INTERNATIONAL STANDARD

ISO 17607-4

First edition
2023-12

Steel structures — Execution of structural steelwork —

Part 4: **Erection**

Structures en acier – Exécution des charpentes et ossatures en acier —

Partie 4: Montage

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Reference number
ISO 17607-4:2023(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This first edition cancels and replaces ISO 10721-2:1999, which has been technically revised.

A list of all parts in the ISO 17607 series can be found on the ISO website.

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.

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Introduction

Specific requirements for the achievement of structures that are optimal with respect to safety, the state of the economy, development and general values of a nation are given in the appropriate regional or national standards, if they exist.

Many nations do not have their own standards for structural steelwork. Some reference other national or regional standards. Some permit the project's standard to be selected by the owner, designer or constructor of the structure. Some do not require any standards to be followed.

The ISO 17607 series of standards on the execution of structural steelwork was developed to serve as a means to provide a set of requirements and guidance for projects that are constructed without a governing regional or national standard. The ISO 17607 series can also serve to reduce trade barriers.

Additional requirements to be addressed in the execution of structural steelwork, as structures or as fabricated components, can be found in the other parts of the series:

— ISO 17607-1 (General requirements and terms and definitions);

— ISO 17607-2 (Steels);

— ISO 17607-3 (Fabrication);

— ISO 17607-5 (Welding);

— ISO 17607-6 (Bolting).

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Steel structures — Execution of structural steelwork —

Part 4: Erection

1 Scope

This document defines the general requirements for erection of steels used in the execution of structural steelwork as structures or as manufactured components in conjunction with ISO 17607-1.

Additional requirements to be addressed in the execution of structural steelwork, as structures or as fabricated components, can be found in other parts of the ISO 17607 series.

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 4463-1, *Measurement methods for building — Setting-out and measurement — Part 1: Planning and organization, measuring procedures, acceptance criteria*

ISO 7976-1, *Tolerances for building — Methods of measurement of buildings and building products — Part 1: Methods and instruments*

ISO 7976-2, *Tolerances for building — Methods of measurement of buildings and building products — Part 2: Position of measuring points*

ISO 17607-1, *Steel structures — Execution of structural steelwork — Part 1: General requirements and vocabulary*

ISO 17607-3, *Steel structures — Execution of structural steelwork — Part 3: Fabrication*

ISO 17607-5, *Steel structures — Execution of structural steelwork — Part 5: Welding*

ISO 17607-6, *Steel structures — Execution of structural steelwork — Part 6: Bolting*

ISO 22966, *Execution of concrete structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17607-1 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/

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4 Execution specification and quality requirements

4.1 General

See ISO 17607-1.

This clause specifies the requirements for the erection of structural steelwork.

When work performed on site involves operations similar to fabrication, the work shall be performed in accordance with ISO 17607-3.

NOTE 1 Examples of similar operations include cutting, holing, and assembling of components prior to erection.

NOTE 2 Welding and structural bolting are addressed in ISO 17607-5 and ISO 17607-6.

4.2 Execution specification

National standards and documents that provide technically equivalent conditions may be used, in whole or in part, in place of referenced ISO standards or requirements of this document. In these cases, the technically equivalent national standards and documents, and deviations from the requirements of this document, shall be referenced in the execution specification.

The necessary information and technical requirements for execution of each part of the structural steelwork shall be agreed upon and complete before commencement of execution of that part of the structural steelwork.

The execution specification shall include the following items as are relevant:

a) additional information, see A.1;

b) options that may be specified, see A.2;

c) requirements related to the execution levels, see A.3;

d) identification and traceability requirements in accordance with ISO 17607-1;

e) geometrical tolerances, see Clause 7.

There shall be procedures for making alterations to a previously agreed upon execution specification.

5 Constituent products

5.1 General

ISO 17607-1 provides information and requirements for constituent products.

5.2 Anchorages, foundation bolts and other anchorages

ISO 17607-6 provides information and requirements for anchorages, foundation bolts and other anchorages.

5.3 Grouting materials

5.3.1 General

The grouting materials to be used shall be specified in the execution specification. They shall be cement-based grout, special grout, or fine concrete.

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5.3.2 Cement-based grout

Cement-based grout for use between steel bases or bearing plates and concrete foundations shall be as follows:

a) for nominal thickness not exceeding 25 mm: Neat Portland cement mortar;

b) for nominal thickness between 25 mm and 50 mm: Fluid Portland cement mortar that is not leaner than 1:1 cement to fine aggregate;

c) for nominal thickness of 50 mm and above: Dry as possible Portland cement mortar that is not leaner than 1:2 cement to fine aggregate.

5.3.3 Special grout

Special grout includes cement-based grout used with admixtures, expanding grout and resin-based grout. Those with low shrinkage characteristics are recommended.

Special grout shall be accompanied by detailed instructions for use that are in conformity with the manufacturer's recommendations.

5.3.4 Fine concrete

Fine concrete shall only be used between steel bases or bearing plates and concrete foundations that have gaps with nominal thickness of 50 mm and above.

5.4 Expansion joints for bridges

Requirements for type and characteristics of expansion joints shall be specified.

6 Erection

6.1 General

This clause gives requirements for erection and other work undertaken on site including grouting of bases as well as those relevant to the suitability of the site for safe erection and for accurately prepared supports.

Work carried out on site that includes fabrication, welding, and structural bolting shall be in accordance with ISO 17607-3, ISO 17607-5, and ISO 17607-6, respectively.

Inspection and acceptance of the structure shall be performed in accordance with the requirements specified in Clause 8.

6.2 Site conditions

Erection shall not commence until the site for the construction works conforms with the technical requirements with respect to the safety of the structural steelwork. This shall include the following items where relevant:

a) provision and maintenance of hard standing for cranes, and access equipment;

b) access routes to the site, and within the site suitable for delivery, and movement of material, components, equipment and personnel;

c) soil conditions affecting the safe operations, and construction at the site;

d) possible settlement of erection supports for the structure;

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e) details of underground services, overhead cables, or site obstructions, including the necessity to relocate overhead obstructions such as power lines from the area of erection;

f) limitations on dimensions, or weights of components that can be delivered onto the site;

g) special environmental, and climatic conditions on, and around the site;

h) particulars of adjacent structures affecting, or affected by the works;

i) adequate and suitable storage space for material, and components.

Access routes to the site and within the site shall be given in a site plan. This shall show areas available for storage, dimensions and level of access routes, and level of the prepared working area for site traffic and plant.

If the structural steelwork is inter-linked with other trades, the coherence of technical requirements with respect to the safety of the structural steelwork should be coordinated with those for other parts of the construction works. This check shall consider the following items as relevant:

j) prearranged procedures for co-operation with other constructors, including availability of hoisting equipment;

k) availability of site services;

l) analysis and definition of maximum construction and storage loads permitted on the steelwork;

m) control of concrete placement during composite construction (see ISO 22966).

6.3 Erection method

6.3.1 Design basis for the erection method

If the structural stability in the part-erected condition is not evident, a safe method of erection on which the design was based shall be provided. This design basis method of erection shall consider the following items:

a) positions and types of site connections;

b) maximum piece size, weight and location;

c) identification of critical lifts, such as lifts above a selected proportion of crane capacity and multi-crane lifts;

d) sequence of erection;

e) stability concept for the part-erected structure, including any requirements for temporary bracing or propping (shoring);

f) propping or other measures for the execution of phased concreting of composite structures;

g) conditions for removal of temporary bracing or propping, or any requirement for de-stressing or stressing the structure including foundation bolts and anchor rods;

h) features that can create a safety hazard during construction;

i) timing and method for adjustment of foundation connections or bearings and for grouting;

j) camber and pre-sets required in relation of those provided at fabrication stage;

k) use of diaphragms (e.g. profiled steel sheeting, precast panel) to ensure stability;

l) use of diaphragms to provide lateral restraint;

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m) transportation of units, including attachments for lifting, turning or pulling;

n) positions and conditions for supporting and jacking;

o) stability concept for the bearings;

p) expected settlements of the supports;

q) particular positions and loads from, e.g. cranes, stored components, counterweight, for the various construction phases;

r) instructions for the delivery, storage, lifting, positioning, and pre-tensioning of stay cables;

s) actions required to account for deformations of the partly erected structure, such as the use of propping, jacks or loads that must be adjusted as erection progresses to set or maintain camber, position within the specified tolerances or pre-stress;

t) analysis, design and details of all temporary works and attachments to permanent works with instructions as to their removal.

6.3.2 Constructor's erection method statement

A method statement describing the constructor's erection method shall be prepared and it shall be checked in accordance with design rules, notably against resistance of the partly erected structure to erection loads and other loading.

The erection method statement may deviate from the design basis method of erection, provided that it is a safe alternative.

Amendments to the erection method statement, including those necessitated by site conditions, shall be checked and reviewed in accordance with the above requirement.

The erection method statement shall describe procedures to be used to safely erect the steelwork and shall consider the technical requirements regarding the safety of the structural steelwork.

The procedures should link to specific work instructions, written or verbal as appropriate.

The erection method statement shall address all relevant items in 6.3.1, and shall also consider the following items as relevant:

a) experience from any trial assembly undertaken in accordance with 6.6.4;

b) restraints necessary to ensure stability prior to welding and to control local movement of the joint;

c) lifting devices necessary;

d) necessity to mark either weights or centres of gravity, or both, on large or irregularly shaped pieces;

e) relationship between the weights to be lifted and the radius of operation where cranes are to be used;

f) identification of sway or overturning forces, particularly those due to the predicted wind conditions on site during erection, and the exact methods of maintaining adequate sway and overturning resistance;

g) methods of minimizing risk from identified safety hazards;

h) provision of safe working positions and safe means of access to them.

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In addition, the following apply for composite steel and concrete structures:

i) sequence of fixing of profiled steel sheeting for composite slabs shall be planned to ensure that sheets are adequately supported by supporting beams before fixing, and are securely fixed before they are used to gain access to subsequent working positions;

j) profiled steel sheeting should not be used to gain access for welding of shear connectors unless the sheeting is secured already by fasteners in accordance with i);

k) sequence of placing and method of securing and sealing permanent formwork to ensure that formwork is secure before being used to gain access for subsequent construction operations and supporting slab reinforcement and deck concrete.

Factors associated with the execution of the concrete works should be considered as relevant, such as sequence of placing concrete, pre-stressing, and temperature difference between steel and freshly placed concrete, jacking and supports.

6.4 Survey

6.4.1 Reference system

Unless otherwise specified, site measurements for the structural steelwork shall be related to the system established for the setting out and measurement of the construction works in accordance with ISO 4463-1.

A documented survey of a secondary net (a survey grid established to control the building) shall be provided and used as the reference system for setting out the steelwork and establishing the deviations of supports. The coordinates of the secondary net given in this survey shall be accepted as true if they conform with the acceptance criteria given in ISO 4463-1.

When required by the execution specification, the reference temperature for setting out and measuring the steelwork shall be specified.

6.4.2 Position points

The position points which mark the intended position for the erection of individual components shall be in accordance with ISO 4463-1.

6.5 Supports

6.5.1 General

Supports may include foundation bolts, anchor rods, anchors, embedded plates and bearings.

6.5.2 Measuring and documenting suitability of supports

The condition and location of the supports shall be checked using appropriate visual and measurement means and shall be confirmed as suitable before the commencement of erection. Unsuitable supports shall be corrected prior to the commencement of erection. Nonconformities shall be documented and records shall be available to the constructor performing steel erection.

All supports for the steelwork shall be suitably prepared to receive the steel structure. Installation of structural bearings shall conform with either the relevant standards or documents or product manufacturer's instructions, or combination thereof.

Erection shall not commence until the location and levels of the supports are in accordance with the acceptance criteria in Clause 7, or an appropriate amendment to the specified requirements has been issued.

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The survey used to check the positions of the supports shall be documented.

If foundation bolts are to be pre-stressed, methods and procedure requirements shall be specified in the execution specification.

6.5.3 Maintaining suitability of supports

During erection, the supports for the steelwork shall be maintained in a condition to serve their intended function.

Areas of supports that require protection against rust staining shall be identified and appropriate protection provided.

Compensation for settlement of supports is permitted, unless otherwise specified in the execution specification. This shall be done by grouting or packing between steelwork and support.

6.5.4 Temporary supports

Shims, packings and other supporting devices used as temporary supports under base plates shall present a flat surface to the steel and be of adequate size, strength and rigidity to avoid local crushing of the substructure concrete or masonry.

If shims, packings or other supporting devices are subsequently to be grouted, they shall be placed so that the grout will provide the packings with a minimum lateral cover of 25 mm, unless otherwise specified in the execution specification.

If shims, packings or other supporting devices are left in position after grouting they shall be made from materials with the same durability as the structure.

If adjustment to the position of the base is achieved using levelling nuts on the foundation bolts under the base plate, these may be left in position unless specified in the execution specification. The nuts shall be selected to ensure that they are suitable to maintain the stability of the part-erected structure without adversely affecting the performance of the foundation bolt in service.

Shims, blocks, half-nuts or plastic nuts may be used for levelling.

6.5.5 Grouting

Grouting shall be carried out in accordance with Annex B.

6.5.6 Anchoring

Anchoring devices in concrete parts of the structure or adjacent structures are not addressed by this document and shall be set in accordance with their specification.

6.6 Erection and work at site

6.6.1 Erection drawings

Erection drawings or equivalent instructions shall be provided and form a part of the erection method statement (see 6.3.1 and 6.3.2).

Drawings shall be prepared showing plans and elevations and at such a scale that the erection marks for all components can be shown on them.

Drawings shall show grid locations, bearing positions and assembly of components together with requirements for special tolerances and those that differ from the requirements of this document.

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Foundation plans shall show the base location and orientation of the steelwork, any other components in direct contact with the foundations, their base location and level, the intended bearing level and the datum level. Foundation plans shall include column base support and other structural supports.

Elevations shall show required levels for floors, structure, or both.

Drawings shall show necessary details for fixing of steel or bolts to the foundations, the method of adjustment by packing and wedging, and grout requirements as well as fixing of steelwork and bearings to their supports.

Drawings shall show details and arrangements of any steelwork or other temporary works necessary for erection purposes to ensure the stability of the construction or the safety of personnel.

Drawings shall state the weight of all components or assemblies over five tonnes and the centre of gravity of all large irregular pieces.

6.6.2 Marking

Components that are individually assembled or erected at the site shall be allocated an erection mark. A component shall be marked with its erected orientation if this is not clear from its shape.

Marking methods shall be in accordance with ISO 17607-3.

6.6.3 Handling and storage on site

Handling and storage of fabricated steel, filler metals and bolting products on site shall be in accordance with ISO 17607-3, ISO 17607-5, and ISO 17607-6 respectively, and those given below.

Components shall be handled and stacked in such a way that the likelihood of damage is minimized. Particular attention shall be paid to slinging methods to avoid damage to the steelwork and protective treatment.

Steelwork damaged during off-loading, transportation, storage or erection shall be restored to conformity.

The procedure for restoration shall be defined before undertaking the repair. For execution levels EXL2, EXL3 and EXL4, the procedure shall also be documented.

All small plates and other fittings shall be suitably packed and identified.

6.6.4 Trial assembly

Any site trial assembly shall be performed in accordance with ISO 17607-3.

Trial assembly should be considered:

a) to confirm fit between components;

b) to prove methodology to maintain stability during erection if the erection sequence needs evaluating in advance;

c) to prove duration of operations if site conditions are restricted by limited possession time.

6.6.5 Erection methods

6.6.5.1 General

The erection of the steelwork shall be carried out in conformity with the erection method statement and in such a way as to ensure stability at all times.

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Foundation bolts shall not be used to secure un-guyed columns against overturning unless they have been checked for this mode of use.

Throughout the erection of the structure, the steelwork shall be made safe against temporary erection loads, including those due to erection equipment or its operation and against the effects of wind loads on the unfinished structure.

