, which shall be given by:

$$t_{inic,desp} = \left(\frac{c}{k_{app,carb}}\right)^2$$

where

c: minimum coating, in mm

$k_{\text{app,carb}}$: apparent carbonation rate, expressed in mm/year $^{1/2}$

The value of $k_{ap,carb}$ should preferably be determined, experimentally, according to UNE 83993-1. In which case, in the absence of experimental data, the author of the project may estimate its value from the following expression:

$$k_{ap,carb} = c_{env} \cdot c_{air} \cdot a(f_{ck} + 8)^b$$

where:

c_{env} y c_{air}: are environmental factor and air-entraining factor, respectively, which may be obtained according to Tables A12.3.1.a and A12.3.1.b.

f_{ck} : specified characteristic strength for concrete, expressed in N/mm^2

a, b: dimensionless parameters, according to Table A12.3.1.c

Table A12.3.1.a. Factor c_{env} to estimate the apparent carbonation coefficient.

Ambient	c_{env}
Protected from rain	1,0
Exposed to rain	0,5
Underground elements, above water table	0,3
Underground elements, below water table	0,2

Table A12.3.1.b. Factor c_{air} to estimate the apparent carbonation coefficient

Occluded air	c_{air}
< 4,5 %	1,0
≥ 4,5 %	0,7

Table A12.3.1.c. Coefficients a and b to estimate the apparent carbonation coefficient

Binder	a	b
Portland cement	1800	-1,7
Portland cement + 28% fly ash	360	-1,2
Portland cement + 9% amorphous silica	400	-1,2

3.2 Chloride ions penetration in concrete

In the case of elements located in exposure classes XS or XD, for the purpose of determining the progress of chloride ions inside the concrete as a function of time, the project author may use the following expression:

$$C_{th}=C_b + (C_S - C_b) \cdot \left[1 - erf\left(\frac{c}{2\sqrt{D_{app,C,}(t)\cdot t}}\right)\right]$$

where:

C_{th}: content limit of chloride ions in the concrete, which causes the initiation of corrosion in the reinforcement, expressed as a percentage of the cement weight and defined at a depth x, expressed in mm, and at an age t, expressed in years.

C_{b}: content of chlorides contributed by the materials used in the manufacture of concrete, expressed as a percentage of the weight of cement, in accordance with:

$$C_b = \sum_{i=1}^{n} C_{b,i}$$

being $C_{\mathrm{b},i}$ contents the chloride ion of each of the component materials (cement, aggregates, additions, additives, etc.).

C_S: content of chloride on the surface of the concrete, expressed as a percentage of the weight of cement. In the absence of additional specific information, it may be obtained from table A12.3.2.a.

Table A12.3.2.a. Estimation of chlorides content Cs on the surface of the concrete

Exposure Classes	Distance L to coast (m)	C_S (% on weight of concrete)
XS1	Spray zone, next to the splash zone	0,25
	Rest up to L ≤ 5000	0,15
XS2	n/a	0,40
XS3	n/a	0,50
XD1, XD2, XD3	n/a	0,40

c: coating, expressed in mm

t: period of time (in years) elapsed up to corrosion starts, where $t = t_{inic}$

$D_{app,}(t)$: apparent chloride diffusion coefficient, expressed in mm^2/year, at age t, obtained by obtained experimentally in the following way:

a) In existing structures, based on experimental determinations of the chloride content at different depths on cores extracted from the structural element.
b) In the design stage for concretes with exhibition class XS3, according to the following expression::

$$D_{app,C}(t) = k_e \cdot D_{app,C}(t_0) \left(\frac{t_0}{t}\right)^n$$

where $D_{app,C}(t_0)$ is the apparent chlorides diffusion coefficient at age t_0 = 28 days (0,0767 years), whose determination should be made from specific chloride diffusion tests, according to UNE-EN 12390-11.

For guidance purposes and preliminary evaluation only, the values of $D_{app,}(t_0)$ are included in Table A12.3.2.b obtained from the test defined in the NT BUILD 492 standard

Table A12.3.2.b. Indicative values of the apparent chloride diffusion coefficient obtained with the NT BUILD 492 standard

Values of $D_{app,C}(t_0)$ [10^{-12} (m^2/s)						
Binder Class	ratio $(^W/_C)_{eq}$ (*)					
	0,35	0,40	0,45	0,50		
CEM I	-	8,9	10,0	15,8		

CEM II/B-V, CEM I with addition of more than 22% fly ash	-	5,6	6,9	9,0		
CEM I with addition of amorphous silica higher than 5%	4,4	4,8	-	-		
CEM III/B	-	1,4	1,9	2,8		

(*)The effective water / binder ratio $(^{W}/_{C})_{eq}$ shall be obtained considering both the clinker content and the additions, weighted in this case by their corresponding efficiency coefficients.

n : coefficient of aging, in the absence of experimental values, may be obtained from table A12.3.2.c, for exposure classes XS2 and XS3:

Table A12.3.2.c. Coefficient of aging

Relation w/c	Type of cement	Coefficient of aging, a
Between 0,40 y 0,50	CEM I	0,30
Other cases		0,50

k_e: coefficient depends on the average environmental temperature, T_{real}, expressed in ºC, according to the following expression:

$$k_e = e^{4800\left(\frac{1}{293}-\frac{1}{273+T_{real}}\right)}$$

Comments

The value of apparent chloride diffusion coefficient should be determined, for a given age, from the actual chloride penetration profiles. These profiles may be obtained either on witnesses of real structures or on specimens kept in the same conditions that are expected to be in practice. In the case of the design of a new structure, this last determination on specimens consumes a lot of time, so this Annex includes a model obtained experimentally.

Any other model used alternatively, also under the responsibility of the author of the project, should also be calibrated with the method of chloride profiles on preserved specimens, at least for several months, under the same conditions to which it will be subject to the real structure.

The error function can be simplified conservatively using the parabola function, in which case the resulting expression to calculate the coating would be:

$$C_{x,t} = C_b + (C_S - C_b)\left[1 - \frac{x}{\sqrt{12 \cdot D_{app,C}(t) \cdot t}}\right]^2$$

In Table A.12.3.2.a we must take into account that the chloride content is expressed as a percentage of the weight of concrete, and that it must be converted into a percentage of the weight of cement for use in the equation.

Likewise, in Table A.12.3.2.b, it must be taken into account that the chlorides diffusion coefficient is expressed in 10^{-12} m^2/s, and it must be converted to mm^2 / year (multiplying by $31{,}536*10^{12}$) for use in the equation. It is also necessary

to remember the chloride diffusion coefficients obtained with different test methods are not the same, so the results obtained in the test established in the NT BUILD 492 standard do not coincide with those of the UNE-EN 12390-11 standard.

3.2.1 Limit content of chloride ions in concrete which causes the start of corrosion in reinforcement.

The author of project may consider a chloride ion limit content C_{th} for passive reinforcements as indicated, as a guideline, in table A12.3.2.1.a depending on the type of exposure and referred to the cement content.

Table A12.3.2.1.a. Chloride ion limit content C_{th}

Exposure class	C_{th} [% on weight of cement]
XS1	0,60
XS2	0,80
XS3	0,60
XD1	0,60
XD2	0,60
XD3	0,40

In the case of active reinforcements, the limit value of the chloride content at the height of the prestressing reinforcement shall be $C_{th,\mathrm{pret}}$ = 0.30 in the general case and 0.20 in the case of class XD3, expressed as a percentage of the cement weight.

Comments

The experimental data on the limit contents of chloride ion are not determinant, at the time of elaboration of this annex, there is a strong dispersion of results, hence the values collected are merely indicative, and may vary significantly from one case to another. For this reason, it is recommended to always make an experimental determination to obtain more reliable data.

The values in Table A12.3.2.1.a do not take into account the effect of the type of cement or the use of additions to the concrete that can modify the threshold of chloride ions which cause the onset of corrosion.

4. Propagation period models in concrete elements

4.1 Corrosion time for the cracking of the coating

The time elapsed from the beginning of the corrosion to the cracking of the coating, may be obtained according to the following expression:

$$t_{fis,corr} = \frac{P_{corr}}{v_{corr}} = \frac{80 \cdot c}{\emptyset \cdot v_{corr}}$$

where:
$t_{fis,\mathrm{corr}}$: time since the initiation of corrosion to the cracking of the coating, in years
P_{corr}: limit corrosion penetration, in µm
c : cover thickness, expressed in mm
∅ : reinforcement steel diameter, expressed in mm
v_{corr} : corrosion rate, expressed in µm/year, according to table A12.4.1.

Table A12.4.1. Corrosion rate

Exposure class			v_{corr} (µm/year)
Normal Environment	Dry or permanently wet	XC1	1
	High humidity	XC2	4
	Moderate humidity	XC3	2
	Cycle wet – dry	XC4	5
Marine Environment	Exposed to marine aerosols	XS1	20
	Permanently submerged	XS2	4
	Tidal zone or splash	XS3	50
Environment with flux salt	Moderate humidity	XD1	35
	High humidity	XD2	20
	Cycle wet – dry	XD3	35

4.2 Corrosion time to an inadmissible diameter loss in reinforcement steel

The time from the initiation of corrosion to the loss of reinforcement section defined by a thickness Δ∅, may be obtained according to the following expression

$$t_{secc,corr} = \frac{\Delta\emptyset_{lim}}{v_{corr}}$$

where:
$t_{f\mathrm{sec,corr}}$: time from the initiation of corrosion to the loss of diameter defined as impermissible in the reinforcement, in years
$\Delta\emptyset_{\mathrm{lim}}$: Diameter variation due to corrosion of the reinforcement, which is considered inadmissible, expressed in µm
v_{corr} : corrosion rate, expressed in µm/year, according to table A12.4.1

Comments

When this model is used, the value of ∆∅lim shall change depending on the Limit State that has been defined as impermissible threshold (cracking of the coating, loss of resistant section, etc.).

Annex 13

Preliminary and characteristics tests of concrete

Content

1 Preliminary tests 3
2 Characteristic tests for strength 4
3 Characteristic tests for dosage 5

1 Preliminary tests

This type of tests shall not be necessary, except in cases in which there has been no prior experience to provide documentary evidence for the use of concretes with the materials, composition and construction methods that are planned for specific works.

The aim of the preliminary tests is to demonstrate, through tests carried out on concrete manufactured in laboratories, that using the planned materials, dosage and construction methods it is possible to obtain concrete that presents the strength and durability conditions required by the design.

For the purposes of these tests, at least four series of samples shall be prepared from different mixes, each consisting of two samples for testing at 28 days old, for each dosage planned for use in the works, proceeding in accordance with the methods for the preparation of samples and for the performance of the strength and durability tests included in this Code.

In the case of compressive strength, the values obtained in this way shall be used to determine an average laboratory strength, f_{cm}, which must be sufficiently high in order that it may be feasibly expected that, with the scattering introduced by the planned manufacturing methods for its use in the works, the actual on-site characteristic strength will be greater, by a sufficient margin, than the characteristic strength specified by the design.

