SLOVENSKI STANDARD
oSIST prEN 1993-1-10:2023

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Evrokod 3: Projektiranje jeklenih konstrukcij - 1-10. del: Izbira kakovosti jekla glede na žilavost in lamelarni lom

Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-10: Stahlsortenauswahl im Hinblick auf Bruchzähigkeit und Eigenschaften in Dickenrichtung

Eurocode 3 - Calcul des structures en acier - Partie 1-10 : Ténacité du matériau et propriétés dans le sens de l'épaisseur

Ta slovenski standard je istoveten z: **prEN 1993-1-10**

ICS:

91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

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Will supersede EN 1993-1-10:2005

English Version

Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties

Eurocode 3 - Calcul des structures en acier - Partie 1-10 : Choix des qualités d'acier

Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-10: Stahlsortenauswahl im Hinblick auf Bruchzähigkeit und Eigenschaften in Dickenrichtung

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 1993-1-10:2022) has been prepared by Technical Committee CEN/TC 250 “Structural Codes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1993-1-10:2005 and EN 1993-1-10:2005/AC:2009.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

— EN 1990 Eurocode: Basis of structural and geotechnical design

— EN 1991 Eurocode 1: Actions on structures

— EN 1992 Eurocode 2: Design of concrete structures

— EN 1993 Eurocode 3: Design of steel structures

— EN 1994 Eurocode 4: Design of composite steel and concrete structures

— EN 1995 Eurocode 5: Design of timber structures

— EN 1996 Eurocode 6: Design of masonry structures

— EN 1997 Eurocode 7: Geotechnical design

— EN 1998 Eurocode 8: Design of structures for earthquake resistance

— EN 1999 Eurocode 9: Design of aluminium structures

— New parts are under development, e.g. Eurocode for design of structural glass

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1993

EN 1993 (all parts) applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural and geotechnical design.

EN 1993 (all parts) is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

EN 1993 is subdivided in various parts:

EN 1993-1, *Design of Steel Structures — Part 1: General rules and rules for buildings;*

EN 1993-2, *Design of Steel Structures — Part 2: Steel bridges;*

EN 1993-3, *Design of Steel Structures — Part 3: Towers, masts and chimneys;*

EN 1993-4, *Design of Steel Structures — Part 4: Silos and tanks;*

EN 1993-5, *Design of Steel Structures — Part 5: Piling;*

EN 1993-6, *Design of Steel Structures — Part 6: Crane supporting structures;*

EN 1993-7, *Design of steel structures — Part 7: Design of sandwich panels.*

EN 1993-1 in itself does not exist as a physical document, but comprises the following 14 separate parts, the basic part being EN 1993-1-1:

EN 1993-1-1, *Design of Steel Structures — Part 1-1: General rules and rules for buildings;*

EN 1993-1-2, *Design of Steel Structures — Part 1-2: Structural fire design;*

EN 1993-1-3, *Design of Steel Structures* — Part 1-3: *Cold-formed members and sheeting*;

NOTE Cold-formed hollow sections supplied according to EN 10219 (all parts) are covered in EN 1993-1-1.

EN 1993-1-4, *Design of Steel Structures* — Part 1-4: *Stainless steels*;

EN 1993-1-5, *Design of Steel Structures* — Part 1-5: *Plated structural elements*;

EN 1993-1-6, *Design of Steel Structures* — Part 1-6: *Strength and stability of shell structures*;

EN 1993-1-7, *Design of Steel Structures* — Part 1-7: *Strength and stability of planar plated structures transversely loaded*;

EN 1993-1-8, *Design of Steel Structures* — Part 1-8: *Design of joints*;

EN 1993-1-9, *Design of Steel Structures* — Part 1-9: *Fatigue strength of steel structures*;

EN 1993-1-10, *Design of Steel Structures* — Part 1-10: *Selection of steel for fracture toughness and through-thickness properties*;

EN 1993-1-11, *Design of Steel Structures* — Part 1-11: *Design of structures with tension components made of steel*;

EN 1993-1-12, *Design of Steel Structures* — Part 1-12: *Additional rules for steel grades up to S960*;

EN 1993-1-13, *Design of Steel Structures* — Part 1-13: *Beams with large web openings*;

EN 1993-1-14, *Design of Steel Structures* — Part 1-14: *Design assisted by finite element analysis*.

All parts numbered EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type such as structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, etc.

All parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type such as steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to EN 1993-1-10

EN 1993-1-10 gives general design rules for the selection of steel qualities to avoid brittle fracture by specifying toughness properties and to avoid lamellar tearing by specifying through-thickness properties.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National annex for EN 1993-1-10

National choice is allowed in this standard where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1993-1-10 can have a National annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1993-1-10 through notes to the following:

4.2.1 (4)	4.2.2.3 (1)	4.2.3 (5)	4.3 (3)
4.4 (3)	5.1 (2)	A1 (1)	

National choice is allowed in EN 1993-1-10 on the application of the following informative annexes:

Annex A

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1993-1-10

(1) EN 1993-1-10 provides rules for the selection of steel grades and qualities related to fracture toughness to avoid brittle fracture.

NOTE Steel toughness quality is also known as subgrade.

(2) EN 1993-1-10 provides rules to specify through thickness properties for welded elements to reduce the risk of lamellar tearing.

(3) EN 1993-1-10 contains additional toughness requirements for specific cases to ensure upper shelf toughness in relation to design ultimate resistance in tension and seismic design.

(4) This document provides rules for structural steels as listed in FprEN 1993-1-1:2022. This document applies to steel grades S235 to S700.

(5) This document provides rules that apply to the selection of parent material only.

(6) This document provides rules that apply to steel materials covered by FprEN 1993-1-1:2022, 5.1 (3), provided that each individual piece of steel is tested in accordance with the requirements of FprEN 1993-1-1:2022, 5.1 (3), and EN 1090-2:2018, 5.1.

(7) This document does not apply to material salvaged from existing steelwork subjected to fatigue or fire.

1.2 Assumptions

(1) Unless specifically stated, EN 1990, EN 1991 (all parts) and the other relevant parts of EN 1993-1 (all parts) apply.

(2) The design methods given in EN 1993-1-10 are applicable if:

— the execution quality is as specified in EN 1090-2 or EN 1090-4, and

— the construction materials and products used are as specified in the relevant parts of EN 1993 (all parts), or in the relevant material and product specifications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. through 'should' clauses) and permissions (i.e. through 'may' clauses).

EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*

EN 1090-4, *Execution of steel structures and aluminium structures - Part 4: Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, ceiling, floor and wall applications*

EN 1990, *Eurocode - Basis of structural design*

EN 1991 (all parts), *Eurocode 1* — Actions on structures

EN 1993 (all parts), *Eurocode 3* — Design of steel structures

FprEN 1993-1-1:2022, *Eurocode 3 —Design of steel structures — Part 1-1: General rules: General rules and rules for buildings*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
***KV*-value**
Charpy V-notch value
impact energy in Joules [J] required to fracture a Charpy V-notch specimen at a given test temperature *T* (i.e. T_{KV})

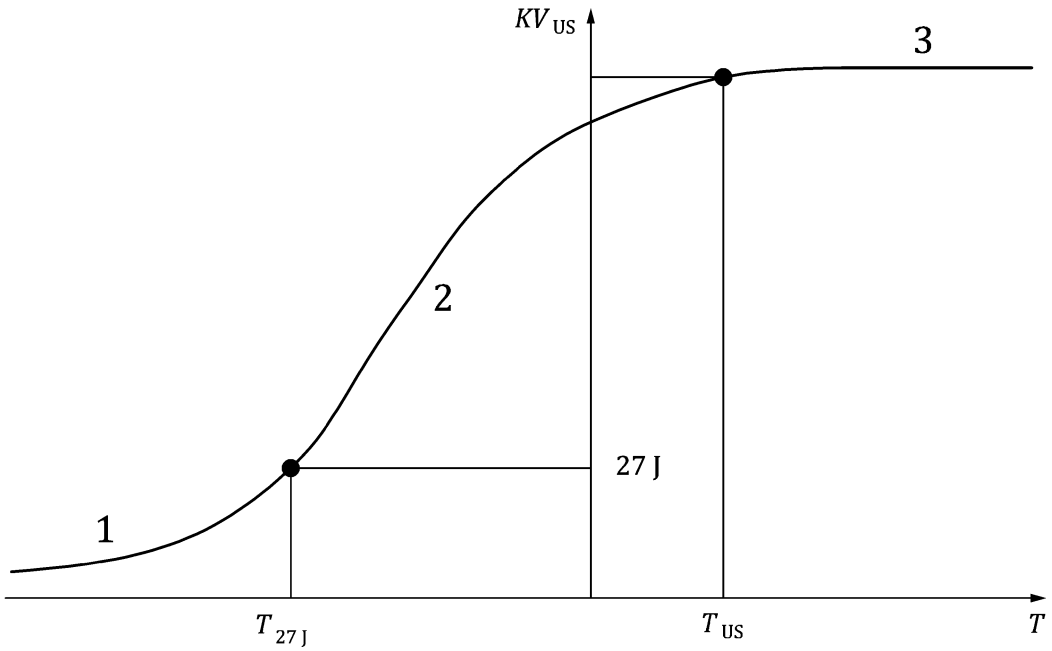
3.1.2
transition region
region of the toughness-temperature diagram showing the relationship *KV(T)* in which the material toughness decreases with the decrease in temperature and the failure mode changes from ductile to brittle

Note 1 to entry See region 2 on Figure 3.1.