For buildings, at least one third of the permanent bolts in each connection should be installed before that connection can be considered to contribute to the stability of the partly completed structure. Further requirements for the degree of completion of connections shall be considered and defined in the stability analysis of the structure during erection.

6.6.5.2 Temporary works

All temporary bracing and temporary restraints shall be left in position until erection is sufficiently advanced to allow their safe removal.

If bracings in tall buildings are required to be de-stressed as erection progresses, to release the forces induced in them by vertical loads, this shall be carried out progressively one panel at a time. During such de-stressing, sufficient alternative bracing shall be in place to ensure stability. If necessary, additional bracing shall be added temporarily for this purpose.

All connections for temporary components provided for erection purposes shall be made in accordance with this document and in such a way that they do not weaken the permanent structure or impair its serviceability.

If temporary erection aids are used to support the structure during welding, it shall be ensured that they are sufficiently strong and that their retaining welds are appropriate for the erection load conditions.

If the erection procedure involves rolling or otherwise moving the structure, or part of the structure, into its final position after assembly, provision shall be made for controlled braking of the moving mass.

All temporary anchoring devices shall be made secure against unintentional release.

Jacks shall be capable of being locked in any position under load unless other safety provisions are made.

6.6.5.3 Fit-up and alignment

Care shall be taken that no part of the structure is permanently distorted or over-stressed by stacking of steelwork components or by erection loads during the erection process.

Each part of the structure shall be aligned as soon as practicable after it has been erected and final assembly completed as soon as possible thereafter.

Permanent connections shall not be made between components until a sufficient portion of the structure has been aligned, levelled, plumbed, and temporarily connected to ensure that components will not be displaced during subsequent erection or alignment of the remainder of the structure.

Alignment of the structure and lack of fit in connections may be adjusted using shims. Shims shall be secured where they are in danger of coming loose.

Shims shall be made of flat steel, unless otherwise specified. Shims shall have similar durability to that of the structure.

If shims are used to align structures composed of coated material, the shims shall be protected in a similar manner to provide the specified durability unless the shims are required to meet a specified friction surface slip factor.

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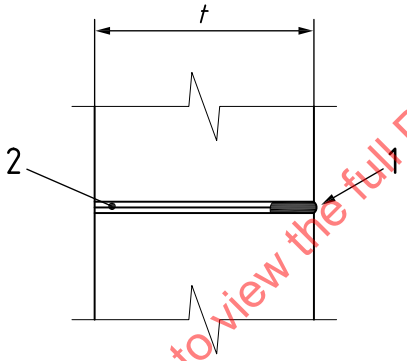
If lack-of-fit between erected components cannot be corrected by the use of shims, components of the structure shall be locally modified in accordance with this document. The modifications shall not compromise the performance of the structure in the temporary or permanent state. This work may be executed on site. Care shall be taken with structures built of welded latticed components and space-frame structures to ensure that they are not subjected to excessive forces in an attempt to force a fit against their inherent rigidity.

Processes for aligning of holes and bolting shall be in accordance with ISO 17607-3 and ISO 17607-6.

6.6.5.4 Bolted splices with full contact bearing

Where full contact bearing is specified for bolted splices, and where the fit-up between surfaces of erected components exceeds the specified tolerance, shims may be used where the gap exceeds the specified limits after initial bolting-up, to reduce the gaps to within the permitted deviation.

Unless otherwise specified, the shims may be made of flat mild steel with a maximum thickness of 3 mm. No more than three shims shall be used at any point. If necessary, and if not prohibited by the execution specification, the shims may be held in place by means of either fillet welds or a partial penetration butt weld extending over the shims, as shown in Figure 1.



Key

t component thickness

1 partial penetration butt weld or fillet weld

2 shims

Figure 1 — Option for securing shims used for bolted splice in full contact bearing

7 Geometrical tolerances

Geometrical tolerances shall be specified in the execution specification.

NOTE Information provided in Annexes C, D, E, and F can be used to specify the geometrical tolerances in the execution specification.

The types and requirements for geometrical deviations and the quantitative values for different types of permitted deviations are given per country in Annexes C, D, E and F, for:

— buildings;

— bridges;

— crane runways;

— concrete foundations and supports.

The permitted deviations given do not include elastic deformations induced by the self-weight of the components.

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In addition, special tolerances may be specified either for geometrical deviations already defined with quantitative values or for other types of geometrical deviations. If special tolerances are required, the following information shall be given as appropriate:

— amended values for tolerances already defined;

— defined parameters and permitted values for the geometrical deviations to be controlled;

— whether these special tolerances apply to all relevant components or only to particular components that are specified.

In each case, the requirements are for final acceptance testing. If fabricated components are used on site to form/build a structure, the tolerances for the final check of the erected structure shall be defined in addition to the tolerances for the fabricated parts.

NOTE The specifier can make direct reference to the Annexes (C, D, E, F).

8 Inspection, testing and correction

8.1 General

ISO 17607-1 provides information and requirements for inspection, testing and correction.

8.2 Erection

8.2.1 Inspection of trial assembly

Requirements for inspection of any trial assembly to 6.6.4 shall be specified.

8.2.2 Inspection of the erected structure

The structure shall be inspected to confirm that all components are erected in the correct location and orientation, and that the connections are completed in conformance with the execution specification.

The condition of the erected structure shall be inspected for any indication that components have been distorted, and to ensure that any temporary attachments have either been removed satisfactorily or are in accordance with the specified requirements.

8.2.3 Survey of geometrical position of connection nodes

8.2.3.1 Survey methods and accuracy

A survey of the structure shall be made. This survey shall be related to the secondary net (survey grid established to control the building). For EXL3 and EXL4 this survey shall be recorded; if there is a requirement to record dimensional checks at acceptance of the structure, this shall be specified.

Methods and instruments used shall be selected from those listed in ISO 7976-1 and ISO 7976-2. The selection shall take into account the capability of the survey process in terms of accuracy relative to the acceptance criteria. If appropriate, the survey shall be corrected for the effects of temperature and the accuracy of the measurements relative to that in 6.4.1 shall be estimated in accordance with the relevant parts of the ISO 17123 series.

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8.2.3.2 System of measurement

The system of permitted deviations is built up from position points at base level (established column line), an envelope for column verticality and a series of intermediate and roof levels referred to as-built floor levels.

NOTE 1 Position points mark the location of individual components, for example columns (see ISO 4463-1).

Each individual value shall be in accordance with the values from the figures and tables. The algebraic sum of the discrete values shall not be greater than the permitted deviations for the total structure.

The system shall set out requirements for positions of connections with defined tolerances. Between these positions the fabrication tolerances define permitted deviations.

NOTE 2 The system does not set out explicit requirements for secondary structural components such as side posts and purlins.

Special attention shall be given to establishing lines and levels when fitting to existing construction.

8.2.3.3 Reference points and levels

Erection tolerances shall generally be specified relative to the following reference points on each component:

a) for components within 10° of the vertical: the centre of the component at each end;

b) for components within 45° of the horizontal (including the tops of lattice trusses): the centre of the top surface at each end;

c) for internal components in built-up lattice girders and trusses: the centre of the component at each end;

d) for other components: the erection drawings shall indicate the reference points which shall generally be the top or outside surfaces of components mainly subject to bending and centre lines of components mainly subject to direct compression or tension.

Alternative reference points may be substituted for ease of reference if they have similar effect to those specified above.

8.2.3.4 Location and frequency

Measurements shall be taken only of the position site connection nodes for major structural components. The location and frequency of measurements shall be specified in the execution specification.

Critical dimensional checks of the as-built structure necessary in relation to special tolerances should be identified and these should be incorporated into the inspection plan.

The positional accuracy of the erected steelwork shall be measured during construction of the project under self-weight of steelwork and dead loads expected during that stage of construction. Survey results shall be interpreted and adjusted in consideration of loads and conditions at the time of the survey. Other conditions under which the measurements take place shall be specified as well as the deviations and movements due to imposed loads, other than those due to self-weight of steelwork, if these can affect dimensional checks.

8.2.3.5 Acceptance criteria

The acceptance criteria shall be specified in the execution specification.

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8.2.3.6 Definition of nonconformity

Assessment of whether a nonconformity exists shall consider the inevitable variability in methods of measurement calculated in accordance with ISO 17607-1.

ISO 3443-1, ISO 3443-2 and ISO 3443-3 give guidance on tolerances for buildings and the implications of variabilities on the fit between components.

NOTE Variabilities include manufacturing, setting-out, and erection deviations.

Accuracy of construction shall be interpreted in relation to the expected deflections, cambers, pre-sets, elastic movements, and thermal expansion of components.

If significant movement of a structure is anticipated that can affect dimensional checking (e.g. for tension structures) an envelope of permissible positions shall be specified.

8.2.3.7 Action on nonconformity

Action on nonconformity shall be in accordance with ISO 17607-1. Corrections shall be carried out using methods that are in accordance with this document.

If a steel structure is handed over with uncorrected nonconformities awaiting action, these shall be listed.

8.2.4 Other acceptance tests

If components of a structure are to be erected to a specific load, rather than position, detailed requirements, including tolerance range on the load, shall be specified.

9 Documents required to claim conformity to this document

9.1 General

Constructors may claim conformity with the requirements of this document either by:

— adoption of the ISO standards referenced in this document, as applicable; or

— adoption of other documents that provide technically equivalent conditions to the ISO documents listed in this document, as applicable.

Unless otherwise listed in the execution specification, it is the responsibility of the constructor to demonstrate that the standards or documents selected provide technically equivalent conditions to those in the corresponding ISO standards.

Prior to execution, adoption of other standards or documents shall be verified and approved by the specifier and shall be incorporated into the execution specifications.

9.2 Declaration of conformity

A constructor claiming conformity with these requirements shall list the applicable supporting standards or documents.

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Annex A
(normative)

Additional information, list of options and requirements related to the execution levels

A.1 List of required additional information

Table A.1 provides the additional information that is required in the text of this document as appropriate to fully define the requirements for execution of the work to be in accordance with this document (e.g. where the wording "shall be specified" is used).

Table A.1 — Additional information

Clause	Additional information required
4	**Execution specification and quality requirements**
4.2	Technically equivalent national standards and documents
4.2	Deviations from the requirements of this document
4.2 d)	Identification and traceability requirements
4.2 e)	Geometrical tolerances
5	**Constituent products**
5.1	Type and characteristics of expansion joints
5.3.1	Grouting materials to be used
5.4	Requirements for type and characteristics of expansion joints
6	**Erection**
6.3.1	Camber and pre-sets required in relation to those provided at manufacturing stage
6.4.1	Reference temperature for setting out and measuring the steelwork
6.5.3	Identification and appropriate protection for areas of supports requiring protection
6.6.1	Requirements for special tolerances
6.6.5.4	Shims may be used where the gap exceeds the specified limits after initial bolting-up
7	**Geometrical tolerances**
7	Geometrical tolerances
8	**Inspection, testing and correction**
8.2.1	Requirements for inspection of trial assembly
8.2.3.3	Erection tolerances relative to reference points
8.2.3.4	Location and frequency of measurements
8.2.3.5	Acceptance criteria
9	**Documents required to claim conformity to these requirements**
9.1	Verification and approval, incorporation of other standards or documents
9.2	List of the applicable and supporting documents

A.2 List of options

Table A.2 lists the items which may be specified in the execution specification to define requirements for the execution of the work where options are given in this document.

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Table A.2 — List of options

Clause	Option(s) to be specified
6	**Erection**
6.5.1	Reference temperature for setting out and measuring the steelwork
6.5.2	If bolts are to be pre-stressed
6.5.3	If compensation for settlement of supports is permitted
6.5.4	If packings subsequently to be grouted, may be placed so that the grout does not totally enclose them
6.5.4	If packings for bridges may be left in position
6.5.4	If levelling nuts on the foundation bolts under the base plate are to be removed
6.6.5.3	If material of shims is to be different from flat steel
7	**Geometrical tolerances**
7	If special tolerances are specified
8	**Inspection, testing and correction**
8.2.3.1	If detailed specific dimensional checks at acceptance are required
8.2.3.4	Extent of measurements for the survey of geometrical position of connection nodes if other than site interconnection nodes
8.2.3.4	Conditions of measurements other than under the self-weight of steelwork
8.2.3.6	An envelope of permissible positions if significant movement of a structure is anticipated that could affect dimensional checking
8.2.4	Tolerance range on the load, if components of a structure are to be erected to a specific load
9	**Documents required to claim conformity to these requirements**
9.1	Demonstration that other standards or documents selected provide technically equivalent conditions to those in the corresponding ISO standards
Annex B	**Grouting**
	If tamping and ramming against properly fixed supports shall be used
	If treatment of steelwork, bearings and concrete surfaces is required before grouting
Annex C	**Geometrical tolerances – Buildings**
	Special tolerances
Annex E	**Geometrical tolerances - Crane runways**
	Special tolerances

A.3 Requirements related to the execution levels

This clause lists requirements specific to each of the execution levels referenced in this document.

Items identified in bold letters in Table A.3 relate to the general system of control of execution and are amenable to a common choice of execution level across the whole of the structural steelwork (or a phase of the structural steelwork). The other items generally demand the selection of the appropriate execution level on a component-by-component or a connection detail-by-detail basis.

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Table A.3 — Requirements to each execution level

Clause	EXL1	EXL2	EXL3	EXL4
6 – Erection				
6.6.3 Handling and storage on site	—	Procedure for restoration if steelwork damaged during off-loading, transportation, storage or erection		
8 – Inspection, testing and repair				
8.2.3.1 Survey of the geometrical position of connection nodes	—		Record of the survey	
Key A dash "—" means no specific requirement in the text.				

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Annex B
(normative)

Grouting

If spaces under base plates are to be grouted, material shall be used in accordance with 5.3 and manufacturer's instructions. Grouting material shall be used as follows:

a) the material shall be mixed and used in accordance with grouting material manufacturer's recommendations, notably regarding its consistency when used. Material shall not be mixed or used below 0 °C unless the manufacturer's recommendations permit this;

b) the material shall be poured under a suitable head so that the space is completely filled;

c) tamping and ramming against properly fixed supports shall be used if either specified or recommended, or both, by the grout manufacturer;

d) vent holes shall be provided, as necessary.

Immediately before grouting, the space under the steel base plate shall be free from liquids, ice, debris and contaminants.

Pocket bases containing columns shall be filled with dense concrete having a characteristic compressive strength not less than that of the surrounding concrete.

If treatment of steelwork, bearings and concrete surfaces is required before grouting, it shall be specified.

Care shall be taken that the external profile of grouting allows water to be drained away from structural steel components.

If there is a danger of water or corrosive liquid becoming entrapped during service, the grout around base plates shall not be surcharged such that it rises above the lowest surface of the base plate and the geometry of the concrete grout shall form an angle from the base plate in accordance with Figure B.1.

The concrete and the grouting shall be carried out in accordance with 5.3 and ISO 22966.

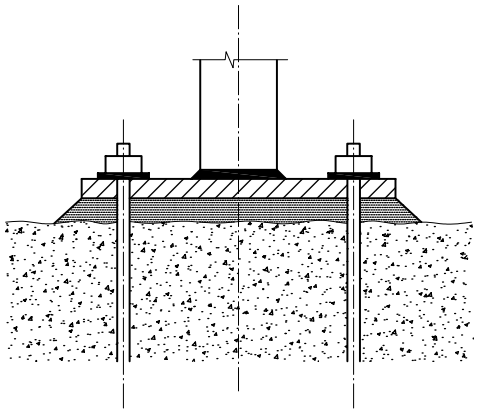

Figure B.1 — Grouting under base plate

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Annex C
(informative)

Geometrical tolerances — Buildings

C.1 General

Permitted deviations for geometrical tolerances in buildings are divided into six categories:

— general;

— beams in buildings;

— columns of single-storey buildings;

— multi-storey buildings;

— full contact end-bearing;

— positions of columns.