The preliminary tests provide information for estimating the average value of the property studied, but are not sufficient to determine the statistical distribution followed by the concrete of the works. Given that neither the specifications in this Code nor the additional specifications included in the design refer in general to average values, as in the case of strength, it is necessary to adopt a series of hypotheses to enable decisions to be made regarding the validity of the dosages tested.

In general, Gaussian distribution may be permitted, with a population standard deviation or coefficient of variation that must be based on the data obtained from the production inspection at the facility at which the concrete will be manufactured. Obviating the variation that exists between the populations of laboratory concrete and those actually manufactured for the works, in the case of strength, the following minimum requirements may be made:

$$\overline{x_n} \geq f_{ck} + 2\sigma$$

where $\overline{x}_n$ is the average strength of the sample obtained during the tests and f_{ck} is the characteristic strength specified in the design.

Standard deviation, σ, is a basic piece of information required for this type of estimate. Where this value is not known for the manufacturing facility to be used, it may be assumed as an initial approximation that:

$$\sigma = 4 N/mm^2$$

The formula above corresponds to certain average conditions of proportioning by weight, with separate and differentiated storage of all component materials and correction of the quantity of water for the humidity incorporated in the aggregates where, in addition, the scales and measuring devices are checked periodically and the raw materials are inspected on receipt or at source.

Comments

The information provided by the preliminary laboratory tests is key to the successful completion of the works, which is why the technical management needs to be aware of it. In particular, making up the maximum number of samples aged less than 28 days may prove very useful.

2 Characteristic tests for strength

This type of testing shall not be necessary, except in cases in which there has been no prior experience to provide documentary evidence for the use of concretes with the materials, dosage and construction methods that are planned for the works. The purpose of the tests is to check, before supply begins, that the characteristics of the concrete to be used in the works are not inferior to those specified by the design.

The tests shall be carried out on 28-day-old samples from n different mixes, for each type of concrete to be used in the works. Two samples shall be cast per mix, which shall be manufactured, stored and tested in accordance with the methods laid down in this Code.

For compressive strength, the average value corresponding to each batch shall be calculated from the individual failure results, enabling a series of n average results to be obtained:

$$x_1 \leq x_2 \leq \cdots . \leq x_n$$

The Project Management shall accept the dosage and corresponding construction method, for the purposes of strength, where:

$$\bar{x}_n - 0{,}97(x_n - x_1) \geq f_{ck}$$

If this is not the case, the concrete shall not be accepted and the plant manager must make the appropriate corrections in order that the aforementioned conditions may be met. In the meantime, the start of the supply of concrete shall be postponed until new characteristic tests have shown that an acceptable dosage and manufacturing method has been achieved.

Comments

It may be useful to test different initial dosages, because if one dosage only is prepared and the required behaviour is not achieved with this mix, the process must begin again, causing the work to be delayed.

3 Characteristic tests for dosage

The aim of these tests is to check, before any concrete is supplied, that the dosages to be used comply with the durability criteria laid down in this Code. They are limited to XA, XS, XD, XF and XM environments. In the case that the concrete is manufactured on site, they are mandatory for these environments and the facultative management will ensure that it is carried out. In the case of prepared concrete, the manufacturer shall state it in the responsible declaration in accordance with the provisions of points 9 and 10 thereof, according to section 1.1.6 of Annex 4.

Independent series of tests shall be carried out for each type of concrete to be used in the works, in order that their respective dosages may be characterised. The aforementioned tests shall include at least compressive strength tests and tests to determine the depth of water penetration under pressure. Furthermore, the Project Technical Specifications or the Project Management may stipulate that further tests shall be carried out in order to determine additional characteristics including, for example, to determine the carbonatation speed or chloride ion diffusion coefficient where the design includes an estimate of the useful life of the structure, in accordance with Annex 12.

Before supply begins, an assay will be carried out in a batch manufactured in the plant with the same dosage that will be used in the work. Each test will be carried out on three specimens in the case of the determination of the depth of penetration of water and on two shots of a sample in the case of the determination of the occluded air. Samples must be taken at the facility that will be used to manufacture the concrete during construction. The time at which this operation is to be carried out, and the laboratory responsible for manufacturing, storing and testing the samples, must be chosen with the prior approval of the person responsible for accepting the concrete, the concrete supplier and, where appropriate, the constructor or prefabricator.

The tests shall be performed in accordance with Section 57.3.3 of this Code. A report shall be compiled of the results obtained which will also indicate the actual dosage used in the concrete tested, as well as the identification of its raw materials.

Annex 14
Tolerances in concrete elements

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1 Specifications of the System of Tolerances

The system of tolerances adopted by the Designer must be clearly indicated in the Project Specific Technical Specifications, either by reference to this Annex or supplemented or modified as appropriate.

2 Terminology

The essential terminology is indicated below.

a) Warping. Deviation of the actual position of any corner of a face of a flat element from the plane defined by the other three corners (Figure A.14.2.a).

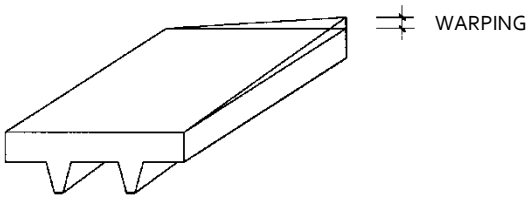


Figure A14.2.a

b) Bowing. Deviation of the position of any point on the actual surface of a theoretically flat element from the basic flat surface (Figure A.14.2.b).

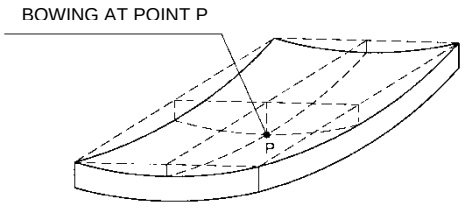


Figure A14.2.b

c) Ridge (Flange). Projection at the joint between the edges of two adjacent members.
d) Leaning. See j).
e) Deviation. Difference between the actual dimension or actual position and the basic dimension or basic position, respectively.
f) Permitted deviation. Accepted limit for deviation, with its sign (Figure A.14.2.c).
g) Deviation in level. Vertical deviation of the actual position of a point, straight line or plane from the basic position of a horizontal reference plane.
h) Lateral deviation. Deviation of the actual position of a point or straight line within a horizontal plane from the basic position of a reference point or straight line situated in that plane.
i) Relative deviation. Deviation between the actual positions of two elements in a plane, or between adjacent elements in a structure, or the distance from a

point, straight line or plane to a reference element.

j) Deviation from the vertical. Deviation between the position of a point, line or plane and the basic position of a reference vertical line or vertical plane. When applied to walls or pillars, this is known as leaning.

k) Basic dimension or basic position. Dimension or position serving as a reference for establishing the limits of deviation (Figure A.14.2.c).

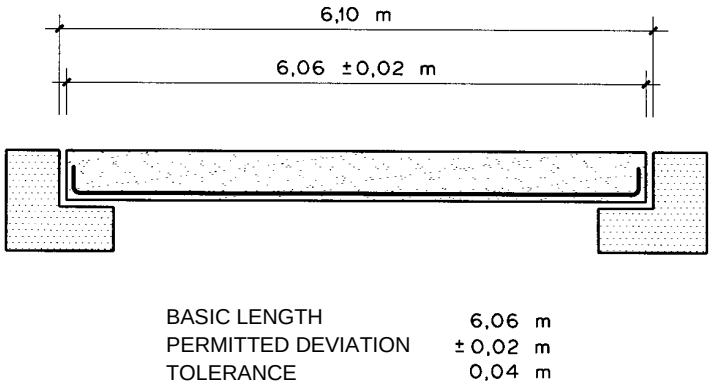


Figure A14.2.c

l) Flatness. The degree by which a surface approximates a plane (Figure A.14.2.d).

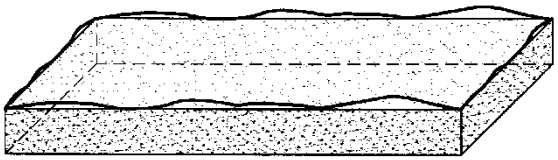


Figure A14.2.d

m) Straightness. The degree by which a line approximates a straight line (Figure A.14.2.e).

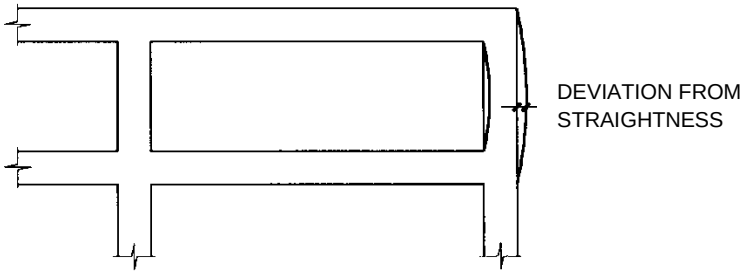


Figure A14.2.e

n) Hidden surface. The surface of a concrete element intended to be covered with plaster, mortar, boards, etc., or which will not be observed by the user during the working life of the structure.

ñ) Exposed surface. The surface of a concrete element which will not be covered, except with paint, and which will be observed by the user during the working life of the structure.
o) Tolerance. The difference between the permitted limits for the deviations of a dimension or position (Figure A.14.2.c). Tolerance is an absolute value without a sign.

For example, for permitted deviations of +30 mm and -20 mm, the tolerance is 50 mm.

3 Selection of the system of tolerances

It is advisable that the tolerances adopted in a project are the widest ones compatible with the proper functioning of the building. Tolerances should not be established whose verification is not necessary for such operation.

The system included in this annex is suitable for concrete works of the usual type. For some specific deviations, different permissible deviations are indicated according to use types or finishing grades. In any case, its adaptation to each specific project may require some specific modification.

4 General principles

a) Tolerances are applied to the dimensions indicated in the drawings. Double dimensioning must be avoided, but, in principle, if several tolerances correspond, in the system described in this document, to one dimension or position, the strictest tolerance shall be understood as applying, unless otherwise indicated.

b) The structure must not under any circumstances exceed the limits of the property, regardless of the deviations indicated in this Annex.

c) In the case of fractional dimensions which form part of a total dimension, the tolerances must be interpreted individually and not accumulatively.

d) Checks must be made before removing timbering, shoring and formwork from those elements in which this operation could cause deformations.

e) The Constructor must maintain the references and marks allowing the deviations to be measured while the structure is being executed.

f) The values of the permitted deviations must be chosen from the preferred series of 10, 12, 16, 20, 24, 30, 40, 50, 60, 80 and 100.

g) If the set tolerances have been met, the elements shall be measured and paid for using the basic dimensions indicated in the drawings, i.e. without taking into

account the deviations which have occurred during execution.

h) If the deviations indicated in this document are exceeded in the structure and could cause problems in its use, the financial penalties laid down for this purpose in the project technical specifications may be applied. However, the acceptance or rejection of the corresponding part of the structure must be based on the study of the effect that these deviations may have on the safety, functionality, durability and appearance of the structure.

