Section 75. Preparation and assembly

75.1. General

This Chapter stipulates the minimum requirements for adequate execution at the intended level of safety according to the design criteria of this Code.

In general, this Chapter applies to all structures subjected to predominantly static loads. For structures subject to fatigue, higher levels of execution are also required according to the classification of the relevant construction details.

The Special Technical Specifications shall include all requirements relating to the manufacture, assembly and materials necessary to ensure the level of safety in the design, and may include additional stipulations without compromising the technological requirements or invalidating the minimum quality values set out in this Code.

Structures that require more careful execution are those that belong to execution classes 3 and 4, in accordance with subsection 6.2.

75.2. Workshop drawings

The Builder shall use the design drawings to draw up workshop drawings in order to completely define all the members of the steel structure, and the specification of levels and compatibility with the rest of the construction shall be checked on site.

75.2.1. Content

Workshop drawings shall contain the following in complete form:

– the dimensions necessary for defining all members of the structure unequivocally;

– beam cambers where planned;

– the arrangement of joints, including temporary joints;
– bolt-hole diameters, stating the machining form; class and diameter of bolts;
– shape and dimensions of welded joints, preparation of edges, welding process and position, input material and order of execution where necessary;
– indications for machining or treatment of members as required;
– auxiliary members (lugs, patterns, reinforced members, holes, etc.) for fixing, turning, straightening or hoisting the main metal members, stating their position and connection to other members, as well as any cleaning up required after they have been removed.

The position and radius of vent holes for overlapping welds.

All workshop drawings shall state the beams, steel class, weight and brand of all the members of the structure contained in the plan.

**75.2.2. Review and modifications**

Before executing the design at the workshop, the Builder shall send two copies of the workshop drawings to Project Management, who shall review them and return a signed, authorised copy specifying any corrections that need to be made if necessary. In such cases, the Builder shall send new copies of the corrected workshop drawings for finalization.

If the design is modified during the execution of the work, the drawings shall be amended so that the finished work is still defined exactly by the drawings.

If it is necessary to make detailed modifications to the content of the workshop drawings during the execution phase, this must be done with the approval of Project Management and included in the plans.

**75.3. Preparation of material**

Before manufacture begins, the products should be handed over in accordance with Chapters VI and XXI, so as to avoid any subsequent rejection that may be attributed to material that might come into conflict with execution.

Appropriate methods shall be used to eliminate surface defects on products, such as burrs, cracks and, where so dictated by the protective treatment, the lamination scale. Should such action cause concealed defects to be detected when the material is handed over, such as inclusion, blowholes, losses outside the tolerances, etc., the delivery is to be reconsidered if corrections are not feasible.

**75.3.1. Marking, handling and storage**

For all the phases of manufacture, a suitable permanent and distinctive marking, in accordance with the representation system used for the workshop drawings, must identify the parts.

The marking allows different members of the structure to be monitored so as to facilitate the checks set out in Chapter XXI, and any storage or warehousing prior to assembly.
Preferably, the marking should be done using paint. For members not subject to fatigue loads or strong tensile stress, which may include those in execution classes 1 and 2, Project Management may authorise marking by means of an imprint or stamp.

For storage, particular attention should be paid to ensuring that the members are not affected by water accumulation, nor come into contact with the ground, and that the durability conditions in Section 31 and subsection 79.2 are maintained.

Appropriate precautions shall also be taken for the storage of auxiliary members such as bolts, electrodes, paint, etc., in accordance with the instructions issued by their Manufacturer.

75.3.2. **Straightening**

Before performing any other activities, it must be ensured that the tolerances in Chapter XVIII are complied with, and covering the possibility of using straightening to make any necessary corrections to any deviations from those tolerances.

Stamps or roller machines are therefore to be used for sheets and profiles. Attenuation may also be used for highly slender light profiles.

If the cold straightening cannot be done using the stated procedures, it is to be done in accordance with subsection 75.3.4.

75.3.3. **Cutting**

Cutting may be performed by awing, shearing or flame cutting. Wherever the finish remains free of irregularities and there is no local hardening above 380 HV10, no subsequent machining will be required.