Permitted deviations are given in:

— Table C.1: Europe;

— Table C.2: Australia and New Zealand;

— Table C.3: Canada;

— Table C.4: China;

— Table C.5: Japan;

— Table C.6: Russian Federation;

— Table C.7: United Kingdom;

— Table C.8: United States.

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C.2 Tolerances for Europe

Unless otherwise noted, the reference standard for Table C.1 is EN 1090-2.

Definitions specific to Table C.1 are:

a) Essential tolerances:
Essential tolerances are essential for the mechanical resistance and stability of the completed structure and are therefore to be fulfilled.

b) Functional tolerances:
Functional tolerances are those required to fulfil other criteria such as fit-up and appearance.

c) Class 1:
Tolerance Class 1 shall be applied unless otherwise specified in the execution specification.

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d) Class 2:
Tolerance Class 2 can substitute Class 1 if smaller tolerance deviations are required, for example if glazed facades are to be fitted.

Table C.1 — Europe

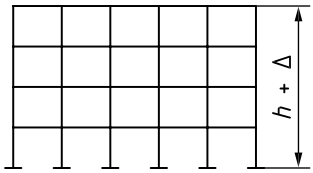
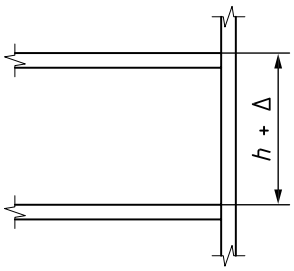
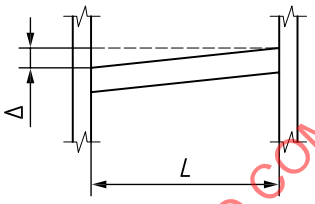
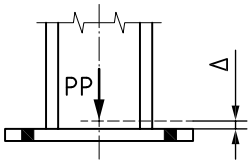
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
1.	**General**				
1.1	Height 	Overall height, relative to the base level (h in metres): $h \leq 20$ m 20 m < h < 100 m $h \geq 100$ m		Δ = ±20 mm Δ = ±0,5 (h+20) mm Δ = ±0,2 (h+200) mm	Δ = ±20 mm Δ = ±0,25 (h+20) mm Δ = ±0,2 (h+200) mm
1.2	Storey height 	Height relative to the adjacent levels		Δ = ±10 mm	Δ = ±5 mm
1.3	Slope 	Height relative to the other end of a beam		Δ = ±L/500, and |Δ| ≤ 10 mm	Δ = ±L/1 000, and |Δ| ≤ 5 mm
1.4	Column splice 	Non-intended eccentricity e about either axis		$e \leq 5$ mm	$e \leq 3$ mm
1.5	Column base 	Level of bottom of column shaft, relative to specified level of its position point (PP)		Δ = ±5 mm	Δ = ±5 mm

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Table C.1 *(continued)*

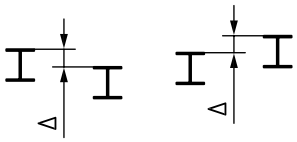
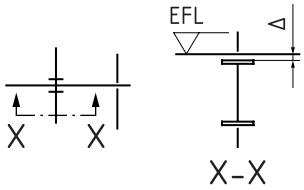
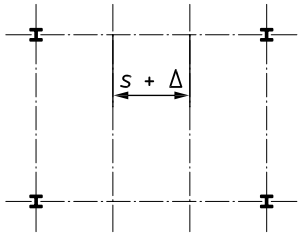
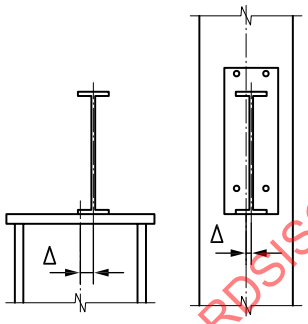
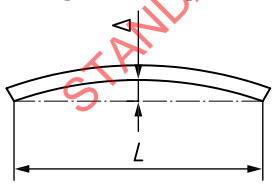
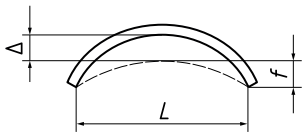
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
1.6	Relative levels 	Levels of adjacent beams, measured at corresponding ends		Δ = ±10 mm	Δ = ±5 mm
1.7	Connection levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL)		Δ = ±10 mm	Δ = ±5 mm
2.	**Beams in buildings**				
2.1	Spacing between beam centrelines 	Deviation Δ from intended distance *s* between adjacent erected beams, measured at each end		Δ = ±10 mm	Δ = ±5 mm
2.2	Location at columns 	Deviation Δ from intended location of a beam-to column connection, measured relative to the column		Δ = ±5 mm	Δ = ±3 mm
2.3	Straightness in plan 	Deviation Δ from straightness of an erected beam or cantilever of length *L*		Δ = ±*L*/500	Δ = ±*L*/1 000
2.4	Camber 	Deviation Δ at mid span from intended camber *f* of an erected beam or lattice component of length *L*		Δ = ±*L*/300	Δ = ±*L*/500

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Table C.1 *(continued)*

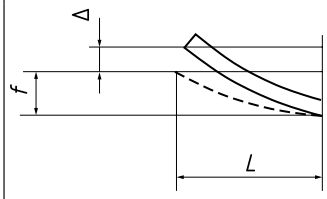
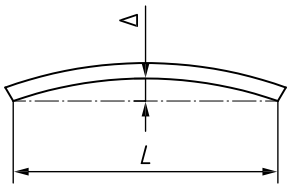
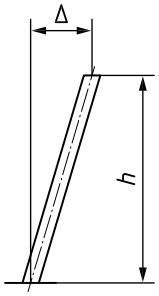
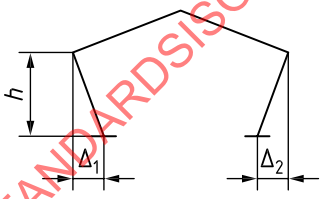
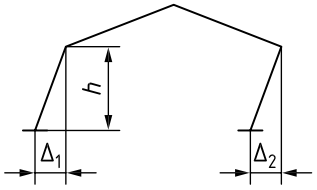
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
2.5	Pre-set of cantilever 	Deviation Δ from intended pre-set at end of an erected cantilever of length L		$\Delta = \pm L/200$	$\Delta = \pm L/300$
2.6	Straightness of beams subject to bending and components subject to compression if unrestrained 	Deviation Δ from straightness relative to length L	$\Delta = \pm L/1\,000$		
3.	**Columns of single storey buildings**				
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height h	$\Delta = \pm h/300$	$\Delta = \pm h/300$	$\Delta = \pm h/500$
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column $\Delta = \Delta_1$ or Δ_2	No requirement	$\Delta = \pm h/150$	$\Delta = \pm h/300$
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame (For two columns the average is $\Delta = (\Delta_1+\Delta_2)/2$)	$\Delta = \pm h/500$	$\Delta = \pm h/500$	$\Delta = \pm h/500$

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Table C.1 *(continued)*

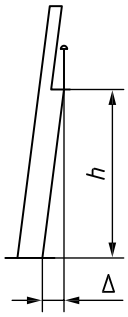
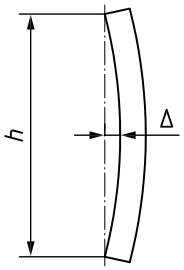
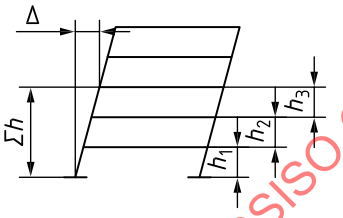
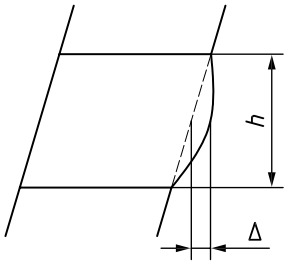
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam	$\Delta = \pm h/1\,000$	$\Delta = \pm 25$ mm	$\Delta = \pm 15$ mm
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom	$\Delta = \pm h/1\,000$	No requirement	No requirement
4.	**Multi-storey buildings**				
4.1	Location at the storey level *n* levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level	$\Delta = \pm\Sigma h/(300\sqrt{n})$	$\Delta = \pm\Sigma h/(300\sqrt{n})$	$\Delta = \pm\Sigma h/(500\sqrt{n})$
4.2	Inclination of a column, between adjacent storey levels 	Location of the column in plan, relative to a vertical line through its centre at the next lower level:	$\Delta = \pm h/300$	$\Delta = \pm h/300$	$\Delta = \pm h/500$
4.3	Straightness of a continuous column between adjacent storey levels 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\,000$	$\Delta = \pm h/1\,000$	$\Delta = \pm h/1\,000$

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Table C.1 *(continued)*

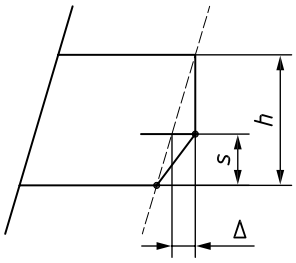
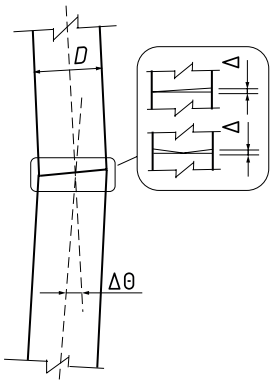
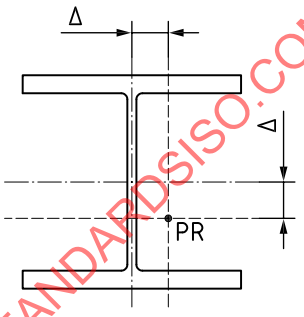
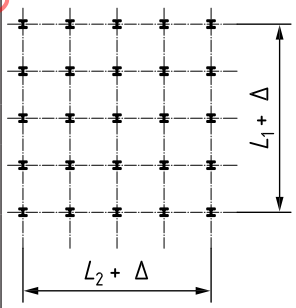
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
4.4	Straightness of a spliced column, between adjacent storey levels 	Location of the column in plan at the splice, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm s/1\,000$, with $s \leq h/2$	$\Delta = \pm s/1\,000$, with $s \leq h/2$	$\Delta = \pm s/1\,000$, with $s \leq h/2$
5.	**Full contact end-bearing**				
5.1	Column splice alignment and gap between bearing surfaces 	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	$\Delta\theta = \pm 1/500$, and Δ = 0,5 mm maximum over at least 2/3 of the area, and Δ = 1,0 mm maximum locally	No requirement	No requirement
6.	**Positions of columns**				
6.1	Location 	Location in plan of the centre of the column at the level of its base, relative to the position point of reference (PR)		Δ = ±10 mm	Δ = ±5 mm
6.2	Overall length of a building 	Distance between end columns in each line, at base level (L in metres) $L \leq 30$ m 30 m < L < 250 m $L \geq 250$ m		Δ = ±20 mm Δ = ±0,25 (L+50) mm Δ = ±0,1 (L+500) mm	Δ = ±16 mm Δ = ±0,2 (L+50) mm Δ = ±0,1 (L+350) mm

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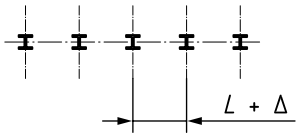
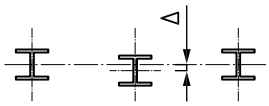
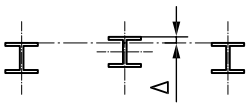
Table C.1 *(continued)*

No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Classes 1 and 2	Class 1	Class 2
6.3	Column spacing 	Distance between centres of adjacent columns at base level: (*L* in metres) $L \leq 5$ m $L > 5$ m		 Δ = ±10 mm Δ = ±0,2 (*L*+45) mm	 Δ = ±7 mm Δ = ±0,2 (*L*+30) mm
6.4	Column alignment generally 	Location of the centre of the column at base level, relative to the established column line (ECL)		Δ = ±10 mm	Δ = ±7 mm
6.5	Perimeter column alignment 	Location of the outer face of a perimeter column at base level, relative to the line joining the faces of the adjacent columns		Δ = ±10 mm	Δ = ±7 mm

C.3 Tolerances for Australia and New Zealand

Unless otherwise noted, the reference standard for Table C.2 is AS/NZS 5131.

Definitions specific to Table C.2 are:

a) Essential tolerances:
Basic limit for a geometrical tolerance necessary to satisfy the design assumptions for a structure in terms of design capacity and stability (see AS 4100, AS 5100.6 and NZS 3404).

b) Functional tolerances:
A tolerance which might be required to meet a function other than those of an essential tolerance, such as for appearance or fit-up.

c) Class 1:
Tolerance Class 1 shall be applied unless otherwise specified in the execution specification.

d) Class 2:
Tolerance Class 2 can substitute for Class 1 if smaller tolerance deviations are required, for example if glazed facades are to be fitted.

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Table C.2 — Australia and New Zealand

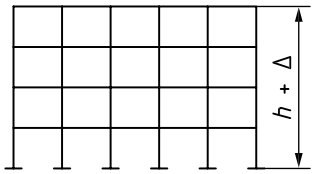
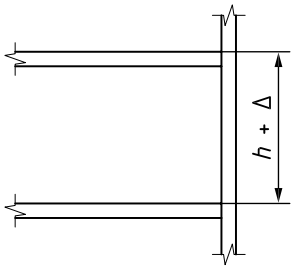
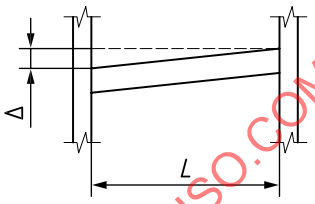
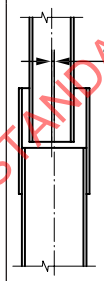
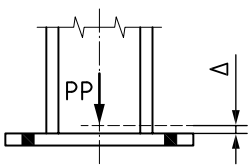
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1.	**General**				
1.1	Height 	Overall height, relative to the base level: (*h* in metres) $h \leq 30$ m $h \geq 30$ m $h \leq 20$ m 20 m < *h* < 100 m $h \geq 100$ m	 Δ = ±20 mm Δ = ±[20 + 0,25(*h*-30)] mm	 Δ = ±20 mm Δ = ±0,5 (*h*+20) mm Δ = ±0,2 (*h*+200) mm	 Δ = ±10 mm Δ = ±0,25 (*h*+20) mm Δ = ±0,1 (*h*+200) mm
1.2	Storey height 	Height relative to the adjacent levels	Δ = ±20 mm	Δ = ±10 mm	Δ = ±5 mm
1.3	Slope 	Height relative to the other end of a beam	Δ = ±*L*/500, and |Δ| ≤ 10 mm	Δ = ±*L*/500, and |Δ| ≤ 10 mm	Δ = ±*L*/1 000, and |Δ| ≤ 5 mm
1.4	Column splice 	Non-intended eccentricity *e* about either axis	2 mm	5 mm	3 mm
1.5	Column base 	Level of bottom of column shaft, relative to specified level of its position point (PP)	Δ = ±10 mm	Δ = ±5 mm	Δ = ±5 mm