5 Permitted deviations

These are always indicated in mm.

5.1 Reinforcements

5.1.1 Passive reinforcements

a) For the cut lengths and bent bars:

For $L \leq 6.000$ mm

Δ=-20mm y +50mm

For L >6.000 mm

Δ=-30mm y +50mm

Being *L* the straight length of the passive reinforcement bars.

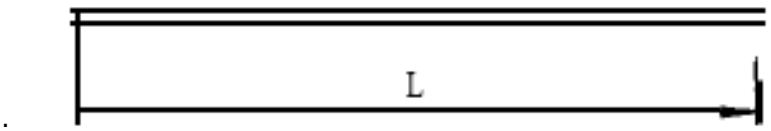


Figure A14.5.1.1.a1

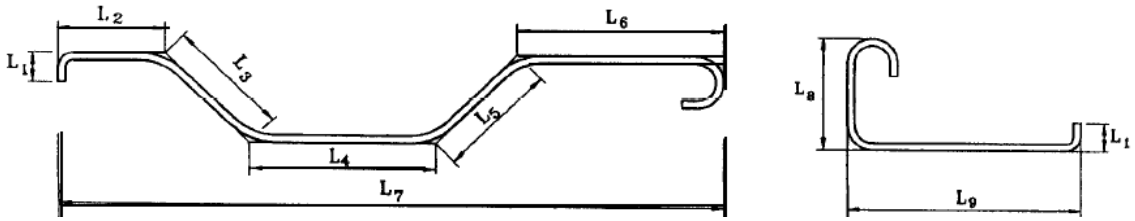


Figure A14.5.1.1.a2

Moreover, the minimum concrete cover specified in the design and the overlapping lengths defined in this Code must always be guaranteed, being allowed to exceed the +50mm tolerance.

b) For stirrups and hoops:
For $\varnothing \leq 25$ *mm*

$\Delta L = \pm 16mm$

For $\varnothing > 25$ *mm*

$\Delta L = -24mm$ *y* $+20mm$

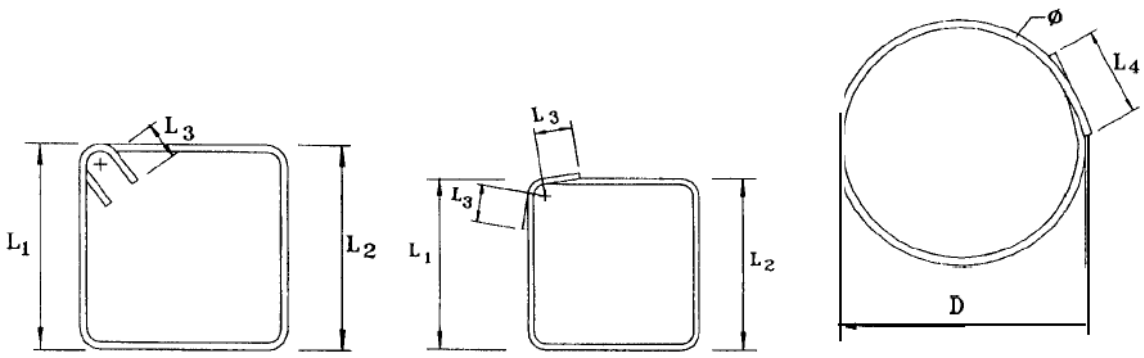


Figure A14.5.1.1.b

Being *L* the length as in figure A.14.5.1.1.b.

Likewise,, $/L_1 - L_2/ \leq 10mm$

c) For the basic position of the axis in parallel bar series, in walls, in slabs, in ground plates, etc.:
$\Delta = \pm 50mm$
and the total number of bars being never lower than the specified one.

d) For the basic position of stirrups and hoops
$\Delta = \pm b/12$ *mm,*

Being *b* the smaller dimension of the rectangular section in the pillar or the depth or width of the beam.

Likewise, the number of stirrups and hoops in the structural element stretch never shall be diminished.

e) For the bending angle in hooks, bents, hooks in U and other curved bars.

$\Delta = \pm 5^{o}$ regarding the design angle

Moreover, the minimum concrete cover specified in the design and the overlapping lengths defined in this Code must always be guaranteed.

5.1.2 Active reinforcements

a) With regard to the position of prestressing tendons, in comparison with the position defined in the design:

For $l \leq 200$ mm

For tendons which are part of a cable, single tendons and strands: $\Delta = \pm 0{,}025l$

For $l > 200$ mm

For tendons which are part of a cable and for single tendons: $\Delta = \pm 0{,}025l$ or $\Delta = \pm 20$ mm (whichever is greater).

For strands: $\Delta = \pm 0{,}04l$ or $\Delta = \pm 30$ mm (whichever is greater).

where l indicates the depth or width of the cross-section.

b) Tolerances other than those defined in paragraph a) may be used if it is proven that these do not reduce the required level of safety.

c) Tolerances for concrete cover. The deviation of the cover shall not exceed the following values:

±5 mm in precast elements

±10 mm in site-cast elements

5.2 Foundations

a) Horizontal variation of the centre of gravity of isolated foundations (see f) for piles) (Figure A.11.5.2.a)

2% of the dimension of the foundation in the corresponding direction, without exceeding ±50 mm.

b) Levels
- Upper face of blinding concrete
  +20 mm

  -50 mm

- Upper face of foundation (see g) for piles)
  +20 mm

  -50 mm

- Thickness of blinding concrete
  -30 mm

c) Horizontal dimensions *(a_1-a* or *b_1-b)* (Figure A.11.5.2.b).
   - Formwork-cast foundations
     +40 mm

     -20 mm

   - Foundations cast against the ground
     Dimension no greater than 1 m

     +80 mm

     -20 mm

     Dimension greater than 1 m but no greater than 2,5 m

     +120 mm

     -20 mm

     Dimension greater than 2,5 m

     +200 mm

     -20 mm

d) Dimensions of the cross-section (at least those set in paragraph 5.3.d)

   +5% $\nearrow$ 120 mm

   -5% $\swarrow$ 20 mm

e) Flatness.
   Deviations measured after hardening and within 72 hours of the concrete being placed, using a 2 m rule placed on any part of the upper face of the foundation and supported on any two points (not applicable to elements with a dimension less than 2 m).

   Of blinding concrete:

   ±16 mm

   Of the upper face of the foundation:

±16 mm

Of side faces (only for formwork-cast foundations):
±16 mm

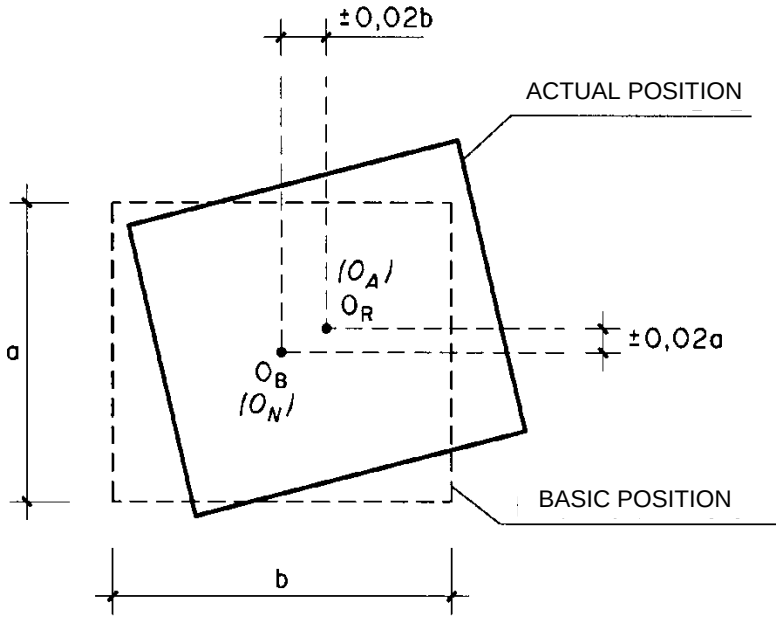


Figure A14.5.2.a

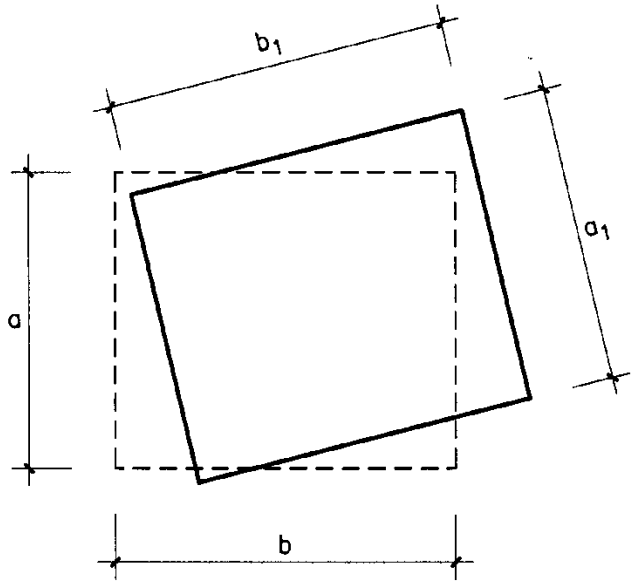


Figure A14.5.2.b

5.3 Site-cast structural elements of buildings

a) Deviation from the vertical

Where *H* is the height of the point in question from the horizontal plane taken as the reference.

a-1) Lines and surfaces in general (Δ in mm for *H* in m)

H ≤ 6 m	Δ = ±24 mm	
6 m < *H* ≤30 m	Δ =±*4H*	⊁ ±50 mm
H ≥ 30 m	Δ =±5*H*/3	⊁ ±150 mm

a-2) Outer edge of pillars with exposed corners and exposed vertical expansion joints (Δ in mm for *H* in m)

H≤6 m	Δ =±12 mm	
6 m<*H*≤30 m	Δ =±*2H*	⊁±24 mm
H≥30 m	Δ =±*4H/5*	⊁ ±80 mm

b) Lateral deviations

- Members in general
  Δ = ±24 mm

- Voids in slabs and floor slabs. Deviation from the centre for voids with a dimension in the direction in question up to 30 cm
  Δ = ±12 mm

- Voids in floor slabs. Deviation from the edges for voids with dimensions in the direction in question greater than 30 cm
  Δ = ±12 mm

- Joints in general
  Δ = ±16 mm

c) Deviations in level

c-1) Upper face of slabs

c-1.1) Upper face of pavement slabs
±20 mm

c-1.2) Upper face of slabs and floor slabs, before removing shoring
±20 mm

c-1.3) Formwork-cast lower face of members, before removing shoring
±20 mm

c-1.4) Lintels, parapets and gutters and also exposed horizontal projections
±12 mm

d) Dimensions of the cross-section

Squareness of beams, pillars and piers, depth of slabs and floor slabs, and thickness of walls (Dimension *D*)

$D \leq 30$ cm
+10 mm
-8 mm
30 cm< $D \leq 100$ cm
+12 mm
-10 mm
100 cm<*D*
+24 mm
-20 mm

e) Relative deviation

e-1) Staircases (applicable to staircases in which the steps are made from the concrete itself, without any covering material).