3.1.3
lower shelf region
region of the impact energy-temperature diagram in which the Charpy V-notch test specimen exhibits cleavage (brittle) modes of failure, See region 1 on Figure 3.1

3.1.4
upper shelf region
region of the toughness-temperature diagram in which the Charpy V-notch test specimen exhibits ductile modes of failure

Note 1 to entry: See region 3 on Figure 3.1



Key

1 lower shelf region

2 transition region

3 upper shelf region

NOTE Charpy transition temperature can also be T_{30J} or T_{40J} – corresponding to Charpy energy values of 30J or 40J. For an explanation of T_{27J} and T_{US} see the list of symbols.

Figure 3.1 — Example of relationship between temperature and Charpy V-notch impact energy

3.1.5
charpy transition temperature
minimum temperature in the transition region, at which the material behaviour changes from ductile to brittle

3.1.6
***Z*-value**
transverse reduction of area of a specimen in a tensile test in through-thickness direction (see EN ISO 6892-1 and EN 10164) to indicate the through-thickness ductility of a specimen, measured as a percentage

3.1.7
degree of cold forming
permanent strain from cold forming measured as a percentage

3.1.8
reference temperature
value of the lowest service steel temperature modified by temperature shifts to account for the crack geometry, the construction detail, the reliability, the strain rates and cold forming as required

3.2 Symbols and abbreviations

3.2.1 Latin upper-case symbols

$CTOD$	crack tip opening displacement
J	elastic plastic fracture toughness value (J-integral value) in N/mm determined as a line or surface integral that encloses the crack front from one crack surface to the other
K	stress intensity factor in $N/mm^{3/2}$
K_{Ic}	plane strain fracture toughness for linear elastic behaviour measured in $N/mm^{3/2}$
$KV(T)$	impact energy in Joule [J] in a test at temperature T_{KV} with Charpy V notch specimen
KV_{US}	impact energy in Joule [J] in a test at temperature T_{US} with Charpy V notch specimen
T	temperature [°C]
T_{Ed}	reference temperature (see 4.2.1)
T_{27J}	transition temperature at which an energy KV should not be less than 27J according to the relevant product standard in a Charpy V-notch impact test
T_{30J}	transition temperature at which an energy KV should not be less than 30J according to the relevant product standard in a Charpy V-notch impact test
T_{40J}	transition temperature at which an energy KV should not be less than 40J according to the relevant product standard in a Charpy V-notch impact test
T_{KV}	impact test temperature for a minimum specified impact energy KV in Joule [J] in a Charpy V-notch test [°C]
$T_{N,min}$	minimum steel temperature [°C] of a member in service with a return period of 50 years for air temperature recommended depending on the type of structure and including a radiation loss
T_{US}	lowest temperature [°C] at which the shear fracture appearance is 100 % in a Charpy V-notch impact test, taken as the starting point of upper shelf region (see 4.3)
Z	Z-quality class [%] differentiated by increasing levels of Z-value (see 5.2)
Z_{Ed}	required design Z-value resulting from the magnitude of strains from restrained metal shrinkage under the weld beads
Z_{Rd}	available design Z-value depending on through thickness properties of the material

3.2.2 Latin lower-case symbols

f_y	yield strength
$f_{y,nom}$	nominal yield strength
t	thickness
t_{max}	maximum permissible element thickness

3.2.3 Greek upper-case symbols

ΔT_R	safety allowance [K], if required, to reflect different reliability levels for different applications
$\Delta T_{\dot{\varepsilon}}$	temperature shift [K] considering a strain rate other than the reference strain rate $\dot{\varepsilon}_0$

$\Delta T_{\varepsilon_{cf}}$ temperature shift [K] considering the degree of cold forming ε_{cf} or ε_{eff}

ΔT_{σ} temperature shift [K] considering stress and yield strength of material, crack imperfection and member shape and dimensions, see 4.2.3 (3)

3.2.4 Greek lower-case symbols

ε_{cf} degree of cold forming (*DCF*) in percent

$\dot{\varepsilon}$ strain rate [1/s]

$\dot{\varepsilon}_0$ reference strain rate [1/s]

ε_{eff} effective strain is the average value of plastic strain in the net section

ε_{pnom} plastic strain to be used for cold bends in hollow sections

σ_{Ed} stresses accompanying the reference temperature T_{Ed}

4 Selection of materials to avoid brittle fracture

4.1 General rules

(1) To avoid brittle fracture, the selection of materials shall be in accordance with the general rules given in EN 1990 and EN 1991 (all parts) and the specific design provisions for steel structures given in the other relevant parts of EN 1993-1 (all parts).