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Table C.2 *(continued)*

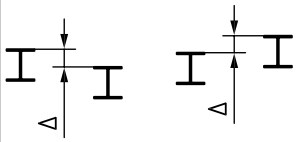
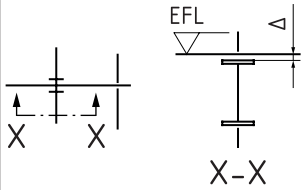
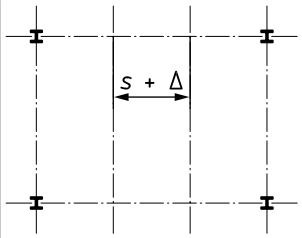
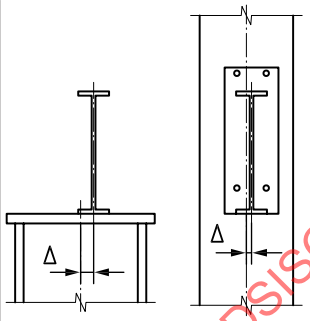
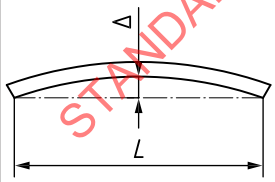
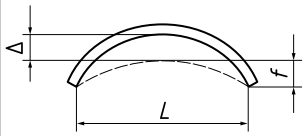
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1.6	Relative levels 	Levels of adjacent beams, measured at corresponding ends	Δ = ±10 mm	Δ = ±10 mm	Δ = ±5 mm
1.7	Connection levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL)	Δ = ±10 mm	Δ = ±10 mm	Δ = ±5 mm
2.	**Beams in buildings**				
2.1	Spacing between beam centrelines 	Deviation Δ from intended distance (s) between adjacent erected beams, measured at each end		Δ = ±10 mm	Δ = ±5 mm
2.2	Location at columns 	Deviation Δ from intended location of a beam-to column connection, measured relative to the column	Δ = ±3 mm	Δ = ±5 mm	Δ = ±3 mm
2.3	Straightness in plan 	Deviation Δ from straightness of an erected beam or cantilever of length *L*	Δ = ±*L*/500	Δ = ±*L*/500	Δ = ±*L*/1 000
2.4	Camber 	Deviation Δ at mid span from intended camber f of an erected beam or lattice component of length *L*	No requirement	No requirement	No requirement

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Table C.2 *(continued)*

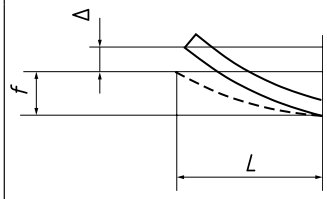
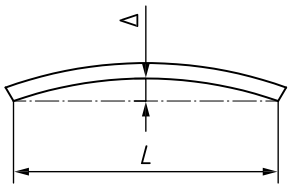
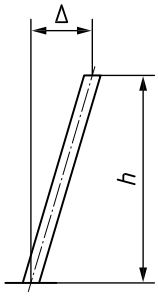
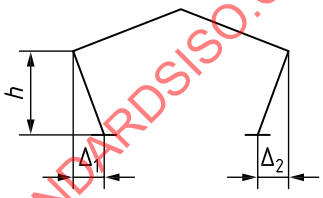
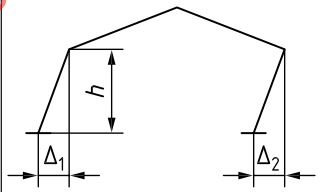
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
2.5	Pre-set of cantilever 	Deviation Δ from intended pre-set at end of an erected cantilever of length *L*	No requirement	No requirement	No requirement
2.6	Straightness of beams subject to bending and components subject to compression if unrestrained 	Deviation Δ from straightness	No requirement	No requirement	No requirement
3.	**Columns of single storey buildings**				
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height *h*	$\Delta = \pm h/500$	$\Delta = \pm h/300$	$\Delta = \pm h/500$
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column $\Delta = \Delta_1$ or Δ_2	No requirement	No requirement	No requirement
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame (For two columns, the average is $\Delta = (\Delta_1 + \Delta_2)/2$)	No requirement	No requirement	No requirement

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Table C.2 *(continued)*

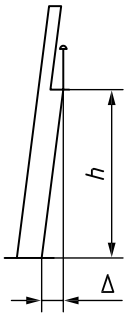
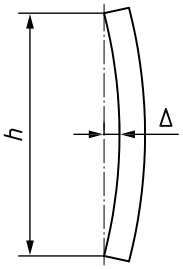
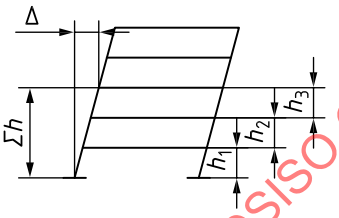
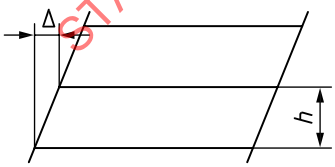
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam	No requirement	No requirement	No requirement
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom:	$\Delta = \pm h/1\,000$	No requirement	No requirement
4.	**Multi-storey buildings**				
4.1	Location at the storey level n levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level: Point < 60 m above base Point > 60 m above base Point at any height above base	$\Delta = \pm \Sigma h/500$, ≤ 25 mm $\Delta = \pm \Sigma h/500$, ≤ 25 +(Σh – 60)/3 mm	$\Delta = \pm \Sigma h/(300\sqrt{n})$	$\Delta = \pm \Sigma h/(500\sqrt{n})$
4.2	Inclination of a column, between adjacent storey levels 	Location of the column in plan, relative to a vertical line through its centre at the next lower level	$\Delta = \pm h/500$	$\Delta = \pm h/500$	$\Delta = \pm h/1\,000$

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Table C.2 *(continued)*

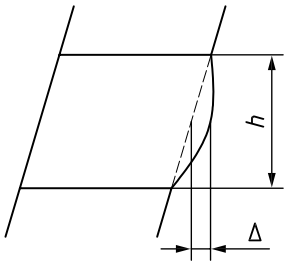
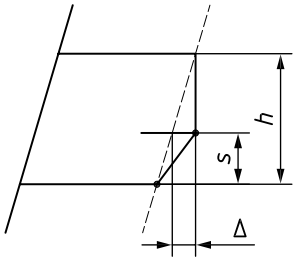
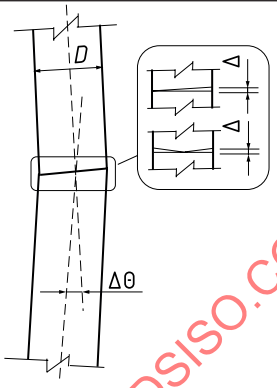
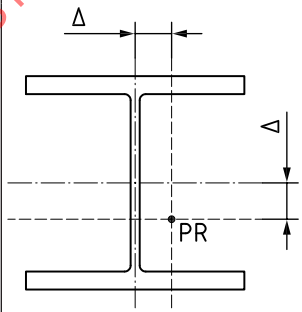
No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
4.3	Straightness of a continuous column between adjacent storey levels 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/500$	$\Delta = \pm h/750$	$\Delta = \pm h/1\,000$
4.4	Straightness of a spliced column, between adjacent storey levels 	Location of the column in plan at the splice, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm s/1\,000$, with $s \le h/2$	$\Delta = \pm s/750$, with $s \le h/2$	$\Delta = \pm s/1\,000$, with $s \le h/2$
5.	**Full contact end-bearing**				
5.1	 Column splice alignment and gap between bearing surfaces	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	$\Delta\theta = \pm 1/500$ radians, and $\Delta = 0{,}5$ mm over at least 67 % of the area, and $\Delta = 1{,}0$ mm maximum locally	No requirement	No requirement
6.	**Positions of columns**				
6.1	Location 	Location in plan of the centre of the column at the level of its base, relative to the position point of reference (PR)	$\Delta = \pm 6$ mm	$\Delta = \pm 10$ mm	$\Delta = \pm 5$ mm

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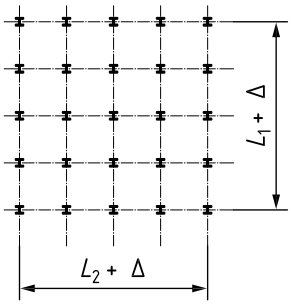
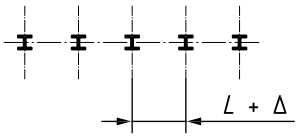
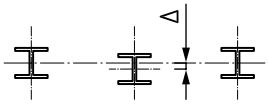
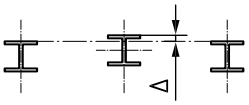
Table C.2 *(continued)*

No	Criterion	Parameter	Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
6.2	Overall length of a building 	Distance between end columns in each line, at base level (L in metres) $L \leq 30$ m 30 m < L < 250 m $L \geq 250$ m	Δ = ±20 mm Δ = ±[20 + 0,25(L-30)] mm Δ = ±[20+ 0,25(L-30)] mm	Δ = ±20 mm Δ = ±0,25 (L+50) mm Δ = ±0,1 (L+500) mm	Δ = ±16 mm Δ = ±0,2 (L+50) mm Δ = ±0,1 (L+350) mm
6.3	Column spacing 	Distance between centres of adjacent columns at base level: (L in metres) $L \leq 5$ m $L > 5$ m		Δ = ±10 mm Δ = ±0,2 (L+45) mm	Δ = ±7 mm Δ = ±0,2 (L+30) mm
6.4	Column alignment generally 	Location of the centre of the column at base level, relative to the established column line (ECL)	Δ = ±15 mm	Δ = ±10 mm	Δ = ±7 mm
6.5	Perimeter column alignment 	Location of the outer face of a perimeter column at base level, relative to the line joining the faces of the adjacent columns	No requirement	No requirement	No requirement

C.4 Tolerances for Canada

Unless otherwise noted, the reference standard for Table C.3 is CSA S16.

Table C.3 — Canada

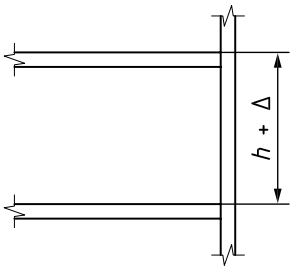
No	Criterion	Parameter	Tolerances
1.	**General**		
1.1	Height	—	No requirement
1.2	Storey height 	Height relative to the adjacent levels	Δ = ±10 mm

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Table C.3 *(continued)*

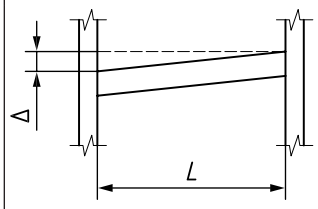
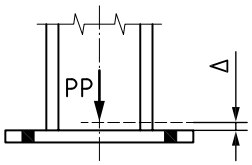
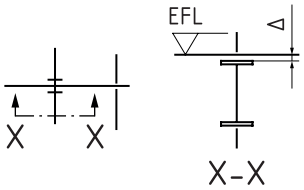
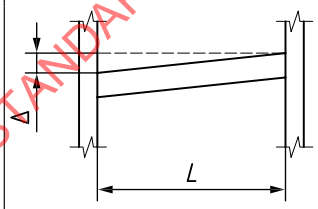
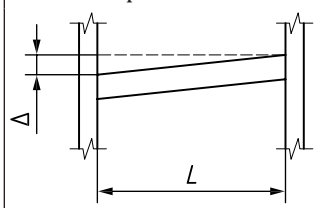
No	Criterion	Parameter	Tolerances	
1.3	Slope 	Height relative to the other end of a beam	$\Delta = \pm L/500$, and $\lvert\Delta\rvert \leq 6$ mm	
1.4	Column splice	Maximum allowable separation after alignment	6 mm	
1.5	Column base 	Level of bottom of column shaft, relative to specified level of its position point (PP)	Simple construction	Δ = ±5 mm
			Continuous construction	Δ = ±3 mm
1.6	Relative levels	—	No requirement	
1.7	Connection levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL)	Δ = ±6 mm	
2.	**Beams in buildings**			
2.1	Spacing between beam centrelines	—	No requirement	
2.2	Location at columns	—	No requirement	
2.3	Straightness in plan	—	No requirement	
2.4	Camber	—	No requirement	
2.5	Pre-set of cantilever	—	No requirement	
2.6	Straightness of beams subject to bending and components subject to compression if unrestrained	—	No requirement	
2.7	Offset of beam 	Offset of one beam end relative to another (except spandrel beams)	$\Delta = \pm L/500$, and $\lvert\Delta\rvert \leq 12$ mm	
2.8	Offset of spandrel beam 	Offset of spandrel beam end relative to another	$\Delta = \pm L/1\,000$, and $\lvert\Delta\rvert \leq 6$ mm	
3.	**Columns of single storey buildings**			

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Table C.3 *(continued)*

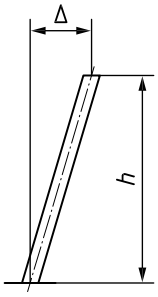
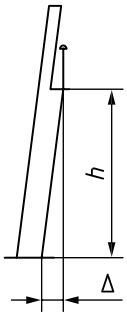
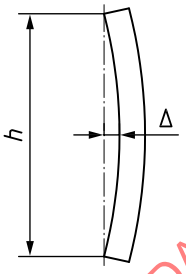
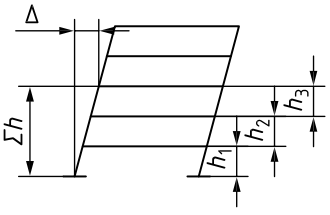
No	Criterion	Parameter	Tolerances
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height *h*	$\Delta = \pm h/500$
3.2	Inclination of individual columns in single storey portal frame buildings	—	No requirement
3.3	Inclination of single storey portal frame buildings	—	No requirement
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam	$\Delta = \pm h/1\ 000$, and $\Delta \leq 6$ mm, but need not be less than 3 mm
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom	$\Delta = \pm h/1\ 000$
4.	**Multi-storey buildings**		
4.1	Location at the storey level n levels above the base, relative to that at the base 	Location of the exterior column in plan, relative to a vertical line through its centre at base level for $n \leq 20$ storeys for $n > 20$ storeys	- indicates toward building line (exterior) + indicates away from building line (exterior) $\Delta = \pm\Sigma h/1\ 000$, and -25 mm $\leq \Delta \leq +50$ mm $\Delta = \pm\Sigma h/1\ 000$, and $\pm\Sigma h/1\ 000 \pm (n\text{-}20)2$ mm, and -50 mm $\leq \Delta \leq +75$ mm

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Table C.3 *(continued)*

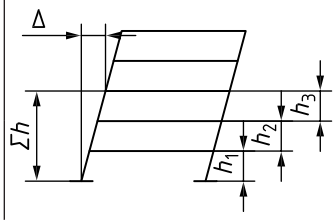
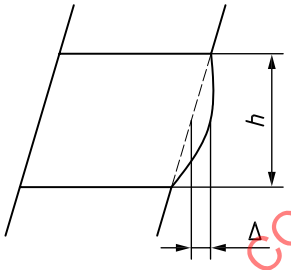
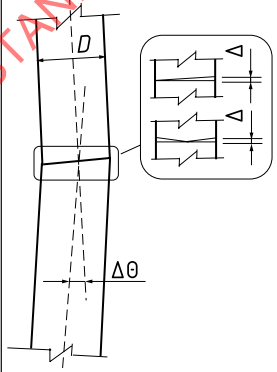
No	Criterion	Parameter	Tolerances
4.1a	Location at the storey level n levels above the base, relative to that at the base 	Location of the columns adjacent to elevator shafts in plan, relative to a vertical line through its centre at base level for $n \leq 20$ storeys for $n > 20$ storeys	$\Delta = \pm\Sigma h/1\,000$, and $\lvert\Delta\rvert \leq 25$ mm $\Delta = \pm\Sigma h/1\,000$, and $\lvert\Delta\rvert \pm (n\text{-}20)$ mm, and $-50\text{ mm} \leq \Delta \leq +50\text{ mm}$
4.2	Inclination of a column, between adjacent storey levels: 	Location of the column in plan, relative to a vertical line through its centre at the next lower level	$\Delta = \pm h/500$
4.3	Straightness of a continuous column between adjacent storey levels: 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\,000$
4.4	Straightness of a spliced column, between adjacent storey levels	—	No requirement
5.	**Full contact end-bearing**		
5.1	Column splice alignment and gap between bearing surfaces 	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	$\Delta\theta = \pm 2/500$, and Δ = 6 mm (1/4 in) if shimmed or Δ = 2 mm (1/16 in) if unshimmed
6.	**Positions of columns**		
6.1	Location	—	No requirement
6.2	Overall length of a building	—	No requirement

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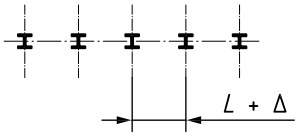
Table C.3 *(continued)*

No	Criterion	Parameter	Tolerances
6.3	Column spacing 	Distance between centres of adjacent columns at base level: (L in metres) $L \leq 5$ m $L > 5$ m	 $\Delta = \pm 10$ mm $\Delta = \pm 0{,}2(L+45)$ mm
6.4	Column alignment, generally	—	No requirement
6.5	Perimeter column, alignment	—	No requirement

C.5 Tolerances for China

Unless otherwise noted, the reference standard for Table C.4 is GB 50205.