Difference in height between consecutive risers:

3 mm

Difference in width between consecutive treads:

6 mm

e-2) Gutters and projections

Basic width less than 50 mm

±3 mm

Basic width between 50 and 300 mm

±6 mm

e-3) Deviation of the formwork-cast face of elements from the theoretical plane, in 3 m

e-3.1) Deviation from the vertical of outer edges of exposed pillars and joints in exposed concrete

±6 mm

e-3.2) Other elements

± 10 mm

e-4) Relative deviation between consecutive panels of formwork for surface elements (the corresponding Class must be selected in the design)

Class A surface
±3 mm
Class B surface
±6 mm
Class C surface

±12 mm

Class D surface

±24 mm

e-5) Flatness of the finish of pavement slabs, slabs and floor slabs

Vertical deviation measured using a 3 m rule placed on any part of the slab or floor slab and supported on two points, before removing the shoring, after the concrete has hardened and within the first 72 hours after placing.

Surface finish:

Mechanical flattening (rotary type)

±12 mm

Screening using a float

±8 mm

Smooth

±5 mm

Very smooth

±3 mm

With regard to the flatness of the finish, tolerances must not be set for not scaffolded slabs and floor slabs as the shrinkage and deflection may significantly affect the measurement of the deviations.

The rule method is very imperfect and nowadays tends to be replaced by the statistical evaluation of flatness and levelling measurements.

f) Openings in elements

f-1) Dimensions of the cross-section

+24 mm

-6 mm

f-2) Location of the centre

±12 mm

5.4 Precast members

In general, for precast elements which have CE marking, the required tolerances will be those set in the corresponding harmonised European product standard. The tolerances set in paragraphs 5.4.1, 5.4.2 and 5.4.3 will only apply in the case of elements without CE marking.

5.4.1 Manufacturing tolerances of linear elements

a) Length of member, L

± 0,001 L

With a minimum of 5 mm for lengths up to 1 m and 20 mm for longer lengths.

b) Transverse dimensions, *D*

D≤150 mm

±3 mm

150 mm<*D*≤500 mm

±5 mm

500 mm<*D*≤1000 mm

±6 mm

D>1000 mm

±10 mm

c) Lateral deflection, measured from the vertical plane containing the axis of the member, shall not exceed L/750. In addition, depending on the span L, the following must be met:

L≤6 m

±6 mm

6 m<*L*≤12 m

±10 mm

L>12 m

±12 mm

d) Deviation of the camber from the basic design value, measured during assembly

- Members in general

  $\pm \frac{L}{750}$ with a limit value of 16 mm

- Consecutive members during placing

  $\pm \frac{L}{1000}$ with a limit value of 12 mm

Where *L* is the length of the member. The second condition only applies where the deviation affects the aesthetic appearance.

e) Flatness of the surface of the upper face. Deviation measured using a 3 m rule placed on any two points, during assembly.

e-1) If the elements do not have to receive a site-cast concrete top slab

±6 mm

e-2) If the elements do have to receive a site-cast concrete top slab

±12 mm

5.4.2 Manufacturing tolerances of surface elements

a) Length, where *L* is the basic dimension

L≤6 m

±8 mm

6 m<*L*≤12 m

+12 mm

-16 mm

L>12 m

+16 mm

-20 mm

b) Deviations in the dimensions of the cross-section (*D*)

D≤60 cm

±6mm

60 cm<*D*≤100 cm

±8 mm

D>100 cm

±10 mm

c) Openings in panels

Dimensions at the opening

±6 mm

Position of the central lines of the opening

±6 mm

d) Embedded elements

Screws

±6 mm

Welded plates

±24 mm

Anchorages

±12 mm

e) Warping measured during assembly

±5 mm per metre of distance to the closest of the adjacent corners, but no more than ±24 mm.

f) Bowing (where *D* is the length of the diagonal of the member)

±0,003*D* with a limit value of 24 mm

5.4.3 Assembly deviations

a) Deviations from the vertical: paragraph 5.3.a applies.
b) Lateral deviations: paragraph 5.3.b applies.
c) Deviations in level: paragraph 5.3.c applies.
d) Deviations in panel walls

d-1) Width of joint at exposed panels
±6 mm

d-2) Variation in width along the joint between two exposed panels:
±2 mm per metre and at least ±1,5 mm between any two points along the joint, without exceeding ±6 mm under any circumstances

d-3) Flanges between two adjacent panels

if $L \leq 6$ m ±6 mm

if $6 \text{ m} < L \leq 9$ m ±12 mm

if $9 \text{ m} < L \leq 12$ m ±24 mm

e) Deviation in level between edges of upper faces of adjacent members

e-1) If they are to receive a top slab
±16 mm

e-2) If they are not to receive a top slab
±6 mm

e-3) Roof members without any top slab
±16 mm

e-4) Elements with functions as guides or screeds
±2 mm

f) Placement of loadbearing and semi-loadbearing joists in floor slabs

f-1) Deviation of the flooring block support on a beam, d_1 (Figure A.14.5.4.3.a)

±5 mm with a limit value of $d_1/3$

measured with regard to the basic dimension indicated in the Authorisation for Use.

In practice, it is easier to control this permitted deviation by controlling the deviation of the distance between beam axes, limited to

$$\pm 10 \text{ mm} > / \pm \frac{2d_1}{3}$$

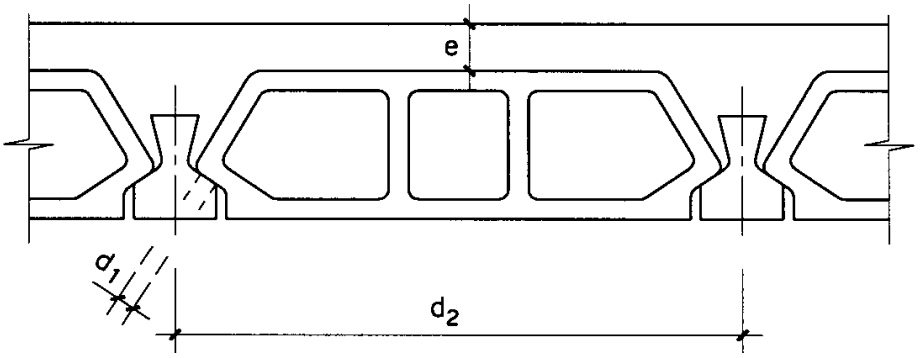


Figure A14.5.4.3.a

f-2) Bearing of beams or reinforcements projecting from beams (Figure A.14.5.4.3.b).

Edge beams (Length L_1)
±15 mm
Inner beams (Length L_2)
±15 mm

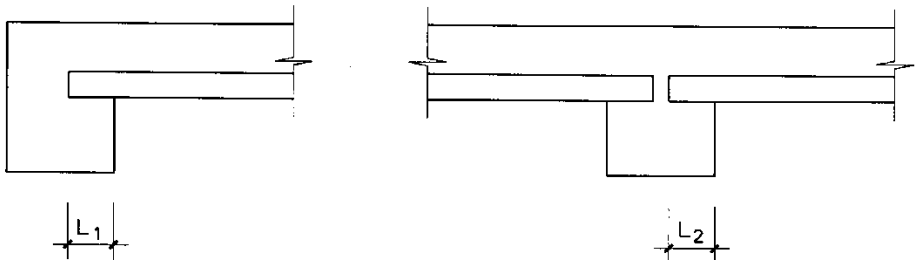


Figure A14.5.4.3.b

f-3) Thickness of top slab, measured by submerging a nail in the fresh concrete, at a flooring block bonding key. The position of the bonding key is determined by feeling with the nail.

-6 mm

+10 mm

5.5 Core walls, cores, towers, chimneys, piers and other elements concreted using slipforms

a) Deviation from the vertical. Horizontal slippage from the basic position of any reference point at the base of the element, depending on the height *H.*

$H \leq 30$ m	$\Delta = \pm 1{,}5H$	with a limit value of 12 mm
$H > 30$ m	$\Delta = \pm \underline{2}\ H$	with a limit value of 100 mm

$$\Delta = \frac{5}{H}$$

where Δ in mm and H in m

b) Lateral deviation between adjacent elements
±50 mm

c) Thickness of internal and external walls
Thickness no greater than 25 cm
+12 mm
-10 mm
Thickness greater than 25 cm
+16 mm
-10 mm

d) Relative deviation of formwork-cast flat surfaces
These may deviate from the basic flat position without exceeding ±6 mm in 3 m.

5.6 Retaining walls and basement walls

a) Deviation from the vertical. Horizontal slippage of any point of the elevation from the basic position of any reference point situated on the upper face of the foundation, depending on the height *H.*
$H \leq 6$ m
Extrados
±30 mm
Intrados
±20 mm
$H > 6$ m
Extrados
±40 mm
Intrados
±24 mm

b) Thickness *e*:
$e \leq 50$ cm
+16 mm
-10 mm
$e > 50$ cm
+20 mm
-16 mm

For walls concreted against the ground, the maximum deviation will be +40 mm.

c) Relative deviation of the flat intrados or extrados surfaces.
These may deviate from the basic flat position without exceeding ±6 mm in 3 m.

d) Deviation in level of the upper edge of the intrados, for exposed walls:
±12 mm

e) Finishing tolerance of the upper face of the elevation, for exposed walls:
±12 mm using a 3 m rule supported on any two points, once the concrete has hardened.

5.7 Hydraulic and sanitary works

5.7.1 Channels

a) Lateral deviation
Straight sections
±50 mm
Curved sections
±100 mm

b) Width of the section at any level, where B is the basic width:
$\Delta = \pm(2{,}5B+24)$ mm

with Δ in mm for B in metres

c) Deviation in level

c-1) Floor
±12 mm

c-2) Top of side walls where H is the total depth
$\Delta = \pm(5H+24)$ mm

with Δ in mm for H in metres

d) Thickness e of floors and side walls
$\pm e/10$, provided that the basic value is maintained, determined as the average of the measurements at any three points which are 10 m apart along the channel.

5.7.2 Drains, siphons, etc.

a) Lateral deviation

a-1) Axis line
±24 mm

a-2) Position of points on the inner surface, where D is the maximum internal dimension:

$\Delta = \pm 5D$ mm with a limit value of 12 mm
with Δ in mm for D in m

b) Deviation in level

b-1) Floors or bottoms
±12 mm
b-2) Surfaces of side walls ±12 mm

c) Dimension *e* of the thickness

$e \leq 30$ cm

$+0{,}05e \not< 12$ mm

-8 mm

$e > 30$ cm

$+0{,}05e \not< 16$ mm

$-0{,}025e \not> -10$ mm

5.8 Site-cast bridges and similar structures (for slip piers, see 5.5)

a) Deviation from the vertical

Exposed surfaces
±20 mm
Concealed surfaces
±40 mm

b) Lateral deviation
Axis
±24 mm

c) Deviation in level
Upper face of concrete surfaces and horizontal mouldings and channels
Exposed
±20 mm
Concealed
±40 mm

d) Flatness of paving
Longitudinal direction
3 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.
Transverse direction
6 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.

e) Pavements and ramps

In any direction:
6 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.

f) Dimensions of the cross-section

f-1) Thickness *e* of the top slab

$e \leq 25$ cm

+10 mm

-8 mm

$e > 25$ cm

+12 mm

-10 mm

f-2) Transverse dimensions, *D*, of piers, beams, walls, stirrups, etc.