The cutting equipment used must be reviewed at regular intervals so that it ensures any irregularities are smaller than the maximum permitted size.

Sawing, plasma and automatic oxycuts are preferred to shearing and manual oxycuts. The latter process is not to be used for execution classes 3 and 4 unless machining follows it. The Designer or Project Management may stipulate the cutting method to be used for classes 1 and 2.

Shearing may be used with the express permission of Project Management for thicknesses of up to 25 mm, although mandatory machining shall be used for parts of any thickness in execution class 4 and parts in execution class 3 that have a thickness greater than 15 mm. The removal of burrs and damaged parts is mandatory unless they are cast for subsequent welding.

Cuts shall be made to sheets and profiles in such a way that there are no re-entrant angles with sharp edges, so as to avoid any notching effect. Re-entrant angles shall be rounded at the edges, with a minimum radius of 5 mm. The minimum radius shall be 8 mm for execution classes 3 and 4.

75.3.4. **Shaping**

This may be performed by bending or folding until the required form is obtained, using either heat or cold, provided that the properties of the worked material are not reduced below those specified.
For cold folding or bending, the minimum radii recommended by UNE-EN 10025 shall be adhered to. In the event of non compliance with the tables in that standard, and wherever the extreme tensioned fibre does not exceed an elongation equal to one quarter of the fracture in the material, a specific procedure must be drawn up, stating the heat treatment to be applied and the relevant control measures. Hot-forming of steel by means of thermomechanical treatment is not permitted (UNE-EN 10025-3 and UNE-EN 10025-4), and the same applies to hardened and tempered steel unless it satisfies the requirements of UNE-EN 10025-6:2007+A1.

The supplier's instructions for heat-forming must be followed, particularly in the case of fine-grained steel. The duration and speed of both the mechanical work and of cooling must be sufficient to avoid deterioration of the steel's tenacity and resistance. In particular, no manipulation of any kind is permitted in the blue colour range (from 250°C to 380°C). The folding or bending must be carried out at a light cherry red temperature (from 950°C to 1050°C) and must be stopped if the temperature falls below dark red (approximately 700°C). The working temperature must be determined effectively.

In view of the limitations above, the shape may be corrected by means of the controlled application of heat using a blowtorch.

All forming processes shall be subject to a procedure drawn up by the Builder, which must be approved by Project Management. It may set out relevant tests or control procedures to ensure that the process is adequate, particularly if a blowtorch is used to apply heat to structures of execution classes 3 and 4.

75.3.5. Holing

Bolt-holes may be made by drilling or punching. The hole may be made at the final diameter or at a diameter 2 mm smaller, by means of subsequent reaming.

Punching is only permitted at the final diameter if there are no fatigue loads. The material must be less than 25 mm thick, and the diameter of the hole should not exceed this thickness.

For parts that are subjected to fatigue loads, in execution class 4, the holes are to be made by drilling.

In the case of holes for bolts with countersunk heads, the countersunk angle must be identical to that of the head on the bolt.

Long slotted holes may be punched once or even drilled using two holes, but they require subsequent finishing to ensure displacement of the bolt throughout the oval if such slippage is foreseen, and they must also be machined.

Wherever possible, the holes for two parts of the same joint should be drilled at the same time.

Burrs must be removed from holes before assembly, except where the holes are drilled as a single operation through members that are solidly joined together and which do not need to be separated after drilling.

The Special Technical Specifications must state whether all or part of the structure belongs to any of the execution classes indicated in subsection 6.2, or classes for which more careful manufacture is required. In such case, the edges of
holes that attain local hardening greater than 380HV10 for classes 3 and 4 must be corrected.

75.4. Pre-assembly at the workshop

This operation consists of presenting the members prepared at the workshop and assembling them before they are assembled on site. The joints must fit within the tolerances in Section 80 that apply, without forcing or damaging the members.

The adjustment of supporting contact surfaces must be checked with regard to dimensions, orthogonality and flatness.

Where the applicable tolerances are adhered to, it is acceptable to use saw machining on the contact surfaces.

Unaligned and non-coincident holes may be corrected by means of reaming if they fall within the limits defined in subsection 76.2, otherwise the members in question will be rejected. In order to avoid such inconvenience, the use of patterns or a drill set is recommended.