Table C.4 — China

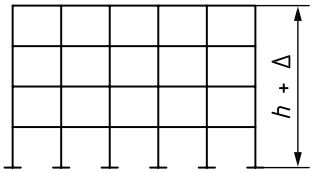
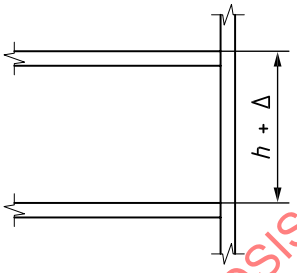
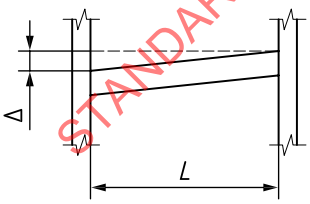
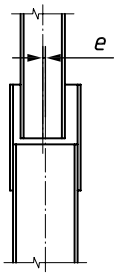
No	Criterion	Parameter	Tolerances
1.	**General**		
1.1	Height 	Overall height, relative to the base level: $h \leq 20$ m 20 m < h < 60 m 60 m < h < 100 m $h \geq 100$ m	 $\Delta = \pm h/1\,000$, and $\Delta_{max} = 20$ mm $\Delta = \pm h/1\,000$, and $\Delta_{max} = 30$ mm $\Delta = \pm h/1\,000$, and $\Delta_{max} = 50$ mm $\Delta = \pm h/1\,000$, and $\Delta_{max} = 100$ mm
1.2	Storey height 	Height relative to the adjacent levels	$\Delta = \pm 3$ mm
1.3	Slope 	Height relative to the other end of a beam	$\Delta = \pm L/1\,000$, and $\lvert\Delta\rvert \leq 10$ mm
1.4	Column splice 	Non-intended eccentricity e about either axis	$e \leq 3$ mm

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Table C.4 *(continued)*

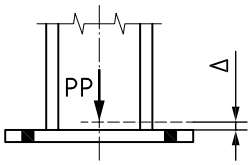
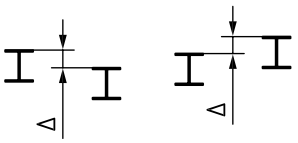
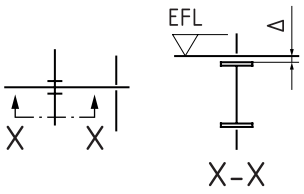
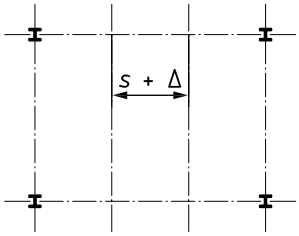
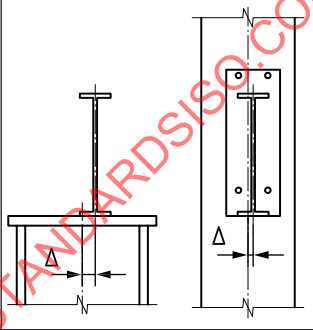
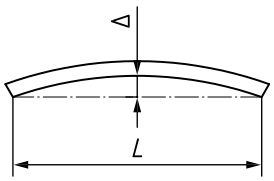
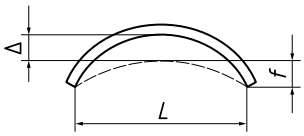
No	Criterion	Parameter	Tolerances
1.5	Column base 	Level of bottom of column shaft, relative to specified level of its position point (PP)	Δ = ±3 mm
1.6	Relative levels 	Levels of adjacent beams, measured at corresponding ends	Δ = ±10 mm
1.7	Connection levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL)	Δ = ±3 mm
2.	**Beams in buildings**		
2.1	Spacing between beam centrelines 	Deviation Δ from intended distance (s) between adjacent erected beams, measured at each end	Δ = ±3 mm
2.2	Location at columns 	Deviation Δ from intended location of a beam-to column connection, measured relative to the column	Δ = ±5 mm
2.3	Straightness in plan 	Deviation Δ from straightness of an erected beam or cantilever of length L	Δ = ±L/2 000, and Δ_{max} = 10 mm
2.4	Camber 	Deviation Δ at mid span from intended camber f of an erected beam or lattice component of length L	Δ = ±L/1 000, and Δ_{max} = 10 mm, and Δ_{min} = -5 mm

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Table C.4 *(continued)*

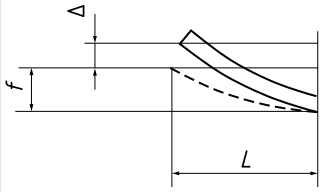
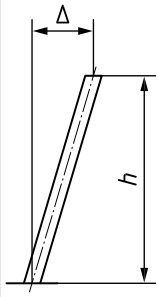
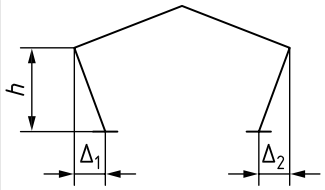
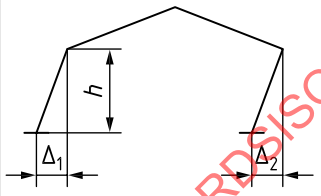
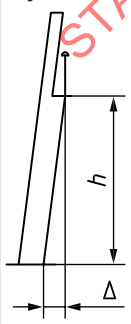
No	Criterion	Parameter	Tolerances
2.5	Pre-set of cantilever 	Deviation Δ from intended pre-set at end of an erected cantilever of length L	$\Delta = \pm L/300$, and $\Delta_{max} = 4$ mm
3.	**Columns of single storey buildings**		
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height h	$\Delta = \pm h/1\,000$, and $\Delta_{max} = 25$ mm
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column $\Delta = \Delta_1$ or Δ_2	$\Delta = \pm h/500$, and $\Delta_{max} = 25$ mm
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame (For two columns the average is $\Delta = (\Delta_1 + \Delta_2)/2$)	$\Delta = \pm h/500$, and $\Delta_{max} = 25$ mm
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam	$\Delta = \pm h/1\,000$, and $\Delta_{max} = 10$ mm

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Table C.4 *(continued)*

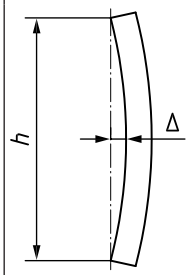
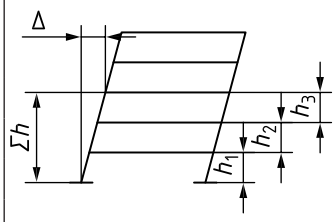
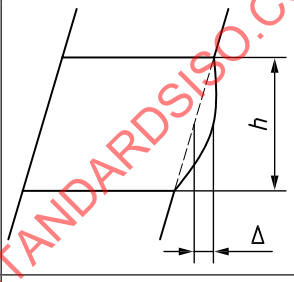
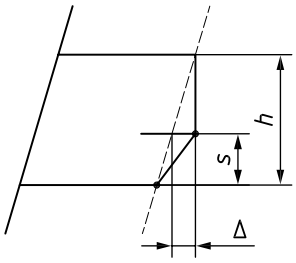
No	Criterion	Parameter	Tolerances
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom	$\Delta = \pm h/1\,000$, and Δ_{max} =12 mm
4.	**Multi-storey buildings**		
4.1	Location at the storey level n levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level: (h in metres) $h \leq 20$ m 20 m < h < 60 m 60 m < h < 100 m $h \geq 100$ m	 $\Delta = \Sigma h/1\,000$, and Δ_{max} = 25 mm $\Delta = \Sigma h/2\,500 + 10$, and Δ_{max} = 30 mm $\Delta = \Sigma h/2\,500 + 10$, and Δ_{max} = 50 mm $\Delta = \Sigma h/1\,000$, and Δ_{max} = 80 mm
4.2	Inclination of a column, between adjacent storey levels 	Location of the column in plan, relative to a vertical line through its centre at the next lower level	$\Delta = \pm h/1\,000$, and Δ_{max} = 10 mm
4.3	Straightness of a continuous column between adjacent storey levels 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\,000$, and Δ_{max} = 10 mm
4.4	Straightness of a spliced column, between adjacent storey levels 	Location of the column in plan at the splice, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\,000$, and Δ_{max} = 10 mm
5.	**Full contact end-bearing**		

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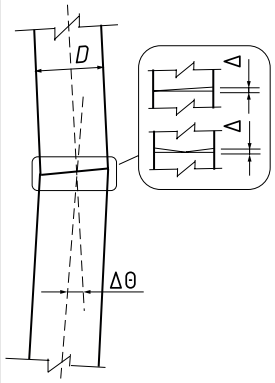
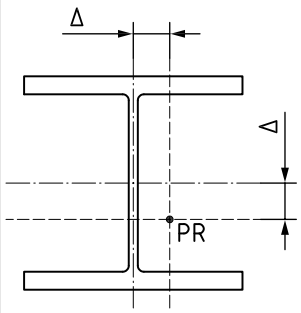
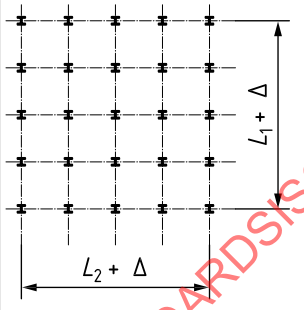
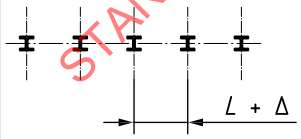
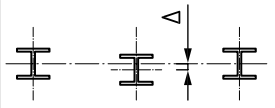
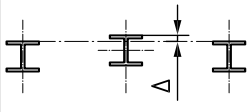
Table C.4 *(continued)*

No	Criterion	Parameter	Tolerances
5.1	Column splice alignment and gap between bearing surfaces 	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	$\Delta\theta$ = ±1/500, and Δ = 0,8 mm over at least 2/3 of the area, and Δ = 0,8 mm maximum locally
6.	**Positions of columns**		
6.1	Location 	Location in plan of the centre of the column at the level of its base, relative to the position point of reference (PR)	Δ = ±3 mm
6.2	Overall length of a building 	Distance between end columns in each line, at base level	Δ = L/20 000, and Δ_{max} = 3 mm
6.3	Column spacing 	Distance between centres of adjacent columns at base level: $L \leq 5$ m $L > 5$ m	 Δ = ±4 mm Δ = ±4 mm
6.4	Column alignment generally 	Location of the centre of the column at base level, relative to the established column line (ECL)	Δ = ±3 mm
6.5	Perimeter column alignment 	Location of the outer face of a perimeter column at base level, relative to the line joining the faces of the adjacent columns	Δ = ±5 mm

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C.6 Tolerances for Japan

The reference standard for Table C.5 is JASS 6.

a) The tolerances shown in this annex are classified into limit tolerances and control tolerances.

b) The limit tolerance is a maximum or minimum value for the acceptance criteria and shall not be exceeded, as a rule.

c) The control tolerance is a target value defined as a criterion for fabrication or erection so that 95 % or more products may be accepted and in the receiving inspection of dimensional accuracy, an accepted value to judge each product with the purpose of judging whether the inspection lot will be accepted or rejected.

d) When the limit tolerance of dimensional accuracy is exceeded in the receiving inspection, the product shall be rejected and re-fabricated, as a rule. However, when re-fabrication is impossible, remedial works equivalent to re-fabrication shall be made and the product shall be re-inspected.

e) When the control tolerances are exceeded but are within the limit tolerances, repair or scrapping of product shall not be required. In sampling inspection using the control tolerance as the acceptance criteria, when the inspected lot is rejected, all the remaining products of the same lot shall be inspected.

f) In spite of the inspection lot, with regard to the products that exceed the limit tolerance, the discussion with the engineer, and remedial work, re-fabrication or other necessary measures shall be taken.

Table C.5 — Japan

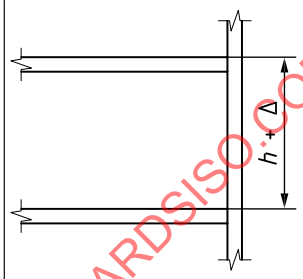
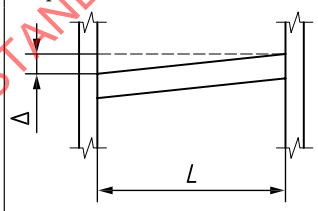
No	Criterion	Parameter	Limit tolerances	Control tolerances
1.	**General**			
1.1	Height	—	No requirement	No requirement
1.2	Storey height 	Height relative to the adjacent levels	Δ = ±8 mm	Δ = ±5 mm
1.3	Slope 	Height relative to the other end of a beam	$\Delta \leq L/700 + 5$ mm and Δ ≤ 15 mm	$\Delta \leq L/1\,000 + 3$ mm and Δ ≤ 10 mm
1.4	Column splice	—	No requirement	No requirement

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Table C.5 *(continued)*

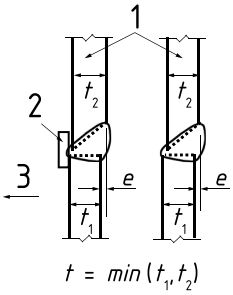
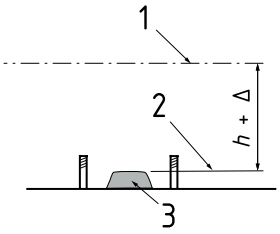
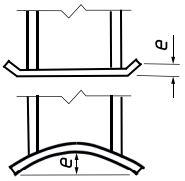
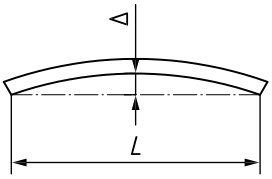
No	Criterion	Parameter	Limit tolerances	Control tolerances
1.4a	Column splice  Key 1 Column surface plate 2 Backing metal 3 Inside	Non-intended eccentricity e about either column surface $t \leq 15$ mm $t > 15$ mm	$e \leq 1{,}5$ mm $e \leq t/10$ and $e \leq 3$ mm	$e \leq 1$ mm $e \leq t/15$ and $e \leq 2$ mm
1.5	Column base	—	No requirement	No requirement
1.5a	Column base  1 Reference height 2 Installation level 3 Base mortar	Distance between the reference height and the column installation level	Δ = ±5 mm	Δ = ±3 mm
1.5b	Column base  	Amount of bend e from a base plate Deviation e from straightness of a base plate	$e \leq 3$ mm	$e \leq 2$ mm
1.6	Relative levels	—	No requirement	No requirement
1.7	Connection levels	—	No requirement	No requirement
2.	**Beams in buildings**			
2.1	Spacing between beam centre-lines	—	No requirement	No requirement
2.2	Location at columns	—	No requirement	No requirement
2.3	Straightness in plan  	Deviation Δ from straightness of an erected beam or cantilever of length L	$\Delta \leq 1{,}5\ L/1\,000$ and $\Delta \leq 15$ mm	$\Delta \leq L/1\,000$ and $\Delta \leq 10$ mm
2.4	Camber	—	No requirement	No requirement
2.5	Pre-set of cantilever	—	No requirement	No requirement
3.	**Columns of Single Storey Buildings**			