(2) The execution shall be in accordance with the requirements in EN 1090-2 or EN 1090-4.

(3) The rules in Clause 4 are applicable to elements and details subject to tensile stresses obtained using combination in Formula (4).1).

(4) The rules in Clause 4 may be applied for elements not subject to tension stresses because the rules are conservative in this situation. For elements under compression stress a minimum toughness property may be determined for a nominal stress of $\sigma_{Ed} = 0{,}25\, f_y(t)$.

(5) Steel product standards specify that test specimens shall not fail at an impact energy lower than a specified energy *KV* at a specific test temperature T_{KV}.

(6) The rules should be applied to the minimum impact energy KV_2 for the specified grade listed in the relevant steel product standard. New material of a less onerous quality (sub-grades) should not be used even though test results show equivalent or better values of impact energy.

(7) The rules contained in 4.1 refer to lower shelf toughness and the transition region, see 4.2. Additional rules for upper shelf toughness in relation to design ultimate resistance in tension and seismic design are given in 4.3 and 4.4 respectively.

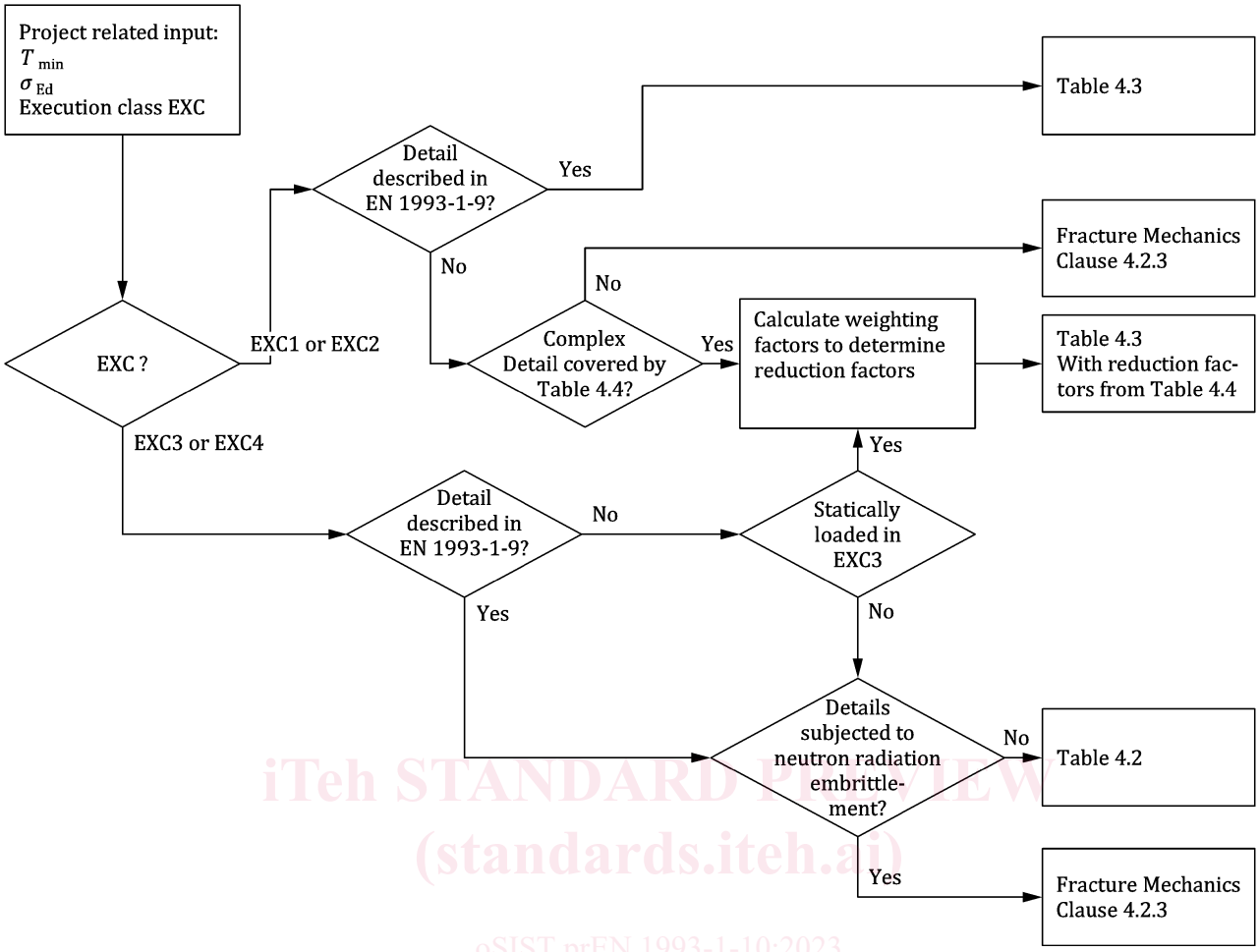
(8) The selection of a design procedure for brittle fracture assessment shall be made as shown in Figure 4.1.