For butt-welded joints, it must be ensured that the geometric tolerances between edge preparations are within those required for the intended type of welds.

Adequate safety measures shall be adopted for all temporary joints or parts used for assembly in the workshop, and the criteria of this Code shall apply as if the members were the final ones to be installed on site.

All requirements relating to cambers or pre-adjustments stated in the Special Technical Specifications shall be complied with.

Where it is not possible to assemble certain sections at the workshop owing to lack of space, patterns may be prepared so that it may be checked whether the adjacent parts have been assembled correctly.

Section 76. Mechanical fastening

76.1. General

This Code discusses various possibilities for construction arrangements that allow for reasonable execution in accordance with the structure's quality and safety requirements in every specific case.

The execution of joints using bolts must consider the specific design characteristics, the requirements of which are set out in Section 58, and the properties of the materials used, which appear in Section 29. Hole diameters, shared and edged partitions, tightening systems and surface state, among other data, must therefore be stated in the Special Technical Specifications, and it is recommended that they also appear in the drawings.

The Builder shall recognise the classification of the bolted joints that are to be made in accordance with subsection 58.2, in such a way that the workshop drawings may be developed using construction arrangements that allow the hypothesis considered in the design to be fulfilled.
76.2. Position and size of holes

The diameter of holes in relation to the diameter of bolts must be appropriate for the principles stated in the preceding subsection. For base plates and head plates that house anchor bolts in concrete, other arrangements apply that are not discussed here.

The nominal clearances that give the diameter of the hole when added to the diameter of the bolt are:

a) normal round holes:
   1 mm for M12 and M14 bolts;
   2 mm for M16 to M24 bolts;
   3 mm for M27 and greater bolts;

b) oversized round holes in joints with slip resistance:
   3 mm for M12 bolts;
   4 mm for M14 to M22 bolts;
   6 mm for M24 bolts;
   8 mm for M27 and greater bolts;

c) Long slotted holes of short length in joints that are resistant to normal slippage:
   4 mm for M12 and M14 bolts;
   6 mm for M16 to M22 bolts;
   8 mm for M24 bolts;
   10 mm for M27 and greater bolts.

The clearances for long-slotted holes are, strictly speaking, identical to those of round holes.

Calibrated bolts are placed in holes with a clearance of 0.3 mm.

For joints that are resistant to slippage, clearances greater than those given for length may be used if they do not exceed two and a half times the nominal diameter of the bolt.

For external joints, long-slotted holes must remain covered by flashing or washers with adequate dimensions, the holes on which must be of normal clearance.

The distances between the axes of bolts and those of edges must comply with the minimum and maximum values set out in the design, particularly if the joint has been designed to allow plastic redistribution of force in bolts and its capacity is determined by resistance to flattening.

76.3. Use of bolts

Unless otherwise specified that shear in the threaded part has been considered, the bolt length must be determined so that the shearing plane remains outside the threaded part of the shank for all sheet thicknesses and washers.
In this case, bolts that are threaded as far as the head may be used. The above does not apply to calibrated bolts.

After tightening, at least one full thread shall remain clear between the nut and the unthreaded part of the shank. Bolts that are not preloaded must also have at least one full thread on the other side of the nut, i.e. inside the joint. For pre-loaded bolts, this latter requirement shall be for a minimum of four fillets.

Bolts shall not be welded unless a qualified welding process is specified in accordance with UNE-EN ISO 15609-1 and explicitly stated in the Special Technical Specifications.

76.4. Use of nuts

Nuts shall be adequate for the type of bolt that is used, particularly where they are pre-loaded in accordance with the tables in Section 29.

It should run freely on the bolt before they are fitted. Their designation must be visible for inspection after assembly Special measures shall be taken for structures that are subjected to vibrations, so as to avoid loss of thread and any possibility of the bolt falling out. In such case, bolts with a vertical axis shall have their head in the upper part of the joint. Nuts for bolts that are not pre-loaded must be fitted with lock nuts or another effective mechanism. It is not necessary to use lock nuts for preloaded bolts.