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Table C.5 *(continued)*

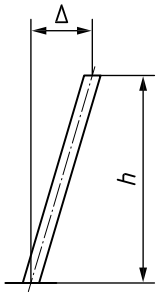
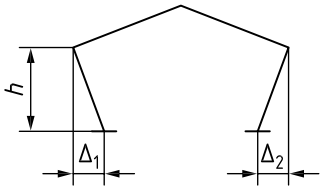
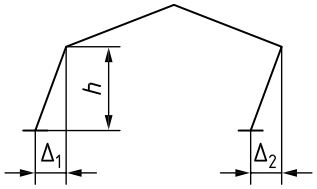
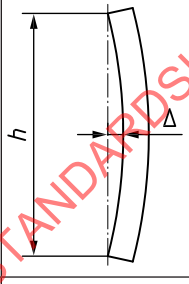
No	Criterion	Parameter	Limit tolerances	Control tolerances
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height *h*	$\Delta \leq h/700$ and $\Delta \leq 15$ mm	$\Delta \leq h/1\,000$ and $\Delta \leq 10$ mm
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column $\Delta = \Delta_1$ or Δ_2	$\Delta \leq h/700$ and $\Delta \leq 15$ mm	$\Delta \leq h/1\,000$ and $\Delta \leq 10$ mm
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame (For two columns the average is: Δ = (Δ1 + Δ2)/2)	$\Delta \leq h/700$ and $\Delta \leq 15$ mm	$\Delta \leq h/1\,000$ and $\Delta \leq 10$ mm
3.4	Inclination of any column that supports a crane gantry	—	No requirement	No requirement
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom	$\Delta \leq h/1\,000$ and $\Delta \leq 8$ mm	$\Delta \leq h/1\,500$ and $\Delta \leq 5$ mm
4.	**Multi-storey buildings**			
4.1	Location at the storey level n levels above the base, relative to that at the base	—	No requirement	No requirement
4.2	Inclination of a column, between adjacent storey levels	—	No requirement	No requirement
4.3	Straightness of a continuous column between adjacent storey levels	—	No requirement	No requirement
4.4	Straightness of a spliced column, between adjacent storey levels	—	No requirement	No requirement

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Table C.5 *(continued)*

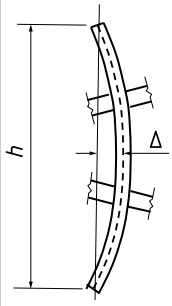
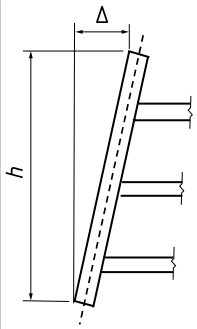
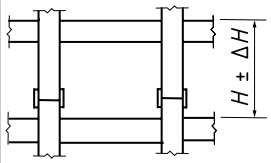
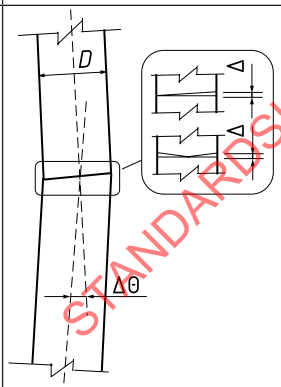
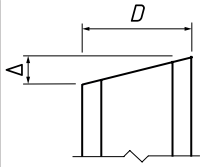
No	Criterion	Parameter	Limit tolerances	Control tolerances
4.5	Straightness of a sectioned column 	Location of the sectioned column in plan, relative to a straight line between position points at top and bottom NOTE: Verified by receiving inspection in-house, generally, and estimated at each tier, not each floor.	$\Delta \leq h/1\,000$ and $\Delta \leq 8$ mm	$\Delta \leq h/1\,500$ and $\Delta \leq 5$ mm
4.6	Inclination of sectioned columns 	Inclination in a sectioned column height h NOTE: The criteria tend to be difficult to observe for short columns.	$\Delta \leq h/700$ and $\Delta \leq 15$ mm	$\Delta \leq h/1\,000$ and $\Delta \leq 10$ mm
4.7	Story height at field joint 	Story height at field joint	$\Delta = \pm 8$ mm	$\Delta = \pm 5$ mm
5.	**Full contact end-bearing**			
5.1	 Column splice alignment and gap between bearing surfaces	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	No requirement	No requirement
5.1a	Mating surface 	Distance between the mating surface and the horizontal plane of the column	$\Delta \leq 2{,}5\,D/700$	$\Delta \leq 1{,}5\,D/1\,000$
6.	**Positions of columns**			
6.1	Location	—	No requirement	No requirement

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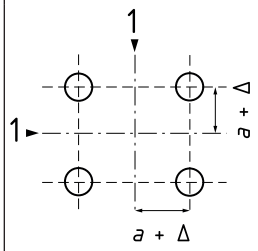
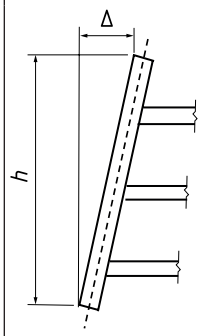
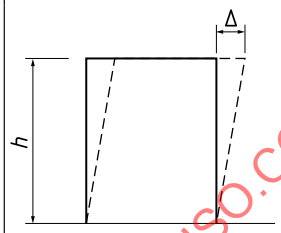
Table C.5 *(continued)*

No	Criterion	Parameter	Limit tolerances	Control tolerances
6.2	Overall length of a building	—	No requirement	No requirement
6.3	Column spacing	—	No requirement	No requirement
6.4	Column alignment generally	—	No requirement	No requirement
6.5	Perimeter column alignment	—	No requirement	No requirement
6.6	Location  1 Column centreline	Location of the anchor bolt at the base level, relative to the centrelines of the column	Δ = ±5 mm	Δ = ±3 mm
6.7	Inclination of sectioned columns  	Inclination in a sectioned column height *h*	Δ ≤ *h* /700 and Δ ≤ 15 mm	Δ ≤ *h* /1 000 and Δ ≤ 10 mm
6.8	Inclination of buildings  	Overall inclination in a building height *h*	Δ ≤ *h* /2 500 + 10 mm and Δ ≤ 50 mm	Δ ≤ *h* /4 000 + 7 mm and Δ ≤ 20 mm

C.7 Tolerances for Russian Federation

Unless otherwise noted, the reference standard for Table C.6 is SP 70.13330.

Table C.6 — Russian Federation

No	Criterion	Parameter	Tolerances
1.	**General**		

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Table C.6 *(continued)*

No	Criterion	Parameter	Tolerances
1.1	Before assembly	Limit deviations of dimensions that determine the assembly of structures (length of elements, distance between groups of mounting holes).	
		Intervals of nominal dimensions	
		for linear dimensions, mm	
		500 to 2 500	5 mm
		2 500 to 4 000	6 mm
		4 000 to 8 000	8 mm
		8 000 to 16 000	10 mm
		16 000 to 25 000	12 mm
		25 000 to 40 000	16 mm
		for equal diagonals, mm	
		500 to 2 500	No requirement
		2 500 to 4 000	16 mm
		4 000 to 8 000	20 mm
		8 000 to 16 000	24 mm
		16 000 to 25 000	30 mm
		25 000 to 40 000	40 mm
2.	**Columns and supports**		
2.1	Deviations of the elevation of the supporting surfaces of the column and supports from the design elevations	Elevation deviations of supporting surfaces, mm	±5 mm
2.2	The difference in elevations of the supporting surfaces of adjacent columns and supports in a row and in a span	Difference in elevations of supporting surfaces, mm	±3 mm
2.3	Offset of the axes of columns and supports relative to the center axes in the reference section	Displacement of axes of columns and supports, mm	±5 mm
2.4	Maximum deviation of column axes from the vertical in the upper section with the length of the columns	length of the columns, mm	
		4 000 to 8 000	±10 mm
		8 000 to 16 000	±12 mm
		16 000 to 25 000	±15 mm
		25 000 to 40 000	±20 mm
2.5	Deflection (curvature) of the column, support and ties along the columns, mm	—	0,001 3 of the distance between fixing points, but not more than 15 mm
2.6	One-sided clearance between milled surfaces at column joints	—	0,000 7 of the cross-section of the column; contact area should be at least 65 % of the cross-sectional area
3.	**Columns of single storey buildings**		

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Table C.6 *(continued)*

No	Criterion	Parameter	Tolerances
3.1	Elevations of reference nodes, mm	—	±10 mm
3.2	Offset of trusses, girder beams from the axes on the column heads from the frame plane	—	±15 mm
3.3	Arrow of deflection (curvature) between the anchoring points of the compressed sections of the truss chord and the girder beam	—	0,001 3 of the length of the fixed section, but not more than 15 mm
3.4	The distance between the axes of trusses, beams, girders, along the upper chords between the anchoring points	—	±15 mm
3.5	Alignment of the axes of the lower and upper chords of trusses relative to each other (in plan)	—	0,004 of the truss height
3.6	Deviation of the symmetry of the installation of the truss, beam, girder, floor panel and covering (with a support area of 50 mm or more)	—	±10 mm
3.7	Deviation of the lamp posts and panels from the vertical	—	±8 mm
3.8	Distance between purlins	—	±5 mm
4.	**Multi-storey buildings up to 150 m tall**		
4.1	Deviation from the alignment of the marks of the geometric axes of the columns in the upper section with the marks of the center axes at the length of the columns, mm	length of the columns, mm 500 to 4 000 4 000 to 8 000 8 000 to 16 000 16 000 to 25 000 25 000 to 40 000	 No requirement ±12 mm ±15 mm ±20 mm ±25 mm
4.2	Difference in elevation of the top of the columns of each tier	n is the number of the tier	0,5 n + 9 mm
4.3	Offset of the girder axis, girder from the column axis	—	8 mm
4.4	Deviation of the distance between the axes of the girders and beams in the middle of the span	—	10 mm
4.5	Difference between the top marks of two adjacent girth rail	—	15 mm
4.6	Difference in the marks of the top of the crossbar at its ends	—	0,001 L, but not more than 15 mm
5.	**Beams in buildings**		

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Table C.6 *(continued)*

No	Criterion	Parameter	Tolerances
5.1	Farms, crossbars, beams and girders	Reference Node Elevation	±10 mm
		Offset from the axes on the column heads from the plane of the frame	±15 mm
		Deflection arrow (curvature) between the fixing points of the compressed sections of the truss chord and beam	0,004
		Distance between axes of structures along the upper chords between fixing points	0,001 3 of the length of the fixed section, but not more than 15 mm
		The combination of the axes of the lower and upper chords of truss relative to each other (in plan)	0,004 of truss height
		Deviation of the symmetry of the installation of the structure (with a support platform length of 50 mm or more)	±10 mm

C.8 Tolerances for United Kingdom

Unless otherwise noted, the reference standard for Table C.7 is BCSA NSSS.

Table C.7 — United Kingdom

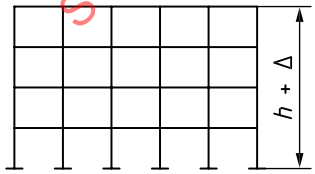
No	Criterion	Parameter	Tolerances
1.	**General**		
1.1	Overall height 	Overall height, relative to the base level (h in metres) $h \leq 20$ m 20 m < h < 100 m $h \geq 100$ m	 Δ = ±20 mm Δ = ±0,5 (h+20) mm Δ = ±0,2 (h+200) mm

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Table C.7 *(continued)*

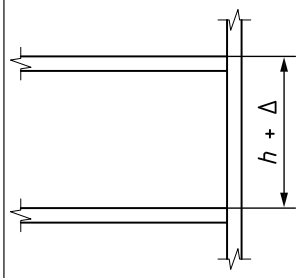
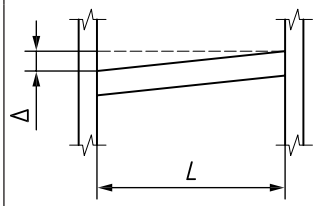
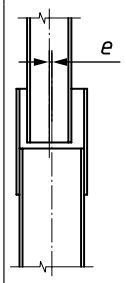
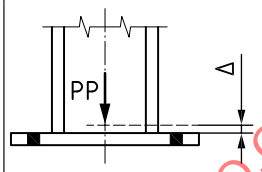
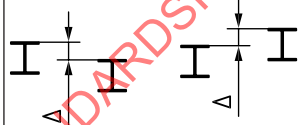
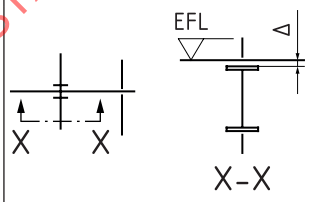
No	Criterion	Parameter	Tolerances
1.2	Storey height 	Height relative to the adjacent levels	Δ = ±10 mm
1.3	Beam slope 	Height relative to the other end of a beam	Δ = *L*/500, but not greater than 10 mm
1.4	Eccentricity at column splice 	Non-intended eccentricity e about either axis	*e* ≤ 5 mm
1.5	Level of Columns at base 	Level of bottom of column shaft, relative to specified level of its position point (PP)	Δ = ±5 mm
1.6	Relative beam levels 	Levels of adjacent beams, measured at corresponding ends	Δ = ±10 mm
1.7	Beam levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL) NOTE: The established floor level is the level representing a series of beams at one storey level.	Δ = ±10 mm
2.	**Beams in buildings**		

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Table C.7 *(continued)*

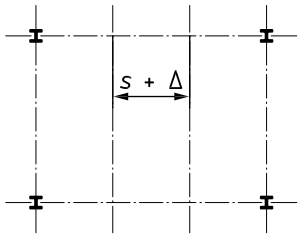
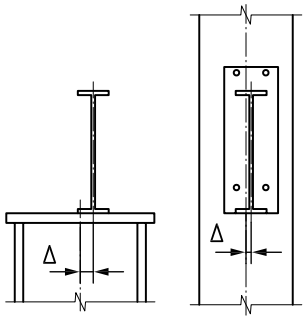
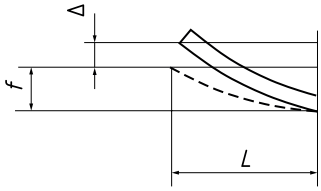
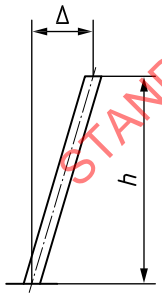
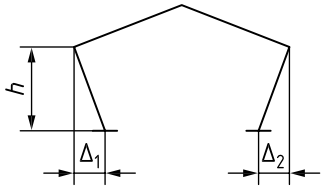
No	Criterion	Parameter	Tolerances
2.1	Spacing between beam centrelines 	Deviation Δ from intended distance (s) between adjacent erected beams, measured at each end	Δ = ±10 mm
2.2	Beam location 	Deviation Δ from intended location of a beam-to-column connection, measured relative to the column	Δ = ±5 mm
2.3	Straightness in plan	—	No requirement
2.4	Camber	—	No requirement
2.5	Pre-set of cantilever 	Deviation Δ from intended pre-set at end of an erected cantilever of length L	Δ = ±L/200
2.6	Straightness of beams subject to bending and components subject to compression if unrestrained	—	No requirement
3.	**Columns of Single Storey Buildings**		
3.1	Inclination of columns of single storey buildings 	Inclination of top relative to base on main axes. NOTE: Excluding portal frames, see BCSA NSSS:2021, 9.6.6 and 9.6.7, and columns supporting crane gantries, see 9.6.24	Δ = ±h/300
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column Δ = Δ_1 or Δ_2	Δ = ±h/150