$D \leq 30$ cm

+10 mm

-8 mm

$30 \text{ cm} < D \leq 100$ cm

+12 mm

-10 mm

$D > 100$ cm

+16 mm

-12 mm

f-3) Dimensions of voids in concrete elements

±12 mm

g) Relative deviation

g-1) Position of voids in concrete elements

±12 mm

g-2) Formwork-cast flat surfaces with regard to the basic position of the plane. Deviations in 3 m.

Exposed surfaces

±12mm

Concealed surfaces

±24 mm

g-3) Surfaces not cast in formwork, apart from paving and pavements, with regard to the basic position of the reference plane. Deviations:

In 3 m

±6 mm

In 6 m

±10 mm

5.9 Paving and pavements (not applicable to roads)

a) Lateral deviations

a-1) Position of tie rods. Deviation from the axis

±24 mm

a-2) Deviation of tie rods from the axis of the paving (slippage of the end of the tie rod in the direction of the joint)

±6 mm

b) Flatness deviations

b-1) In the longitudinal direction:
3 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.

b-2) In the transverse direction:
6 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.

b-3) Pavements and ramps. In any direction:
6 mm using a 3 m rule supported on any two points, once the concrete has hardened and within 72 hours of placing.

5.10 Civil works, involving very thick elements, not included in other sections

a) Deviation from the vertical
Exposed surfaces
±30 mm
Hidden surfaces
±50 mm

b) Lateral deviation
Exposed surfaces
±30mm
Hidden surfaces
±50 mm

c) Deviation in level
Exposed surfaces, floated or formwork-cast
±12 mm
Hidden, floated or formwork-cast
±24 mm

d) Relative deviation

d-1) Formwork-cast flat surfaces with regard to the basic position of the plane. Deviations in 3 m.
Exposed surfaces
±12 mm
Concealed surfaces
±24 mm

d-2) Surfaces not cast in formwork, apart from pavements and sidewalks, with regard to the basic position of the reference plane. Deviations:
In 3 m

±6 mm
In 6 m
±10 mm

6 Applicable tolerances for reducing the partial safety factors for materials

6.1 Site-cast structures

In accordance with the criteria defined in Annex 19, the partial safety factor for steel may be reduced to the value indicated in this section, provided that it is ensured that the geometric deviation in the position of the reinforcement (Δc) is within the limits given in Table A.14.6.1.a.

Table A14.6.1.a Limit of the deviation in the position of reinforcements

Dimension *h* o *b* (mm)	Position of the reinforcement ±Δ*c* (mm)
≤ 150	5
400	10
≥2.500	20

Note 1: The intermediate values may be determined by linear interpolation.

Nota 2: Δc refers to the mean value determined for passive reinforcements or for prestressing tendons in the cross-section or in a width of 1.0 m in the case of slabs or walls.

Likewise, in accordance with the criteria defined in Annex 19, the partial safety factor for concrete may be reduced to the value indicated, provided that it is ensured that the geometric deviations in the cross-section *(Δh, Δb)* from the nominal dimensions are within the limits given in Table A.14.6.1.b.

Table A14.6.1.b Limit of the geometric deviations in the loadbearing section

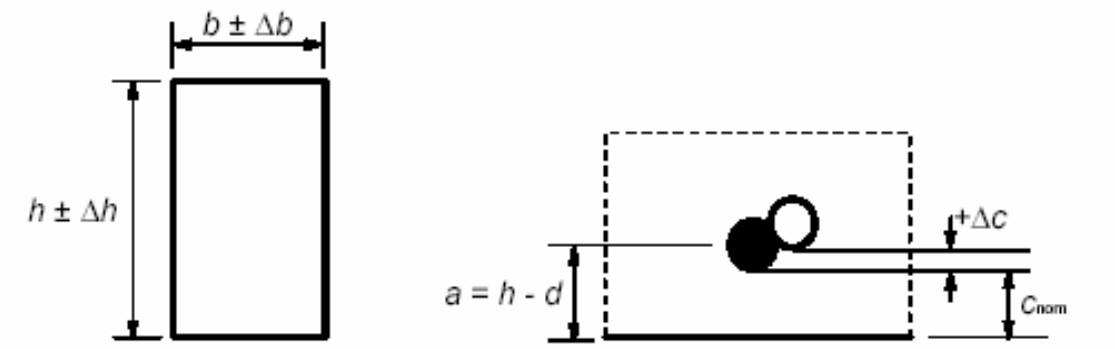
Dimension *h* o *b* (mm)	Cross-section ±Δ*h*, Δ*b* (mm)
≤ 150	5
400	10
≥ 2.500	30

Nota 1: The intermediate values may be determined by linear interpolation.

6.2 Precast elements

The rules laid down in section 6.1 for site-cast structures also apply to precast elements as defined above.

In the specific case of precast elements, the partial safety factor for concrete may be reduced as laid down in Annex 19 if the loadbearing capacity of the section is calculated using either the actual values measured in the finished structure or a reduced loadbearing section with critical geometric dimensions determined from the nominal values reduced by the deviations contained in section 6.1 of this Annex.



a) Cross-section

b) Position of the reinforcement (in the unfavourable direction for calculating the effective depth)

Figure A14.6.2. Reduced load bearing section

Annex 15

Checking frequencies of the inspection units in the execution of concrete structures

Content

1 INTRODUCTION 3

2 CHECKING FREQUENCIES OF THE INSPECTION UNITS 3

2.1 CHECKING FREQUENCIES DEPENDING ON THE EXECUTION PROCESS 4
2.2 CHECKING FREQUENCIES DEPENDING TO THE TYPE OF ELEMENT 5

1 Introduction

Project Manager shall implement the execution control of the steel structures, by means of one of the two options admitted in Article 17.

In option A, the execution control shall be carried out by the Project Manager itself, assisted, where appropriate, by an independent control agent who develops his activity for the facultative management.

In option B, the control of the execution of each execution batch and inspection unit shall be carried out by the constructor, and the Project Manager, assisted or not by an independent control agent, will perform a contrast control of the constructor's control.

This annex includes, in an indicative manner, the checking frequencies for the different inspection units, defined in section 63.2 of this Code. These frequencies shall be adapted to the characteristics of the work and to the means available in it, so that the Project Manager, on its own initiative or at the proposal of the constructor, may authorize values different from those included in this annex.

2 Checking frequencies of the inspection units

In the case that the execution control is organized according to option B defined in Article 17, for each process or execution activity included in a execution batch, the Constructor Control (defined in the following tables simply as Control) will develop the control of the execution with minimum verification frequencies obtained according to the number of inspection units, the execution control level (normal or intensive) and the execution class, according to the indications in tables A15.2.1, A15.2.2.a and A15.2.2.b. For its part, the project management may further develop a contrast control, by performing checks whose number will also be a function of the number of inspection units, the level of control and the type of execution, according to the criteria of the aforementioned tables.

In the event that the control of the execution is organized through option A defined in Article 17 of this Code, the Control shall be carried out by the Project Manager in the terms described in said article, and therefore it will not be necessary for the project management itself optional perform additional contrast checks.

2.1 Checking frequencies depending on the execution process

Table A15.2.1 Checking frequencies for the execution processes included in table 63.2a of this Code

Execution processes	Minimum number of inspection units to be controlled for acceptance per each execution batch			
	Normal control level (according to section 22.4)		Intense control level (according to section 22.4)	
	Control(1)	External comparative control(2)	Control(1)	External comparative control(2)
Warehousing management control	100%	3	100%	20%, with a minimum of 3
Setting out	2	1	100%	20%
Falsework	1	1	100%	50%
Cut of plans for reinforcements designed in accordance with the design	1	1	1	1
Elaboration of reinforcements by means of ties or non-resistant welding (including processes of straightening, cutting, bending and reinforcement, where appropriate)	2	1	5	1
Removing the falsework	1	1	3	2
Joining of precast elements	3	1	5	1

(1) Control = Control of the builder in option B of control defined in Article 17 this Code or Project Manager's control in option A of control defined in Article 17 of this Code
(2) External comparative control of the project management, only in control option B defined in Article 17 of this Code

Comments

Table A15.2.1 defines reference values to define the minimum number of inspection units that must be controlled to check the compliance of each execution batch. However, as already indicated, the inspection units should be defined in the control program according to the type and characteristics of the work, as well as the means available in it. This could advise that the number of inspection units planned for that process, defined in the control program, does not allow the frequencies indicated in table A15.2.1 to be developed. In such cases, it is recommended to adapt the frequencies and minimum number of inspections to the characteristics of the work.

When a process or activity is inspected in its entirety, the verification of said process shall be understood as being either part of the Builder's self-control or within the external control of the Project Manager, as the case may be, and independently of the number of inspections that have been made.

An example of what was stated in the previous paragraph would be that of a process or activity that could be executed in a very short period of time, due to having sufficient material and human resources, and in which, in addition, both the builder and the Project Manager, they shall carry out their total inspection in a number of inspections inferior to those indicated in the articles.

2.2 Checking frequencies depending to the type of element

Table A15.2.2.a Checking frequencies for an intense control level of the inspection units according to the type of element defined in Table 63.2.b of this Code

Intense control level												
Element type	Construction processes											
	Installation of passive reinforcements		Prestressing application operations		Pouring and compaction		Forms and Removing from forms		Concrete curing		Finishing operations	
	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)
Foundation elements with volumes less than 350 m^3	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Foundation elements with volumes greater than 350 m^3	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Elevations of pillars and walls in building	25	5	100%	100%	5	2	3	1	5	2	5	2
Elevations of piles, buttresses and walls in the case of bridges	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Concrete pile with climbing formwork	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Concrete pile with sliding formworks	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Beams, slabs and other elements work by flexure in building Top and bottom slab frames	100%	20%	100%	100%	100%	10%	50%	10%	50%	20%	100%	20%
Decks in general	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%

Annex 15
Checking frequencies of the inspection units in the execution of concrete structures

Intense control level												
Element type	Construction processes											
	Installation of passive reinforcements		Prestressing application operations		Pouring and compaction		Forms and Removing from forms		Concrete curing		Finishing operations	
	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)
Decks executed in phases	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%
Decks executed by segments	100%	20%	100%	100%	100%	20%	100%	20%	100%	20%	100%	20%

(1) C.: Control = Control of the builder in option B of control defined in Article 17 this Code or Project Manager's control in option A of control defined in Article 17 of this Code

(2) C.C: External comparative control of the project management, only in control option B defined in Article 17 of this Code

Table A15.2.2.b Checking frequencies for a normal control level of the inspection units according to the type of element defined in Table 63.2.b of this Code

Normal control level										
Element type	Execution processes									
	Installation of passive reinforcements		Pouring and compaction		Forms and Removing from forms		Concrete curing		Finishing operations	
	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)	C.(1)	C.C.(2)
Foundation elements with volumes less than 350 m^3	50%	10%	50%	10%	50%	10%	50%	10%	50%	10%
Foundation elements with volumes greater than 350 m^3	50%	10%	50%	10%	50%	10%	50%	10%	*50%*	*10%*
Elevations of pillars and walls in building	15	3	3	1	1	1	3	1	3	1
Beams, slabs and other elements work by flexure in building Top and bottom slab frames	50%	10%	50%	10%	50%	10%	50%	10%	50%	10%

(1) C.: Control = Control of the builder in option B of control defined in Article 17 this Code or Project Manager's control in option A of control defined in Article 17 of this Code

(2) C.C: External comparative control of the project management, only in control option B defined in Article 17 of this Code

In any case, depending on the characteristics of the work, the facultative management may adapt the verification frequencies indicated in this section. Thus, for example, in the case of engineering works of minor importance and also building works without any special structural complexity (made of conventional beams, pillars and floors, not prestressed, with openings of up to 6.00 metres and a number of storeys no greater than ten), where a normal control level is carried out, the Project Manager may opt to modify the checking frequencies by applying table A15.2.2.c, which indicates the minimum verifications to be carried out in each execution process for the acceptance of each batch.