The provisions for bolts in the preceding subsection shall apply to the welding of nuts.

76.5. Use of washers

Irrespective of their quality, bolts that are not pre-loaded do not require the use of washers unless the surfaces have a very thick coating where local damage should be avoided.

Washers may be used to fulfil the requirement of keeping the threaded part outside the hole in the case of calibrated bolts, or even outside the shear plane if so stipulated in the Special Technical Specifications for bolts, whether pre-loading or not.

Washers of variable thickness or with a wedge are to be used for sloping surfaces in all cases. The use of washers under the part that is to be turned during tightening, or the bolt head or nut is mandatory in the case of pre-loaded bolts. It is recommended that this requirement be extended to the fixed portion, particularly under the aforementioned assumption that bolts that are not pre-loaded will protect coatings. Flat or chamfered washers that are to be used with pre-loaded bolts shall comply with UNE-EN 14399-5 and UNE-EN 14399-6.

If direct tension indicators are used, they shall be fitted with the protrusions in contact with the part that does not turn during tightening. In any case, the Manufacturer’s instructions shall be followed, and they must be set out in detail in the Special Technical Specifications.

76.6. Tightening of non-preloaded bolts

Bolts for joints that are not preloaded shall be tightened up to the adjusted contact condition for components surrounding each bolt. Local clearances of 2 mm are permitted to remain separate from the area where the bolts are arranged. Bolts should
be tightened gradually, working from the inside outwards so as to avoid exceeding the limit.

Determination of the tightening torque value by obtaining the adjusted contact condition is unnecessary. It is the value corresponding to that given by a worker using a normal key without an extension, and equivalent to the point at which a pneumatic key starts to have an effect.

Where the clearance limit of 2 mm or less is exceeded, wedges or lining may be inserted if stated in the Special Technical Specifications, or even comb gauges that cover the bolts.

Any of the bolt types given in Section 29 may be used for joints that are not pre-loaded. This class of joint includes base plates with anchor bolts in concrete.

**76.7. Tightening of preloaded bolts**

For joints that use pre-loaded bolts, only types 8.8 and 10.9 may be used, in accordance with Section 29. These joints are considered resistant to slippage, and are subject to the requirements of the corresponding subsection.

The maximum clearance between contact surfaces is limited to 1 mm. In cases where such clearance exceeds this value and is not greater than 2 mm in corrosive environments and 4 mm in internal environments, it is possible to use a lining-based adjustment system.

The bolts may start to be preloaded once the adjusted contact condition has been obtained. Preloading should be carried out in an ordered, gradual way. Unless otherwise stated in the Special Technical Specifications, it is considered that the pre-stress force that must be obtained in the bolt shank is 70 % of the traction resistance of the bolt, $f_{ub}$, multiplied by the resistant area, $A_s$:

$$N_0 = 0.7 f_{ub} A_s$$

Table 76.7. Minimum pre-load force, $N_0$ (kN)

<table>
<thead>
<tr>
<th>Property class</th>
<th>Bolt diameter (mm)</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt class 8.8</td>
<td></td>
<td>47</td>
<td>88</td>
<td>137</td>
<td>170</td>
<td>198</td>
<td>257</td>
<td>314</td>
<td>458</td>
</tr>
<tr>
<td>Bolt class 10.9</td>
<td></td>
<td>59</td>
<td>110</td>
<td>172</td>
<td>212</td>
<td>247</td>
<td>321</td>
<td>393</td>
<td>572</td>
</tr>
</tbody>
</table>

This pre-load force may be obtained using one of the following methods:

- Torque;
- direct tension indicator;
- combined method.
76.7.1.  **Torque method**

The torque applied to bolts induces a pre-load force in the bolt shank, depending on its diameter and on a factor that sums up the characteristics of friction between the components and the part that turns.

Torque wrench shall have a level of precision that avoids errors greater than 4% when the torque is applied. This must be verified daily throughout assembly.

As a guideline, where the nut and bolt are delivered in lightly lubricated condition, the torque value will be:

\[ M_t = 0.18 d N_0 \]

The torque shall be recommended by the Manufacturer of the nut and bolt set, in accordance with the classification set out in standard UNE-EN 14399-1. It shall be applied without any amendments to the supply conditions (it is standard practice to use molybdenum disulphide-based lubricants or wax on galvanised bolts so as to reduce the internal slip factor to values similar to those of non-galvanised bolts).