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Table C.7 *(continued)*

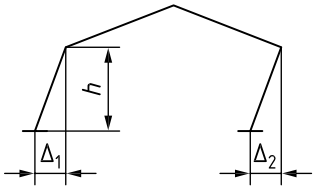
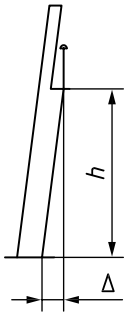
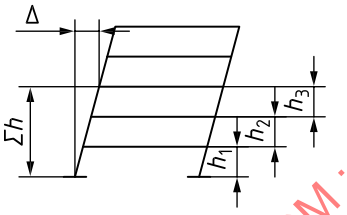
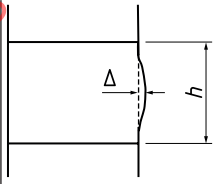
No	Criterion	Parameter	Tolerances
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame For two columns, the average is $\Delta = (\Delta_1 + \Delta_2)/2$	$\Delta = \pm h\ /500$
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam	$\Delta = \pm h/1\ 000$ up to a maximum of 25 mm
3.5	Straightness of a single storey column	—	No requirement
4.	**Multi-storey buildings**		
4.1	Location at the storey level n levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level	$\Delta = \pm\Sigma h/(300\sqrt{n})$ and $\Sigma\, h = h_1 + h_2 + h_3$, + etc.
4.2	Inclination of a column, between adjacent storey levels 	Location of the column in plan, relative to a vertical line through its centre at the next lower level	$\Delta = \pm h/300$
4.3	Straightness of a continuous column between adjacent storey levels 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\ 000$

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Table C.7 *(continued)*

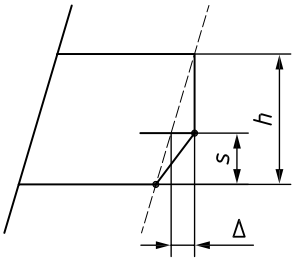
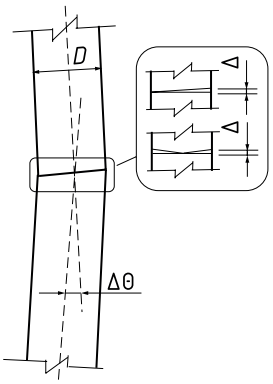
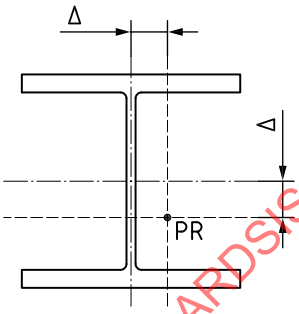
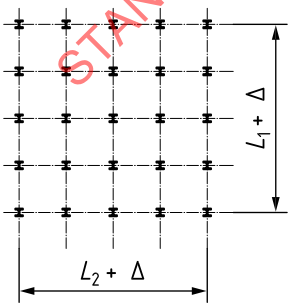
No	Criterion	Parameter	Tolerances
4.4	Straightness of a spliced column, between adjacent storey levels 	Location of the column in plan at the splice, relative to a straight line between position points at adjacent storey levels s is the position of the column splice	$\Delta = \pm s/1\,000$, with $s \leq h/2$
5.	**Full contact end-bearing**		
5.1	Column splice alignment and gap between bearing surfaces 	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X" NOTE See BCSA NSSS:2021, 4.3.3, 7.2.3 and 9.6.12.	$\Delta\theta = \pm 1/500$, and $\Delta = 0{,}5$ mm over at least 2/3 of the area, with a maximum of 1,0 mm locally
6.	**Positions of columns**		
6.1	Position of columns at base 	Location in plan of the centre of the column at the level of its base, relative to the position point of reference (PR)	$\Delta = \pm 10$ mm
6.2	Overall length of a building 	Distance between end columns in each line, at base level (L in metres) $L \leq 30$ m 30 m < L < 250 m $L \geq 250$ m	 $\Delta = \pm 20$ mm $\Delta = \pm 0{,}25\,(L+50)$ mm $\Delta = \pm 0{,}1\,(L+500)$ mm

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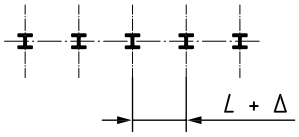
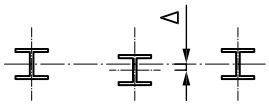
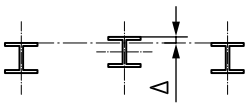
Table C.7 *(continued)*

No	Criterion	Parameter	Tolerances
6.3	Column spacing 	Distance between centres of adjacent columns at base level (*L* in metres) $L \leq 5$ m $L > 5$ m	 Δ = ±10 mm Δ = ±0,2 (*L*+45) mm
6.4	Column alignment, generally 	Location of the centre of the column at base level, relative to the established column line (ECL) NOTE: See BCSA NSSS: 2021, 9.6.17 for perimeter columns. The established column line is the alignment representing a series of columns in one line.	Δ = ±10 mm
6.5	Perimeter column alignment 	Location of the outer face of a perimeter column at base level, relative to the line joining the faces of the adjacent columns	Δ = ±10 mm

C.9 Tolerances for the United States

Unless otherwise noted, the reference standard for Table C.8 is AISC 303.

Table C.8 — United States

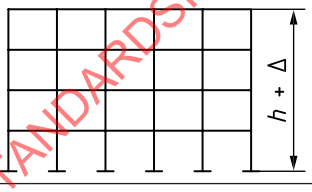
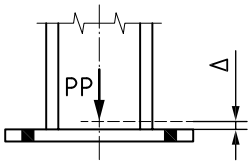
No	Criterion	Parameter	Tolerances
1.	**Buildings**		
1.1	Height 	Overall height, relative to the base level: $h \leq 20$ m 20 m < h < 100 m $h \geq 100$ m	Function of base elevation tolerance and column length tolerance
1.2	Storey height	—	No requirement
1.3	Slope	—	No requirement
1.4	Column splice	—	No requirement
1.5	Column base 	Level of bottom of column shaft, relative to specified level of its position point (PP)	Δ = ±1/8 in [3 mm]

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Table C.8 *(continued)*

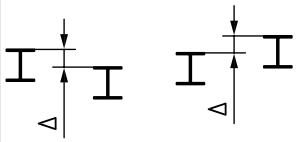
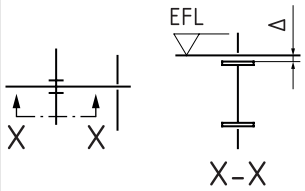
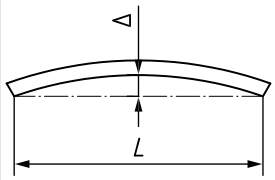
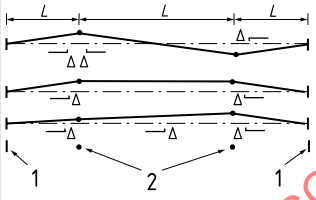
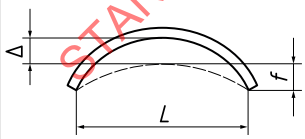
No	Criterion	Parameter	Tolerances
1.6	Relative levels 	Levels of adjacent beams, measured at corresponding ends	Function of fabrication tolerances
1.7	Connection levels 	Level of the beam at a beam-to-column connection, measured relative to the established floor level (EFL)	Δ = + 5 mm, - 8 mm (Δ = + 3/16 in, - 5/16 in) from the next higher splice
2.	**Beams in buildings**		
2.1	Spacing between beam centrelines	—	No requirement
2.2	Location at columns	—	No requirement
2.3	Straightness in plan 	Deviation Δ from straightness of an erected beam or cantilever of length L for $L \leq 14$ m [45 ft] for $L > 14$ m [45 ft]	Δ = 3 mm (L_{mm}/3 m) [Δ = 1/8 in (L_{ft} /10 ft] Δ = 10 mm + 3 mm (L_{mm}/3 m) [Δ = 3/8 + 1/8 in (L_{ft} - 45)/10 ft]
2.3a	Straightness of field spliced members in plan and elevation  Key 1 Support points 2 Splice points	Angular variation from theoretical	Δ = L/500
2.4	Camber 	Deviation Δ at mid span from intended camber f of an erected beam or lattice component of length L For $L \leq 15$ m [50 ft] For $L > 15$ m [50 ft] For lattice	+ 12 mm (1/2 in), - 0 Minimum 75 % specified camber + 12 mm + 3 mm (L – 15 m)/3, - 0 [+ 1/2 in + 1/8 in (L – 50 ft)/10], - 0 Minimum 75 % specified camber Δ = L/800

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Table C.8 *(continued)*

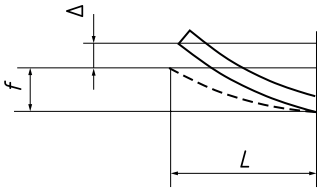
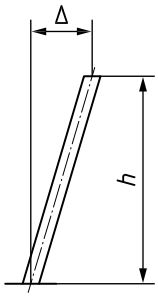
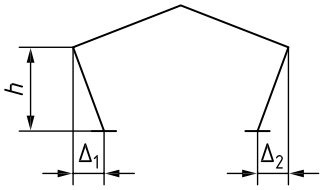
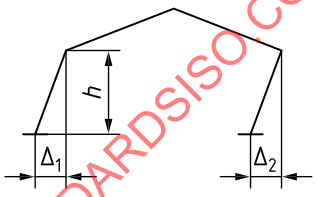
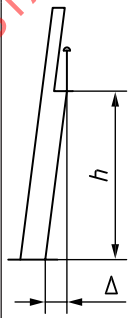
No	Criterion	Parameter	Tolerances
2.5	Pre-set of cantilever 	Deviation Δ from intended pre-set f at end of an erected cantilever of length L	$\Delta = \pm L/500$
NOTE Source: ASTM A6/A6M:2019			
3.	**Columns of single storey buildings**		
3.1	Inclination of columns of single storey buildings 	Overall inclination in storey height h	$\Delta = \pm h/500$
3.2	Inclination of individual columns in single storey portal frame buildings 	Inclination Δ of each column $\Delta = \Delta_1$ or Δ_2	Same as other columns
3.3	Inclination of single storey portal frame buildings 	Average inclination of all the columns in the same frame (For two columns the average is Δ = (Δ1 + Δ2)/2	Same as other columns
3.4	Inclination of any column that supports a crane gantry 	Inclination from floor level to bearing of crane beam:	See AISC Design Guide 7 for crane structure tolerances. No different tolerances for column plumbness.

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Table C.8 *(continued)*

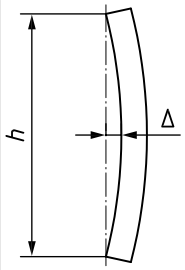
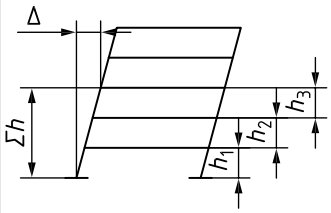
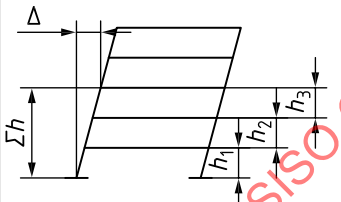
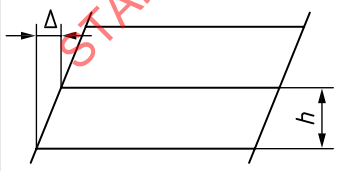
No	Criterion	Parameter	Tolerances
3.5	Straightness of a single storey column 	Location of the column in plan, relative to a straight line between position points at top and bottom	Fabrication tolerance, not an erection tolerance $\Delta = \pm h/1\,000$
4.	**Multi-storey buildings**		
4.1	Perimeter Columns — Location at the storey level n levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level: For n = 1 - 20 For n > 20	Measured from the established column line at perimeter columns. Working point at a splice inside a 38 mm (1-½ in) envelope + indicates toward building exterior, - indicates toward building interior $\Delta = h/500$ + 6 mm (1/4 inch) not to exceed – 50 mm, + 25 mm (not to exceed - 2 in, + 1 in) $\Delta = \Delta_{20} + \Sigma(n\text{-}20)(2\text{ mm})$, not to exceed - 75, + 50 mm [$\Delta = \Delta_{20} + \Sigma(n\text{-}1)(1/16\text{ in})$, not to exceed - 3, + 2 in]
4.1a	Elevator columns —Location at the storey level n levels above the base, relative to that at the base 	Location of the column in plan, relative to a vertical line through its centre at base level For n = 1-20 For n > 20	Measured from the established column line at columns at elevator shaft. Working point at a splice inside a 38 mm (1½ in) envelope + indicates toward building exterior, - indicates toward building interior $\Delta = h/500$ + 6 mm (1/4 in), not to exceed 25 mm (1 in) - $\Delta = \Delta_{20} + \Sigma(n\text{-}20)(1\text{ mm})$ (1/32 in), not to exceed 50 mm (2 in)
4.2	Inclination of a column, between adjacent storey levels 	Location of the column in plan, relative to a vertical line through its centre at the next lower level	$\Delta = \pm h/500$

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Table C.8 *(continued)*

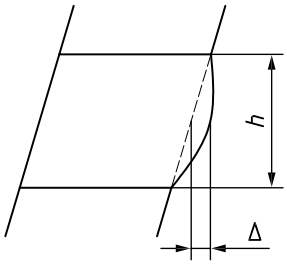
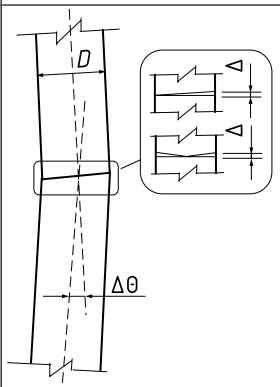
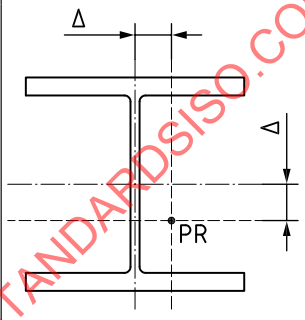
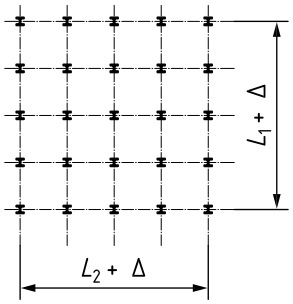
No	Criterion	Parameter	Tolerances
4.3	Straightness of a continuous column between adjacent storey levels 	Location of the column in plan, relative to a straight line between position points at adjacent storey levels	$\Delta = \pm h/1\,000$
4.4	Straightness of a spliced column, between adjacent storey levels	—	No requirement
5.	**Full contact end-bearing**		
5.1	 Column splice alignment and gap between bearing surfaces	Local angular misalignment $\Delta\theta$ occurring at the same time as gap Δ at point "X"	$\Delta\theta = \pm 2/500$ and Δ = 6 mm (1/4 in) if shimmed or Δ = 2 mm (1/16 in) if unshimmed
6.	**Positions of columns**		
6.1	Location 	Location in plan of the centre of the column at the level of its base, relative to the position point of reference (PR):	Δ = ±6 mm (1/4 in)
6.2	Overall length of a building 	Distance between end columns in each line, at base level: $L \leq 30$ m 30 m < L < 250 m $L \geq 250$ m	Function of accumulated column location tolerance at base and column plumbness tolerances
6.3	Column spacing	—	No requirement

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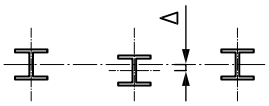
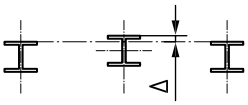
Table C.8 *(continued)*

No	Criterion	Parameter	Tolerances
6.4	Column alignment, generally 	Location of the centre of the column at base level, relative to the established column line (ECL)	Δ = ±6 mm (1/4 in)
6.5	Perimeter column alignment 	Location of the centreline of a perimeter column at base level, relative to the line joining the faces of the adjacent columns: up to 90 m (300 ft) tall ± above 90 m (300 feet) tall	 within an envelope that is 38 mm (1-1/2 in) wide add 12 mm per 30 m (1/2 in per 100 ft), maximum 75 mm (3 in)

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Annex D
(informative)

Geometrical tolerances — Bridges

D.1 Tolerances per country — Bridges

Permitted deviations for geometrical tolerances in bridges are referenced in national standards shown in:

— Table D.1: Europe;

— Table D.2: Australia / New Zealand;

— Table D.3: Canada;

— Table D.4: China;

— Table D.5: Japan;

— Table D.6: Russian Federation;

— Table D.7: United Kingdom;

— Table D.8: United States.

