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Welded joints performance for seismic steel structures

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 167, *Steel and aluminium structures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Structural safety is needed in high public occupancy facilities, tall or large-scale structures, and other important facilities. Higher performance is needed for structures subjected to seismic actions. In the case of steel frame structures, integrity of welded joints determines the structural safety of these structures, because welding is often used with beam to column connections, joints of steel members, member assembly, etc. It is especially important to ensure the strength and toughness of the welds.

This document addresses the mechanical testing methods and acceptance criteria for weld metal and heat affected zones. These mechanical properties, coupled with appropriate designs for the seismic force resisting system, proper connection designs and detailing, as well as appropriate weld quality and inspection criteria are essential to ensuring the high structural safety of steel structures of seismic design.

This document specifies the target performance regarding the strength and toughness of welded joints in the acceptance criteria, but does not mention the means for realizing the performance. Rather, the document intends to present the performance-based standards, in recognition of diverse construction methods and the need to promote and disseminate new technologies.

Welded joints performance for seismic steel structures

1 Scope

This document defines two performance levels for welded joints, namely Basic Demand and Critical Demand, for longitudinal tensile strength of weld metals, impact toughness of weld metals and heat affected zones (HAZ) to suit the level of seismic performance specifications required for welded steel structures.

This document supplements the provisions of the standards or codes for welding procedure qualification in the application of new steel materials, welding consumables, or complex joints, for welds that require the performance of Basic or Critical Demands as specified by the engineer in the contract.

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.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 4063:2023, *Welding, brazing, soldering and cutting — Nomenclature of processes and reference numbers*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
structural performance
qualitative or quantitative representation of the behaviour of a structure related to its safety and serviceability, durability, and robustness under various actions

3.2
basic demand
required properties of welded joints based on the conventional welding parameters and specifications of materials used

3.3
critical demand
required properties of welded joints that prevent brittle fracture and ensure sufficient level of cumulative plastic deformation capacity expected of beams welded to beam-to-column connections

3.4
sequential testing
group or set of tests for which either a certain average or an individual test results, or both, are required, for demonstrating that the specification requirements have been satisfied

4 Welded joints

4.1 Applicable structural performance

This document specifies the two structural performance levels, namely Basic Demand and Critical Demand, for welded joints of steel structures listed below:

— beam to column;

— column to column, beam to beam;

— welded built-up box section column, H-beam and H-column.

The Basic Demand is a performance category considered to be exhibited at a minimum based on the specifications of materials used as base materials. This refers to the performance level that can be ensured even if it is not specified in the design drawing as a special specification, etc., and it is set on the assumption that the performance obtained by the general construction method in the steel frame manufacturing exceeds this. This performance category represents the minimum requirements for mechanical properties of steel structure welded joints for which seismic performance is required.

The Critical Demand is a performance category recommended by various advanced research efforts to ensure higher safety. This is the performance level that is applied when it is specified in the design drawing as a special specification, and to realize this goal, it is necessary to designate special materials for use and to manufacture them with the higher technological system.

This document may be applied to various types of welded joints of steel structures (see Annex A), but the definitive rules on the level of performance to be adopted in individual circumstances of welded joints are not given in this clause. The levels of required performances applicable to various welded joints shall be in accordance with Table 1.

The range of plate thicknesses of welded joints to which this standard applies are the base metal plate thicknesses shown in Table 2 or Table 3. Application to members exceeding this thickness range can be determined by engineers based on structural tests.

Table 1 — Applicable structural performance

Type of welded joint	Welding process[a] (ISO 4063:2023)	Performance[b]	
		Basic Demand	Critical Demand
Single-bevel-groove, butt joint			
Beam flange to through diaphragm (see Figures A.1 and A.2)	111,114, 135,136,138	X	X
Beam to beam (see Figure A.3)	111,114, 135,136,138	X	—
Column to column (see Figure A.4)	111,114, 135,136,138	X	—
Single-bevel-groove, T-joint and corner joint			
Beam flange to column (see Figures A.5 and A.6)	111,114, 135,136,138	X	X
Column to through diaphragm (see Figure A.7)	111,114, 135,136,138	X	—
Welded built-up box section column (Corner welding, see Figure A.8)	111,114,12,135,136,138	X	—
Square-groove, T-joint			

[a] The most commonly applied welding processes, but not limited to those shown in this table.

[b] X : applicable; — : not generally applicable.

Table 1 *(continued)*

Type of welded joint	Welding process[a] (ISO 4063:2023)	Performance[b]	
		Basic Demand	Critical Demand
Inner diaphragm for welded built-up box section column (see Figure A.9)	772	X	X
Double-bevel-groove, T-joint			
Welded built-up H-beam and H-column (T-joint, groove welding, see Figure A.10)	111,114,12,135,136,138	X	—

[a] The most commonly applied welding processes, but not limited to those shown in this table.

[b] X : applicable; — : not generally applicable.

NOTE The Critical Demand is established because brittle fractures of welded joints were conspicuously observed in the damage caused by the Great Hanshin Earthquake in 1995 and subsequent experimental research. In the series of research efforts, brittle fracture of beam flange welds for beam to column connections and inner diaphragm electroslag welds for welded built-up box section columns were regarded especially problematic. In order to prevent such fractures, it has been found that a considerably higher Charpy absorption energy than has conventionally been considered needs to be secured in the welded joints[2-6].

4.2 Mechanical properties of base metal

4.2.1 Toughness of base metal

The steel materials constituting welded joints of seismic steel structures, to which this document applies, shall be structural steels for which the lower limit values of toughness have been specified regarding the Charpy impact absorption energy. The lower limit values shall be greater than or equal to the acceptance criteria regarding Charpy impact tests on welded joints specified in Clause 6. The test temperature shall be the lowest service temperature of the steel structure determined by the engineer based on national regulations, codes, standards, etc. Steel materials for which the lower limit value of Charpy impact absorption energy is not specified may be used if a toughness value was added optionally to the steel material specifications.

4.2.2 Tensile strength of base metal

The range of tensile strength R_m of steel materials constituting welded joints is from 400 MPa to 740 MPa, for which the Basic Demand or Critical Demand defined in this document is required.

5 Mechanical testing

5.1 Type of testing

Two types of mechanical testing performed shall be a weld metal longitudinal tensile test and an impact test.

5.2 Test specimens

5.2.1 Shape and dimensions of specimens

5.2.1.1 Tensile test specimens

The dimensions of test specimens shall be as shown in Figure 1, Type A or Type B test specimen, to suit the plate thickness of the base material.