If there are no such recommendations, one of the following two procedures shall be followed:

a) the torque shall be determined on the basis of the k values given by the manufacturer, applying the formulae in Section 8.5.2 of standard EN 1090-2;

b) the torque shall be determined by means of a test in accordance with Annex H to EN 1090-2.

In order to ensure that the force \( N_0 \) is achieved, at least two steps shall be carried out based on the adjusted contact condition with gradual tightening:

- application of 75% of the required torque value \( M_t \);
- tightening until 110% of \( M_t \) is achieved.

It is not advisable to exceed this value, since it might result in the bolt fracturing if the friction in the thread is less than that given.

A torque value obtained by means of a test in accordance with UNE-EN 14399-2 may be used.

76.7.2.  **Direct tension indicator (DTI) method**

This method consists of using special washers, in accordance with standard EN 14399-9, that are arranged below the fixed part. When a turning force is applied to the opposite part, a pre-load force is induced in the bolt shank, which acts on some protrusions or protuberances on the washer. In order to achieve the prescribed value, these protrusions are flattened and direct contact is made with the nut or bolt head, eliminating the clearance that they occupy.

The Manufacturer's instructions must be followed, and the requirements in Annex J to standard EN 1090-2 relating to flatness and mean clearance must be met.
76.7.3. Combined method

Based on the adjusted contact condition, 75 % of the torque is applied. The position of the nuts is then marked, and an additional turn is applied in accordance with previous tests and UNE-EN 14399-2.

The following table may be used for joints with flat surfaces, depending on the total thickness, including washers and lining.

Table 76.7.3. Additional rotation depending on joint thickness

<table>
<thead>
<tr>
<th>Joint thickness</th>
<th>Further angle of rotation to be applied, degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>t &lt; 2d</td>
<td>60 degrees</td>
</tr>
<tr>
<td>2 d &lt; t &lt; 6</td>
<td>90 degrees</td>
</tr>
<tr>
<td>6d &lt; t &lt; 10d</td>
<td>120 degrees</td>
</tr>
</tbody>
</table>

76.8. Contact surfaces in slip-resistant joints

Preloading the bolts for joints of this type involves a compression state of the joined surfaces that is affected by the slip factor between those surfaces and prevents relative slippage. The final state of these surfaces is determined by their slip factor.

The Special Technical Specifications must stipulate which surface class is to be obtained, particularly if the design uses high values for the slip factor. The surfaces must be clean and free of grease. Blowtorch cleaning is not acceptable.

The table that follows gives the surface treatments and the corresponding slip factor. In the first two cases, blast cleaning and shot blasting mean that grade Sa 2½ must be obtained in accordance with UNE-EN ISO 8504-1.

In the event that contact surfaces have not been protected by priming at the workshop and they have been assembled in a different way, incipient oxidation and any other contamination must be removed using a wire brush made of mild steel.

Table 76.8. Slip factor values depending on surface treatment

<table>
<thead>
<tr>
<th>Class</th>
<th>Treatment</th>
<th>μ factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A1 – Blast with shot of grit without pitting</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>A2 – Blast cleaning or shot blasting and spray metallized with Alumunium</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>A3 – Blast cleaning or shot blasting, spray metallized, with a zin based c A pulverisation, and slippage test</td>
<td>0.50</td>
</tr>
<tr>
<td>B</td>
<td>Blast cleaning or shot blasting, with alkali-zinc silicate paint with a thickness of 80 microns</td>
<td>0.40</td>
</tr>
<tr>
<td>C</td>
<td>Wire brushed or flame cleaning and removing all scale or rust</td>
<td>0.30</td>
</tr>
<tr>
<td>D</td>
<td>Untreatment</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Contact surfaces made of galvanised steel and treated with wire brushing shall be regarded as class C. Untreated galvanised surfaces shall be class D.

For cases not covered by this table, or in order to fit the design, the slip factor value may be determined by means of checking, following the instructions in Annex G to standard EN 1090-2.