D.2 Tolerances for Europe

Table D.1 — Europe

Standard	Title	Notes
EN 1090-2	Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures	
EN 1993-2	Eurocode 3: Design of steel structures – Part 2: Steel Bridges	

D.3 Tolerances for Australia and New Zealand

Table D.2 — Australia and New Zealand

Standard	Title	Notes
AS/NZS 5100.6	Structural steelwork – Fabrication and erection	Referenced from AS/NZS 5100.6 Bridge design – Part 6: Steel and composite construction

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D.4 Tolerances for Canada

Table D.3 — Canada

Standard	Title	Notes
CAN/CSA-S6	Canadian Highway Bridge Design Code	
CAN/CSA-W59	Welded Steel Construction	

D.5 Tolerances for China

Table D.4 — China

Standard	Title	Notes
Q/CR 9211	Code for Fabrication of Railway Steel Bridge	

D.6 Tolerances for Japan

Table D.5 — Japan

Standard	Title	Notes
JARA, Part 1	Japanese Design Specifications for Highway Bridges, Part I Common	JARA: Japan Road Association
JARA, Part 2	Japanese Design Specifications for Highway Bridges, Part II Steel Bridges	

D.7 Tolerances for Russian Federation

Table D.6 — Russian Federation

Standard	Title	Notes
SP 70.13330	Load-bearing and separating constructions	
SP 46.13330	Bridges and pipes	Subsection 13
SP 78.13330	Automobile roads	Annex A
ODM 218.2.025	Expansion joints of bridge structures on highways	Tables 1-5

D.8 Tolerances for United Kingdom

Table D.7 — United Kingdom

Standard	Title	Notes
EN 1090-2	Execution of steel structures and aluminium structures	
PD 6705-2	Structural use of steel and aluminium: Part 2: Execution of steel bridges conforming to BS EN 1090-2 – Guide	
MCHW	Manual of Contract Documents for Highway Works Volume 1, Specification for Highway Works, Series 1800 - Structural Steelwork	

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D.9 Tolerances for United States

Table D.8 — United States

Standard	Title	Notes
AASHTO	LRFD Bridge Construction Specifications	
AREMA	Manual for Railway Engineering, Chapter 15	
AASHTO/AWS D1.5M/D1.5	Bridge Welding Code	For welded components

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Annex E
(informative)

Geometrical tolerances — Crane runways

E.1 Tolerances per country — Crane runways

Permitted deviations for geometrical tolerances in crane runways are given in:

— Table E.1: Europe;

— Table E.2: Australia / New Zealand;

— Table E.3: Canada;

— Table E.4: China;

— Table E.5: Japan;

— Table E.6: Russian Federation;

— Table E.7: United Kingdom;

— Table E.8: United States.

E.2 Tolerances for Europe

Unless otherwise noted, the reference standard for Table E.1 is EN 1090-2.

Definitions specific to Table E.1 are:

a) Essential tolerances:
Essential tolerances are essential for the mechanical resistance and stability of the completed structure and are therefore to be fulfilled.

b) Functional tolerances:
Functional tolerances are those required to fulfil other criteria such as fit-up and appearance.

c) Class 1:
Tolerance Class 1 shall be applied unless otherwise specified in the execution specification.

c) Class 2:
Tolerance Class 2 can substitute Class 1 if smaller tolerance deviations are required, for example, if glazed facades are to be fitted.

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Table E.1 — Europe

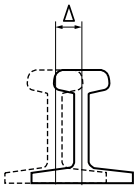
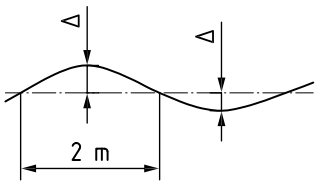
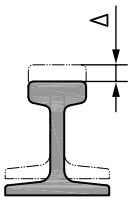
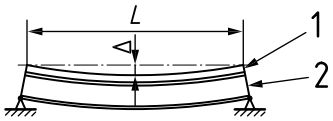
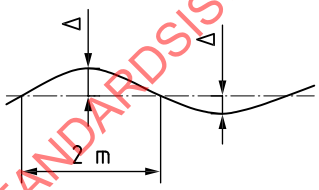
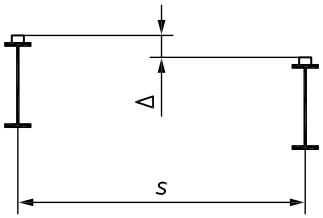
No	Criterion	Parameter	Essential tolerances	Functional	Tolerances
			Class 1 and 2	Class 1	Class 2
1	Location of rail in plan 	Relative to the intended location		Δ = ±10 mm	Δ = ±5 mm
2	Local alignment of rail 	Alignment over 2 m gauge length		Δ = ±1,5 mm	Δ = ±1 mm
3	Level of rail 	Relative to the intended level		Δ = ±15 mm	Δ = ±10 mm
4	Level of rail  Key 1 rail 2 crane beam	Level over span L of crane beam		Δ = ±L/500, but |Δ| ≥ 10 mm	Δ = ±L/1 000, but |Δ| ≥ 10 mm
5	Level of rail 	Variation over 2 m gauge length		Δ = ±3 mm	Δ = ±2 mm
6	Relative levels of rails on the two sides of a runway with span s 	Deviation of level: for s ≤ 10 m for s > 10 m		 Δ = ±20 mm Δ = ±s /500	 Δ = ±10 mm Δ = ±s /1 000

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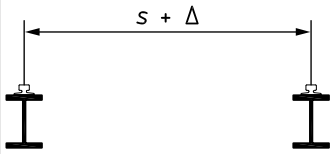
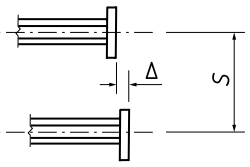
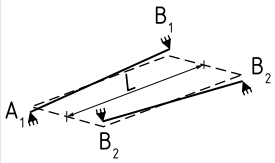
Table E.1 *(continued)*

No	Criterion	Parameter	Essential tolerances	Functional	Tolerances
			Class 1 and 2	Class 1	Class 2
7	Spacing over span *s* between centres of crane rails 	Deviation of spacing: (*s* in metres) for $s \leq 16$ m for $s > 16$ m		 Δ = ±10 mm Δ = ±(10+ [*s* -16]/3) mm	 Δ = ±5 mm Δ = ±(5+ [*s* -16]/4) mm
8	Structural end stops 	Relative location of the stops at the same end, measured in the direction of travel on the runway		Δ = ±*s*/1 000, but |Δ| ≤ 10 mm	Δ = ±*s*/1 000, But |Δ| ≤ 10 mm
9	Inclination of opposite rails  *L* distance between adjacent supports	Inclination of opposite rails Offset: Δ = |N1 - N2| where: N1 inclination — A1 - B1 N2 inclination — A2 - B2		Δ = *L*/500	Δ = *L*/1 000

E.3 Tolerances for Australia and New Zealand

Unless otherwise noted, the reference standard for Table E.2 is AS/NZS 5131.

Definitions specific to Table E.2 are:

a) Essential tolerances:
Basic limit for a geometrical tolerance necessary to satisfy the design assumptions for a structure in terms of design capacity and stability (see AS 4100:2020, AS 5100.6 and NZS 3404).

b) Functional tolerances:
A tolerance which might be required to meet a function other than those of an essential tolerance, such as for appearance or fit-up.

c) Class 1:
Tolerance Class 1 shall be applied unless otherwise specified in the execution specification.

d) Class 2:
Tolerance Class 2 can substitute for Class 1 if smaller tolerance deviations are required, for example if glazed facades are to be fitted.

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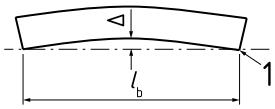
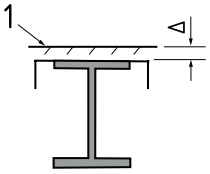
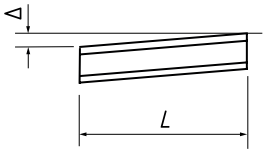
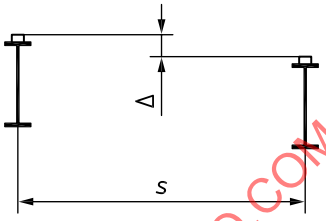
Table E.2 — Australia and New Zealand

No	Criterion	Parameter	Essential tolerances Class 1 and 2	Functional Class 1	Tolerances Class 2
1	Sweep of erected beam 	Deviation (Δ) of beam flange from intended position 1 where: l_b = length between points of effective bracing or restraint	Δ = ±l_b/500 mm		
2	Level of a beam 	Deviation (Δ) at a beam end connection measured relative to the specified level 1	Δ = ±10 mm	Δ = ±15 mm	Δ = ±10 mm
3	Level difference between opposite ends of a crane girder 	Deviation (Δ) in level of one end of beam relative to other end where: L = girder span	Δ = ±L/1 000, and Δ ≤ 10 mm NOTE Deviation is as per AS 1418.18	Δ = ±L/500	Δ = ±L/1 000
4	Relative levels of rails on the two sides of a runway with span s 	Deviation of level for s ≤ 10 m for s > 10 m	Δ = ±s/1 000 Δ ≤ 10 mm NOTE Deviation is as per AS 1418.18	Δ = ±20 mm Δ = ±s/500	Δ = ±10 mm Δ = ±s/1 000
5	Rail alignment	Responsibility to be defined in execution specification. Fixings shall allow sufficient adjustment to permit deviations to be within limit specified	per AS 1418.1		

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E.4 Tolerances for Canada

Table E.3 — Canada

Standard	Title	Notes
CAN/CSA-S16	Design of Steel Structures	
Document		
CISC Design Guide	Crane-Supporting Steel Structures	Most tolerances in this Design Guide refer to the Crane Manufacturers Association of America, Inc. (CMAA), Specification #74

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E.5 Tolerances for China

Unless otherwise noted, the reference standard for Table E.4 is GB 50205.

Table E.4 — China

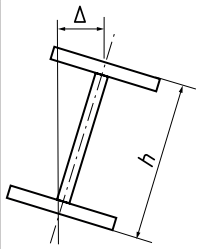
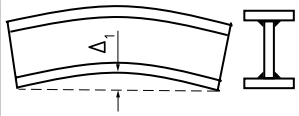
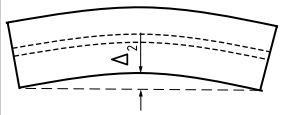
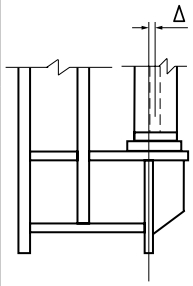
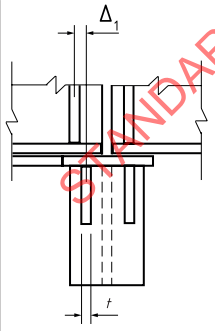
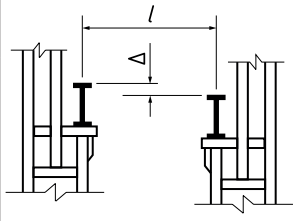
No	Criterion	Parameter	Tolerances	
1	Verticality of web 	Verticality of the middle of beam's span, Δ	$h/500$	
2	Vertical bow 	Vertical and upward bowed-height, Δ_1	10 mm	
3	Lateral bow 	Lateral bowed-height Δ_2	$l/1\,500$, but less than 10 mm	
4a	Displacement of bearings 	Displacement of the centre of bearings supporting beam end, Δ	Deviation from the centre of bracket when mounted on steel column	5 mm
			Deviation from the location axes when mounted on concrete column	5 mm
4b	Deviation of stiffener location 	Deviation of the centre of stiffener plate of crane beam's bearings from the centre of stiffener plate of supporting column, Δ_1	$t/2$	
5	Rail height difference 	Height difference between the top surfaces of crane beams of the same span and section plane, Δ	Areas where support bearings are located	$l/1\,000$, but less than 10 mm
			Other areas	15 mm

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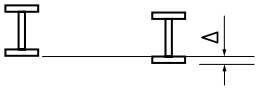
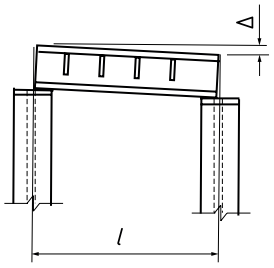
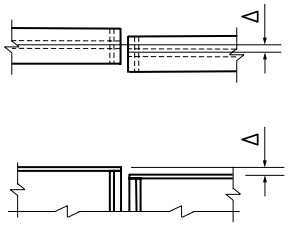
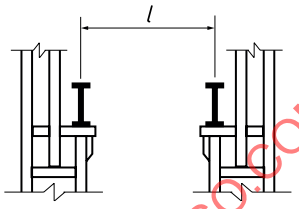
Table E.4 *(continued)*

No	Criterion	Parameter	Tolerances	
6	Hung crane elevation difference 	Height difference between the bottom surfaces of hung crane beams of the same span and section plane, Δ	10 mm	
7	Height difference of crane beam ends 	Height difference between the top surfaces of two neighbouring crane beams of the same row, Δ	*l*/1 500, but less than 10 mm	
8	Joint misalignment and height difference 	Joint between two neighbouring crane beams, Δ	Misalignment of centres	3 mm
			Height difference between the top surfaces bearing loads	1 mm
			Height difference between the bottom surfaces bearing loads	1 mm
9	Deviation of span between crane beams 	Central span of crane beams of the same span and any section plane, Δ	±10 mm	
10	Deviation of rail center to bean web 	Deviation of railway centre from the axis of crane beam's web plate, Δ	*t*/2	

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E.6 Tolerances for Japan

Tolerances for crane runways are established by the execution specification. General tolerances are shown in Table E.5.

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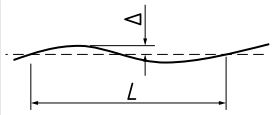
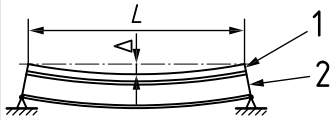
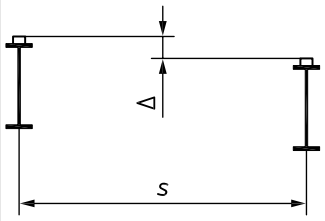
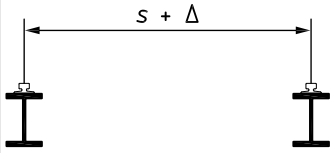
Table E.5 — Japan

No	Criterion	Parameter	Limit Tolerances	Control Tolerances
1	Local alignment of rail 	Alignment over span length		$\Delta \leq L/1\,000$
2	Level of rail  1 crane rail 2 crane beam	Level over span L of crane beam	$\Delta \leq L/500$	$\Delta \leq L/1\,000$
3	Relative levels of rails on the two sides of a runway with span s 	Deviation of level for $s \leq 10$ m for $s > 10$ m	$\Delta \leq s/500$ $\Delta \leq s/500$	$\Delta \leq s/1\,000$ $\Delta \leq s/1\,000$
4	Spacing over span s between centres of crane rails 	Deviation of spacing for $s \leq 16$ m for $s > 16$ m	Δ = ±10 mm Δ = ±10 mm	Δ =±5 mm Δ =±5 mm

E.7 Tolerances for Russian Federation

Unless otherwise noted, the reference standard for Table E.6 is SP 70.13330.

Table E.6 — Russian Federation

No.	Criterion	Tolerance
	Bridge cranes	
1	Distance between the axes of the rails of one span (along the axes of the columns, but at least every 6 m)	±10 mm
2	Offset of the rail axis from the axis of the crane girder	±15 mm
3	Deviation of the rail axis from a straight line at a length of 40 m	±15 mm

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