NOTE The selection is based on temperature (see Formula (4).2)), stress (see Formula (4).1)) and execution classes as defined in FprEN 1993-1-1:2022, Annex A.

(9) For fatigue loaded elements in EXC 2, a reduction factor of 0,5 according to Table 4.5 should be applied to the thickness values of Table 4.3.

(10) For welded elements in EXC 3 not covered by detailed tables related to nominal stress methods in EN 1993-1-9, and which are statically loaded, 4.2.2.3 should be applied.

(11) For details subjected to neutron radiation embrittlement, e.g. structures of nuclear power plants, their toughness should be determined using fracture mechanics according to 4.2.3.



NOTE Table 4.2 for EXC3 and EXC4 was developed mainly for fatigue loaded elements and Table 4.3 for EXC1 and EXC2 was developed mainly for static loaded elements.

Figure 4.1 — Flowchart of material selection procedures for brittle fracture assessment

4.2 Toughness requirements for the lower shelf and the transition region

4.2.1 Procedure

(1) The steel quality should be selected taking account of the following:

(i) steel material properties:

- yield strength depending on the material thickness $f_y(t)$
- toughness quality expressed in terms of T_{27J}, T_{30J} or T_{40J}

(ii) member characteristics:

- member shape and detail
- stress concentrations according to the details geometry and loaded element thickness (t)
- appropriate assumptions for fabrication flaws (e.g. as through-depth cracks or as semi-elliptical surface cracks)

(iii) design situations:

- design value of minimum steel temperature
- maximum applied stresses from permanent and variable actions derived from the design condition described in (4) below
- residual stress
- assumptions for crack growth from fatigue loading during an inspection interval (if relevant)
- strain rate $\dot{\varepsilon}$ from accidental actions (if relevant)
- degree of cold forming (ε_{cf} and ε_{eff}) (if relevant)

(iv) Execution Class according to FprEN 1993-1-1:2022, Annex A.

(2) The maximum permissible thickness of steel elements for fracture should be obtained from Table 4.2 and Table 4.3.

(3) The following design condition should be used:

(i) The maximum nominal applied stress σ_{Ed} should be obtained according to the combination of actions in Formula (4).1):

$$E_d = E\ \{\ A[T_{Ed}]\ \text{“+”}\ \sum G_K\ \text{“+”}\ \psi_1\ Q_{K1}\ \text{“+”}\ \sum \psi_{2,i}\ Q_{Ki}\ \} \qquad (4.1)$$

where:

A is the leading action represented by the reference temperature T_{Ed} that influences the toughness of material of the member considered and might also lead to stress from restraint of movement,

$\sum G_K$ are the permanent actions,

$\psi_1\ Q_{K1}$ is the frequent value of the variable load and

$\psi_{2i}\ Q_{Ki}$ are the quasi-permanent values of the accompanying variable loads, that govern the level of stresses on the material.

(ii) The combination factors ψ_1 and ψ_2 should be in accordance with EN 1990.

(iii) The maximum applied stress σ_{Ed} should be the maximum nominal design tensile stress at the location of the potential fracture initiation. The applied stress σ_{Ed} shall be determined by elastic analyses. Second order effects should be considered where relevant.

NOTE 1 The combination in Formula (4).1) is considered to be equivalent to an accidental combination, because of the assumption of simultaneous occurrence of lowest temperature, flaw size, location of flaw and material property.

NOTE 2 σ_{Ed} can include stresses from restraint of movement from temperature change.

NOTE 3 As the leading action is the reference temperature T_{Ed}, the maximum applied stress σ_{Ed} generally will not exceed 75 % of the yield strength.