Table A15.2.2.c Checking frequencies for a normal control level: Simplified option.

Normal control level		
Execution processes	Control(1)	External comparative control(2)
Warehousing management control	50 % stock pile ordered by material, method of supply, manufacturer and batch supplied	Stock corresponding to 2 materials, method of supply, manufacturer and batch supplied
Setting out.	Setting out corresponding to 20% of each storey or level to be constructed	Setting out corresponding to 10% of each storey or level to be constructed
Falsework	3000 m^3 of falsework	3000 m^3 of falsework
Cut of plans for reinforcements designed in accordance with the design	Plans corresponding to one reinforcement consignment.	Plans corresponding to one reinforcement consignment.
Elaboration of reinforcements by means of ties or non-resistant welding (including processes of straightening, cutting, bending and reinforcement, where appropriate	2	1
Removing the falsework	3000 m^3 of falsework	3000 m^3 of falsework
Joining of precast elements	3	1
Forms and Removing from forms	50% of the elements (in wall, one element will be considered every 5m of wall, in floors 50m^2).	10% of the elements (in wall, one element will be considered every 5m of wall, in floors 50m^2).
Installation of passive reinforcements	Installation of passive reinforcements of 50% of the elements. In the case of pillars and walls, minimum 15 elements (in reinforcing wall corresponding to 5m of wall).	Installation of passive reinforcements of 10% of the elements. In the case of pillars and walls, minimum 3 elements (in reinforcing wall corresponding to 5m of wall).
Pouring and compaction	Concrete corresponding to 50% of the elements (in the pouring wall corresponding to 5m, in slabs, 50 m^2).	Concrete corresponding to 10% of the elements (in the pouring wall corresponding to 5m, in slabs, 50 m^2).
Concrete curing	Surface of 50% of the elements (in wall, one element will be considered every 5m of wall, in floors, 50 m^2).	Surface of 10% of the elements (in wall, one element will be considered every 5m of wall, in floors, 50 m^2).
Finishing operations	Surface of 50% of the elements (in wall, one element will be considered every 5m, in floors, 50 m^2).	Surface of 10% of the elements (in wall, one element will be considered every 5m, in floors, 50 m^2).

(1) Control = Control of the builder in option B of control defined in Article 17 this Code or Project Manager's control in option A of control defined in Article 17 of this Code

(2) External comparative control of the project management, only in control option B defined in Article 17 of this Code

Annex 16
Tolerances in steel elements

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1. Tolerances

The steel elements manufactured in the workshop must have CE marking, and therefore, their dimensional tolerances must comply with the provisions of the harmonized standard UNE-EN 1090-1.

For the rest of the elements, the provisions of this annex must be complied with.

Tolerances are classified as:

- normal tolerances
- special tolerances

Normal tolerances are those that are specified in this Code. The permitted deviations given must not be exceeded under any circumstances, since doing so would compromise the resistance and stability of the structure, bearing the essential tolerances in mind.

The tables further on show other, stricter, deviations within the maximum permitted deviations, compliance with which would allow 1.00 instead of 1.05 as the partial safety factor for γM0 and γM1 for all types of structure, in section 6.1 (1) of Annex 22.

The special tolerances are stricter, and apply to cases where requirements relating to adjustment, finish, aesthetic appearance or operating conditions have to be met. In special cases for assembly, or in order to increase safety or serviceability of structural members, it may be necessary to use special tolerances.

The Special Technical Specifications must give the design tolerances. In the case of special tolerances, it is necessary to stipulate to which members the tolerances apply.

1.1 Normal tolerances. General

The normal tolerances are given in the tables in this Chapter. It must be understood that these are requirements for final acceptance of the structure; the tolerances of pre-fabricated members that are fitted on site are therefore subject to the final check on the executed structure.

If the permitted deviation limits (the tolerance value) result in non-compliance, they should be dealt with in accordance with Chapters 5, 22, 23 and 24 of this Code.

An uncorrected deviation from the essential tolerances may be justified by redesigning the structure, explicitly including the deviation value.

Tolerances for measurements or dimensions and the shape of flat steel products obtained from cold-forming are given in UNE-EN 10131.

The deviations permitted for straight sections of hot-finished structural members are those specified in the following standards: UNE-EN 10024, UNE-EN 10034, UNEEN 10051, UNE-EN 10056-2, UNE-EN 10079, UNE-EN 10279, UNE-EN 10029, UNE-EN 10210-2.

The deviations permitted for straight sections of cold-finished structural members are those specified in standard UNE-EN 10219-2.

1.2 Normal tolerances. Manufacturing

Where standard products are added to a member, the stricter tolerances shall apply to the assembly. Every single product must comply with its own relevant standard:

a) the standards for beams in the case of reinforced sections welded to rolled profiles;

b) standard UNE-EN 10162 for cold-formed profiles. Table A16.1.2a applies to press manufacture;

c) Tables A16.1.2.b and A16.1.2.c for manufactured members;

d) shells of revolution in accordance with the specific execution classes for this type of structure (not contemplated in this Code), shall have the tolerances given in Annex D to EN 1090-2;

e) the permitted deviation is 2 mm for the position of bolt-holes, both individually and as a group;

f) Table A16.1.2.d for cold-formed ribbed sheets.

Table A.16.1.2a. Essential manufacturing tolerances cold-formed profiles

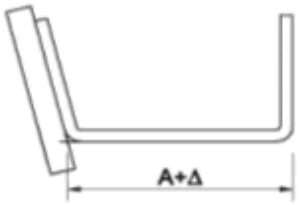
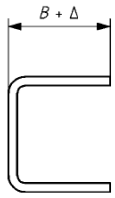
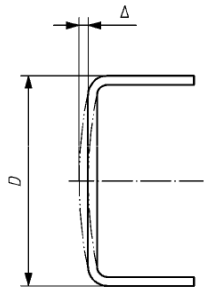
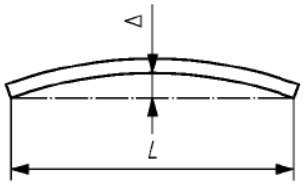
No	Criterion	Parameter	Permitted deviation
1	Internal elements width 	Width A between bends	-Δ=A/50 (note negative sign) Stricter deviation: |Δ|=A/80
2	External element width 	Width B between a bend and free edge	-Δ=B/80 (note negative sign) Stricter deviation: |Δ|=B/100
3	Flatness 	Convexity or concavity	|Δ|=D/50 Stricter deviation: |Δ|=D/80
4	Straightness of compressed parts 	Eccentricity Δ	|Δ|=L/750 Stricter deviation: |Δ|=L/1 000

Table A16.1.2b. Essential manufacturing tolerances for reinforced beams

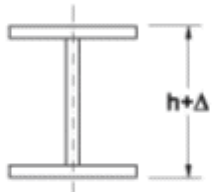
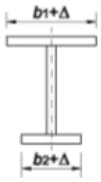
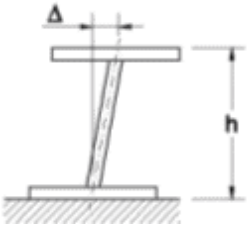
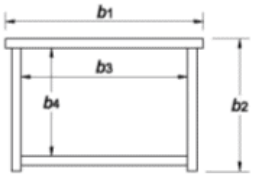
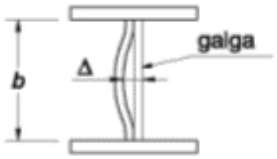
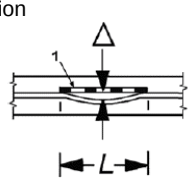
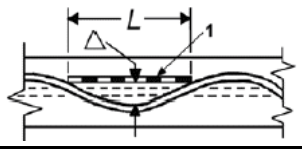
No	Description	Parameter	Permitted deviation
1	Edge 	Total edge h	-Δ=h/50 (note negative sign) Stricter deviation: -Δ=h/100
2	Width 	Flange width: b1 or b2	-Δ=b/100 (note negative sign) Stricter deviation: -Δ=h/150
3	Perpendicularity of supports 	Total web eccentricity for members without stiffened supports	|Δ|=h/200 but |Δ| ≥ t_w Stricter deviation: |Δ|=h/300
4	Width 	External or internal dimensions where b=b1 b2 b3 or b4	-Δ=b/100 (note negative sign) Stricter deviation: -Δ=b/150
5	Plate curvature 	Deviation Δ over plate height b	Δ= ± b/200 if $b/t \leq 80$ Δ= ± b^2/(1600 t) if $80<b/t \leq 80$ Δ= ± b/80 if $b/t > 200$ but |Δ| ≥ t Stricter deviation: |Δ|=b/150
6	Web distortion 	Deviation Δ on gauge length L equal to plate length web b	|Δ|=b/100 but |Δ| ≥ t Stricter deviation: |Δ|=b/100
7	Web undulation 	Deviation Δ on gauge length L equal to plate length b	|Δ|=b/100 but |Δ| ≥ t_w Stricter deviation: |Δ|=b/150
N.B. Notations such as |Δ|=b/100 but |Δ| ≥ t mean that the larger of the two values is permitted			

Table A16.1.2.b (continued). Essential manufacturing tolerances for reinforced beams

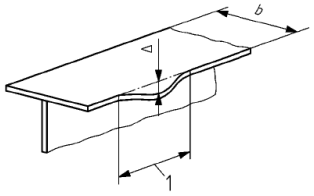
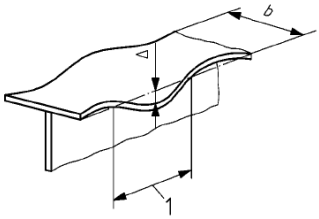
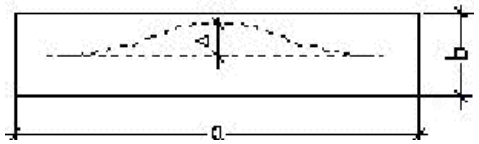
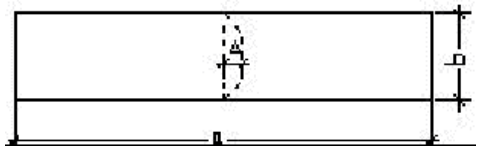
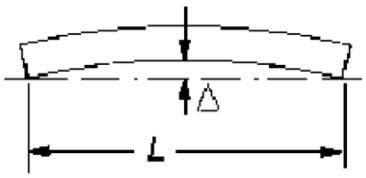
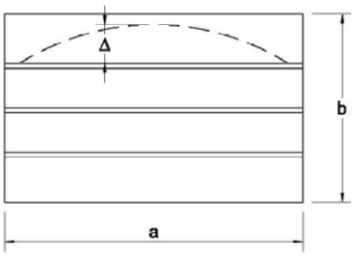
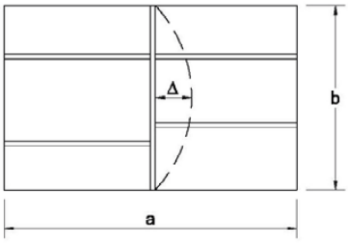
No		Parameter	Permitted deviation
8	Flange distortion of in I sections 	Deviation on gauge n Δ length L where L= flange width b	Δ= ± b/150 if $b/t \leq 20$ Δ= ± $b^2/(3000t)$ if $b/t > 20$ No more stricter deviation is required.
9	Flange undulation of I sections 	Distortion on gauge Δ length L where L= flange width b	Δ= ± b/150 if $b/t \leq 20$ Δ= ± $b^2/(3000t)$ if $b/t > 20$ No more stricter deviation is required.
10	Out of plane imperfection of plate panels between webs or stiffeners (general case) 	Distortion Δ perpendicular to the t plane of the plate if a≤2b if a>2b	|Δ|=a/250 |Δ|=b/125 No more stricter deviation is required.
11	Out of plane Imperfections of the plate panels between webs or stiffeners (special case with transverse compression) The general case applies unless this special case is specified 	Distortion Δ perpendicular to the t plane of the plate if b≤2a if b>2[a]	|Δ|=b/250 |Δ|=a/125 No more stricter deviation is required.
12	Straightness for components to be used unrestrained 	Deviation y Δ from straightness	|Δ|=L/750 Stricter deviation: |Δ|=L/1000

Table A16.1.2.c. Essential manufacturing-stiffened plating tolerances

<table>
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Longitudinal stiffeners in longitudinally stiffened plating</td><td>

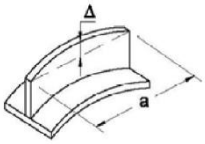
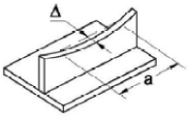
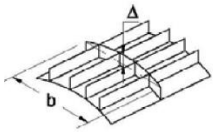
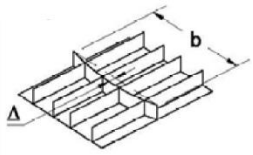
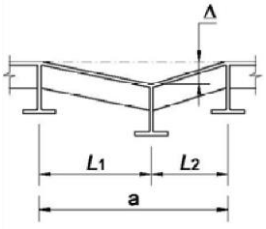
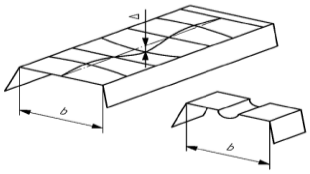
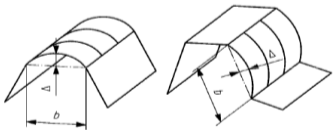
Transverse stiffeners in longitudinally and transversely plating</td></tr>
<tr><td>No</td><td>Criterion</td><td>Parameter</td><td>Permitted deviation</td></tr>
<tr><td>1</td><td rowspan="2">Straightness of longitudinal stiffeners in longitudinally stiffened plating</td><td>Deviation perpendicular to the plate

</td><td>$|\Delta| = a/400$
Stricter deviation: a/500</td></tr>
<tr><td>2</td><td>Deviation parallel to the plate

</td><td>$|\Delta| = a/400$
Stricter deviation: a/500</td></tr>
<tr><td>3</td><td rowspan="2">Straightness of transvers stiffeners in Transversely and longitudinally stiffened plating</td><td>Deviation perpendicular to the plate

</td><td>$|\Delta| = a/400$
$|\Delta| = W400$
Stricter deviation: a/500</td></tr>
<tr><td>4</td><td>Deviation parallel to the plate

</td><td>$|\Delta| = b/400$
Stricter deviation: a/500</td></tr>
<tr><td>5</td><td>Alignment of beams or transversal stiffeners</td><td>Relative difference in level between contiguous stiffeners

</td><td>$|\Delta| = a/400$
Stricter deviation: a/500</td></tr>
</table>

Table A16.1.2d. Essential manufacturing tolerances for cold-formed profiled sheets

No	Criterion	Parameter	Permitted deviation
1	Flatness of unstiffened or stiffened flanges or webs, 	Deviation Δ from flatness of nominally flat element	$\|\Delta\| \le b/50$ Stricter deviation: $\|\Delta\| = b/80$
2	Curvature of flanges or webs 	Deviation Δ from intended shape of e web or flange over curve width b	$\|\Delta\| \le b/50$ Stricter deviation: $\|\Delta\| = b/80$

1.3 Normal Tolerances. Assembly

Erection Deviations in fitted members should be measured relative to a grid of predetermined fixed points.

No deviation more than ± 6 mm is permitted for the centre of a group of anchor bolts or other type of support base.

The centre of a pillar or column may not deviate by more than ± 5 mm from its theoretical plane position.

It is advisable to have bolt-holes in the base plate with adequate clearance (pierced or of larger diameter) in order for this requirement to be met more easily. In such case, larger washers must be used.

The level of the base plates may not deviate by more than ± 5 mm.

The tolerances for the assembly of pillars are given in Tables A16.1.3.a and A16.1.3.b.

The arithmetical mean value of 6 contiguous pillars in a building with several planes must comply with Table A16.1.3.b in both directions (orthogonal frames).

In a group of 6 pillars that comply with this tolerance, an individual deviation of h/100 may be permitted.

The deviation between lines of adjacent pillars shall be within the tolerance of ± 5 mm of theoretical dimension.

This theoretical grid shall be set out before assembly commences.

Where it is anticipated that the groups of bolts will be displaced or misaligned from the theoretical lines, the deviation of ± 6 mm shall apply to displacement in relation to the network of pillars thus formed.

The length standing out from an anchor bolt (in its optimal adjustment position, if it can be adjusted) shall be vertical to within a range of 1 mm to 20 mm. A similar requirement shall apply to a set of horizontal bolts and other angles.

Holes for settling and fixing plates shall be designed bearing in mind the clearances consistent with the permitted deviations for the bolts.

Pillars adjacent to lift shafts may require special tolerances.

Table A16.1.3a. Essential erection- Single storey columns tolerances

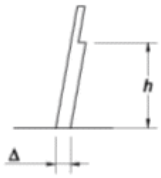
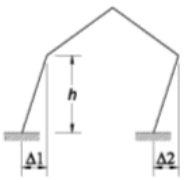
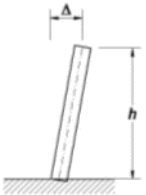
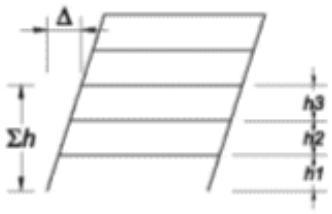
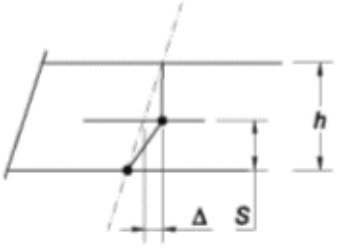
No	Criterion	Parameter	Permitted deviation
1	Inclination of any column that supports a crane gantry a track 	Inclination from floor level to bearing of crane beam	$\lvert\Delta\rvert$=h/1 000 No more stricter deviation is required.
2	Inclination of pillars for frames without bridge cranes 	Most unfavourable inclination of the pillars for each frame Δ=(Δ1+Δ2)/2	$\lvert\Delta\rvert$=h/500 No more stringent deviation is required.
3	Inclination of single- storey columns generally 	Overall inclination in storey height h	$\lvert\Delta\rvert$=h/300 Stricter deviation: $\lvert\Delta\rvert$=h/500
4	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom: Generally structural hollow sections Deviation Δ	$\lvert\Delta\rvert$=h/750 Stricter deviation: $\lvert\Delta\rvert$=h/1 000

Table A16.1.3b. Essential erection – Multi-storey columns tolerances

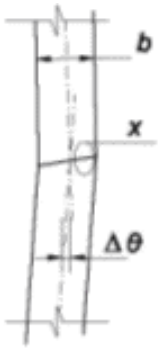
No	Criterion	Parameter	Permitted deviation
1	Combined inclination 	Overall inclination in relation to their base	$\lvert\Delta\rvert = \sum h / \left(300\sqrt{n}\right)$ No more stricter deviation is required.
2	Inclination of a column between adjacent storey levels 	Overall inclination in relation to the bottom	$\lvert\Delta\rvert$=h/500 No more stricter deviation is required.
3	Straightness of a continuous column between adjacent storeys 	Maximum eccentricity in relation to the directrix	$\lvert\Delta\rvert$=h/750 Stricter deviation: $\lvert\Delta\rvert$=h/1 000
4	Straightness of a spliced column with links between adjacent storeys levels 	Eccentricity in the link in relation to the directrix	$\lvert\Delta\rvert$=h/750 Stricter deviation: $\lvert\Delta\rvert$=h/1 000

1.3.1 Total contact supports

Where a total contact support is specified, the surfaces shall be arranged so that when the support and bars that are in contact are aligned locally within an angular deviation of 1 in 1 000, the maximum clearance between the contact surfaces shall not exceed 1 mm locally, nor shall it exceed 0.5 mm throughout at least two-thirds of the contact area, as shown in Table A16.1.3c.

Where the size of the clearance exceeds the specified limits but is not less than 6 mm, wedges or blocks may be used to reduce such clearance to the permitted deviation limits. The wedges shall be made of rubber tyres or strips of mild steel (with low carbon content).

Table A16.1.3c. Mounting tolerances for total contact supports

No	Criterion	Parameter	Permitted deviation
1		Local angular misalignment Δθ that occurs at the same time as the separation distance Δ at point "X"	Δθ= ±1/500 No more stricter deviation is required.
2		Gap at x	|Δ| =0.5 mm over at least two-thirds of the c area, and a local maximum of 1 mm No more stricter deviation is required.

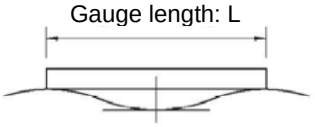
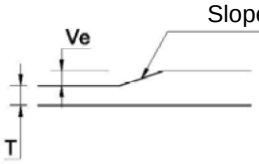
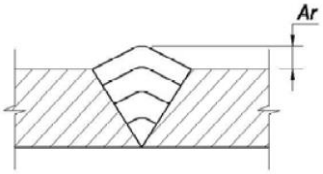
1.4 Normal tolerances for bridges

Supports/piles for bridges shall comply with a tolerance of ± 5 mm on the vertical and the plane.

The webs of main beams shall comply with a tolerance of edge verticality/300.

Other tolerances specific to bridges are given in Table A16.1.4.

Table A16.1.4. Functional erection tolerances for bridges

No	Criterion	Parameter	Permitted deviation
1	Span length	Deviation Δ of distance between two consecutive supports, measured on top of upper flanges	Δ= ± (30+L/10000)
2	Elevation or plan profile bridge	Deviation Δ from nominal profile adjusted for as-built levels of supports L ≤ 20 m: L > 20 m:	|Δ| =±(L/1 000) |Δ| =±(L/2 000+10 mm)≤35 mm
3	Fit-up of orthotropic decks of thickness T after erection Gauge length: L  Deviation: Pr Slope : Dr 	Difference in level at junction: T ≤ 10 mm: 10 mm < T < 70 mm: T > 70 mm: Slope at junction T ≤ 10 mm: 10 mm < T < 70 mm: T > 70 mm: Flatness in all direction: T ≤ 10 mm; T > 70 mm; General case: Lengthwise: N.B. values for Pr may be interpolated for 10 mm <T ≤ 70 mm:	Ve= 2 mm Ve= 5 mm Ve= 8 mm Dr = 8 % Dr = 9 % Dr = 10 % Pr = 3 mm over 1 m Pr = 4 mm over 3 m Pr = 5 mm over 5 m Pr = 5 mm over 3 m Pr = 18 mm over 3 m
4	Orthotropic deck welding 	Protrusion A_r of weld above surrounding surface	Ar = +1 / -0 mm

1.5 Special tolerances

For special tolerances, it is recommended that the supplementary tolerances in Annex D to EN 1090-2 be followed. These set out two levels or classes for manufacture and assembly.

It should be stated to which members the tolerances apply, since they may be used for a single member or also a set.

In some cases where Annex D is cited without specifying the tolerance class, it is to be understood as meaning tolerance 1, which is less strict than class 2.

An example of tolerance class 2 being applied is where a glazed facade is assembled, so as to reduce clearances and improve adjustment.

It should be keep in mind that, in order to specify the supplementary tolerance class (especially class 2), the beams and lintels of moving frames may have relatively large deflection and shift.

Apart from bars that are subjected to dynamic forces, the applicable tolerance may be one five-hundredth of its length.

Annex 17

Checking frequencies of the inspection units in the execution of steel structures

Content

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2 CHECKING FREQUENCIES OF THE INSPECTION UNITS 3

2.1 CHECKING FREQUENCIES DEPENDING ON THE EXECUTION PROCESS 4
2.2 CHECKING FREQUENCIES DEPENDING TO THE TYPE OF WELDING 6

1 Introduction

Project Manager shall implement the execution control of the steel structures, by means of one of the two options admitted in Article 17.

In option A, the execution control shall be carried out by the Project Manager itself, assisted, where appropriate, by an independent control agent who develops his activity for the facultative management.

In option B, the control of the execution of each execution batch and inspection unit shall be carried out by the constructor, and the Project Manager, assisted or not by an independent control agent, will perform a contrast control of the constructor's control.

This annex includes, in an indicative manner, the checking frequencies for the different inspection units, defined in section 101.2. These frequencies shall be adapted to the characteristics of the work and to the means available in it, so that the Project Manager, on its own initiative or at the proposal of the constructor, may authorize values different from those included in this annex.

2 Checking frequencies of the inspection units

In the case that the execution control is organized according to option B defined in Article 17, for each process or execution activity included in a execution batch, the Constructor Control (defined in the following tables simply as Control) will develop the control of the execution with minimum verification frequencies obtained according to the number of inspection units, the execution control level (normal or intensive) and the execution class, according to the indications in tables A17.2.1, A17.2.2.a and A17.2.2.b. For its part, the project management may further develop a contrast control, by performing checks whose number will also be a function of the number of inspection units, the level of control and the type of execution, according to the criteria of the aforementioned tables.

In the event that the control of the execution is organized through option A defined in Article 17 of this Code, the Control shall be carried out by the Project Manager in the terms described in said article, and therefore it will not be necessary for the project management itself optional perform additional contrast checks.

2.1 Checking frequencies depending on the execution process

Table A17.2.1 Checking frequencies for the execution processes included in table 101.2

Execution processes and activities	Minimum number of inspection units controlled per execution batch			
	Normal control		Intensive control	
	Builder's control	External control of project management	Builder's self-check	External control of project management
Warehousing management control	100%	3	100%	20%, with a minimum of 3
Review of workshop plans	25%	3	100%	20%
Handling of steel products at the workshop	50% (3)	10%	100% (3)	25% (1)
Assembly of elements in the workshop, including dimensional control, as well as the check on mechanical fixings and welds	50% (3)	10%	100% (3)	25% (2)
Adjustments, corrections and final finishes	50%	10%	100% (3)	25% (2)
Visual inspection of elements that arrive at the work	100%	10%	100%	25% (2)
Qualification of welders and welding procedures	100%	100%	100%	100%
Welds	According to table A17.2.2.a	According to table A17.2.2.a	According to table A17.2.2.a	According to table A17.2.2.a
Setting out	5	3	100%	20%
Qualification of fixings procedures with mechanical elements	100%	100%	100%	100%
Execution of fixings with mechanical elements for assembly	50%	10%	100%	25% (2)
Application of protective treatments	25%	10%	100%	25%

(1) This control may be progressively reduced up to 15%, in the case that the control program is developed correctly and satisfactory results are obtained in the inspections carried out.

(2) This control may be progressively reduced up to 10%, in the case that the control program is developed correctly and satisfactory results are obtained in the inspections carried out.

(3) In secondary elements, according to the definition expressed in table 101.2, the minimum number of inspection units to be controlled in each execution batch may be reduced up to 25%. In such cases, the contrast control of the project management may also be reduced up to 12%

Comments

Table A17.2.1 defines reference values to define the minimum number of inspection units that must be controlled to check the compliance of each execution batch. However, as already indicated, the inspection units should be defined in the control program according to the type and characteristics of the work, as well as the means available in it. This could advise that the number of inspection units planned for that process, defined in the control program, does not allow the frequencies indicated in table A17.2.1 to be developed. In such cases, it is recommended to adapt the frequencies and minimum number of inspections to the characteristics of the work.

2.2 Checking frequencies depending to the type of welding

Table A17.2.2.a Type and number of tests in the case of welding

Weld type	Test type (1) and control intensity							
	Welding at Workshop, belonging to the construction site (without CE Marking)				Welding on site			
	Normal control		Intensive control		Normal control		Intensive control	
	Builder's Control	External control	Builder's Control (2)	External control	Builder's Control	External control	Builder's Control (2)	External control
Butt-welded chords, in cover plates, webs or elements of responsibility, traction or susceptible to fatigue	RT/UT 100%	RT/UT 10%	RT/UT 100%	RT/UT 20%	RT/UT 100%	RT/UT 10%	RT/UT 100%	RT/UT 20%
Butt-welded chords, in cover plates, webs or elements of responsibility, compressed and not susceptible to fatigue	UT 40%	UT 5%	UT 40%	UT 10%	UT 50%	UT 5%	UT 50%	UT 10%
Angle-welded chords or with partial penetration, in elements of responsibility (braces, sleepers, bulkheads, trusses, etc.), traction or susceptible to fatigue	PM/LP 100%	PM/LP 10%	PM/LP 100%	PM/LP 20%	PM/LP 100%	PM/LP 10%	PM/LP 100%	PM/LP 20%
Angle-welded chords or with partial penetration, in elements of responsibility (bracing, sleepers, bulkheads, trusses, etc.), compressed and not susceptible to fatigue	PM/LP 20%	PM/LP 3%	PM/LP 20%	PM/LP 5%	PM/LP 30%	PM/LP 4%	PM/LP 30%	PM/LP 7%
Butt-welded chords or angle in elements of responsibility, working fundamentally at grade (wing-web union, stiffeners, support bulkheads, etc.)	UT/PM/LP 20%	UT/PM/LP 3%	UT/PM/LP 20%	UT/PM/LP 5%	UT/PM/LP 30%	UT/PM/LP 4%	UT/PM/LP 30%	UT/PM/LP 7%
Angle-welded chords or with partial penetration, in secondary elements (blocks, intermediate stiffeners, cells, bracing, braces, stiffening frames, binding joints, etc.)	PM/LP 10%	PM/LP 3%	PM/LP 10%	PM/LP 5%	PM/LP 10%	PM/LP 3%	PM/LP 10%	PM/LP 5%
Angle-welded chords of connecting bolts	Bending tests	Bending tests	Bending tests 3%	Bending tests 1%	Bending tests 5%	Bending tests 1%	Bending tests 5%	Bending tests 1%

(1) The nomenclature used in the table for the tests is in accordance with UNE-EN ISO 17635:

- LP: penetrating liquids testing, in accordance with UNE-EN ISO 3452-1,
- PM, magnetic particles inspections in accordance with UNE-EN ISO 17638,
- UT: ultrasonic testing in accordance with UNE-EN ISO 17640,
- RT: radiographic testing in accordance with UNE-EN ISO 17636.

(2) Builder's self-check according to section 22.1 of the Structural Code.

Table A17.2.2.b. Checking frequencies on non-destructive tests for the additional checks of the welds, as indicated in section 103.2.2.6

Weld type		Test			
		Welding at Workshop, belonging to the construction site (without CE Marking)		Welding on site	
		C.E. 4 and 3	C.E. 2	C.E. 4 and 3	C.E. 2
Force chords	Butt-welded chords subjected to traction stresses ($k \geq 0,8$) $0,3 < k < 0,8$ $k \leq 0,3$	100 % 50 % 10 %	50 % 20 % 5 %	100 % 100 % 20 %	100 % 50 % 10 %
	Butt-welded chords subjected to compression stress	10 %	5 %	20 %	10 %
	Angle-welded chords.	20 %	10 %	20 %	10 %
	Longitudinal chords	10 %,	5 %	20 %	10 %
Binding joints	Stiffeners, belts, etc.	5 %			

k: Usage factor.

C.E. Execution class.

Comments

When a process or activity is inspected in its entirety, the verification of said process shall be understood as being either part of the Builder's self-control or within the external control of the Project Manager, as the case may be, and independently of the number of inspections that have been made.