76.9. Special fixing

This subsection includes three types of fasteners for joining steel structures to concrete:

- bolts embedded in concrete;
- bolts anchored in drill holes filled with mortar;
- bolts anchored mechanically, of the expansion or wedge type.

In addition to fulfilling the anchoring requirements according to adherence and shape, they must also satisfy all the requirements for bolts in this Code, according to their material and assembly, with the exception of those that refer to hole diameters.

Other joint systems or methods that are not covered by this Code may be used if they are stipulated in the Special Technical Specifications and there is adequate experience of them, and they are covered by other standards, and always under the responsibility of the Designer or Project Management.

76.10. Using special types of bolt

76.10.1. Countersunk head bolts

Bolts with countersunk heads must keep the same level of flush as the surface of the outermost sheet. They may be preloaded not, and they shall be subject to all the preceding subsections.

The countersinking dimensions and tolerances must be specified in every case. The countersinking depth shall be 2 mm less than the nominal thickness of the outside sheet.

Should this operation affect more than two sheets, it must be carried out with both sheets joined firmly.

76.10.2. Calibrated bolts and pins

Calibrated bolts and pins, in hinges or rockers, are considered to be special types of bolt for the purposes of this Code.

Their mechanical properties must comply with subsection 29.2 and their tolerances shall correspond to shank class H13 in UNE-EN 20286-2 (ISO 286-2).

Holes shall be pre-drilled to 3 mm less, and reamed to the final diameter when done in situ. In the case of a joint with several sheets, they must be reamed simultaneously and attached firmly during the operation. Reaming must be done using a fixed screw.
The tolerance for calibrated bolts and pins in holes shall be of class H11 in accordance with UNE-EN 20286-2 (ISO 286-2). If a pin does not need to be calibrated, the clearance defined in subsection 76.2 shall apply.

The thread shall not remain inside the joint in the case of calibrated bolts. For pins, this requirement is not mandatory but avoids the presence of a threaded area on the shearing planes.

This shall be done by striking them lightly and without damaging the thread.

76.10.3. Injection bolts

Injection bolts have a perforated head into which resin is injected to fill any gaps between the shank and the hole.

They are suitable for replacing rivets or other bolts without modifying the existing hole. When resin is injected, they become resistant to flattening. They may be pre-loaded or not.

Their use shall comply with the provisions of Annex J to EN 1090-2.

Section 77. Welding

77.1. General

The quality requirements for welding that are to apply to each execution class in accordance with the requirements of the relevant part of UNE-EN ISO 3834 are those given in Table 77.1.

Table 77.1. Quality requirements for welding, depending on the execution class

<table>
<thead>
<tr>
<th>EXC 1</th>
<th>Part 4, elementary quality requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXC 2</td>
<td>Part 3, standard requirements</td>
</tr>
<tr>
<td>EXC 3 and 4</td>
<td>Part 2 comprehensive quality requirements</td>
</tr>
</tbody>
</table>

77.2. Content of a welding plan

A welding plan should be provided that applies to the steel defined in Chapter VI and includes adequate precautions against the risk of lamellar tearing in the event that tensile stresses are transmitted perpendicular to the thickness of the material.

Implementations of the welding plan shall include as relevant

- joint detail;
- size and type of joint;
- specifications such as electrode type and pre-heating;
- welding sequence, limiting to discontinuous welding, or intermediate tests;
– any turning or flipping of the part that is required in order to weld it;
– detail of temporary fixings;
– Measures to be taken to avoid lamellar tearing;
– reference to the inspection and checking plans;
– all requirements for identifying welds.

77.3. Welding processes

All welding processes to be applied to joints shall be included among the following and be in accordance with the definition given in UNE-EN ISO 4063:

111. Metal-arc welding with covered electrode.
114. Self-shielded tubular cored arc welding.
121. Submerged arc welding with one wire electrode.
122. Submerged arc welding with strip electrode.
131. Metal inert gas welding; MIG welding.
135. Metal active gas welding; MAG welding.
136. Tubular-cored arc welding with active gas shield; MAG welding.
141. Tungsten inert gas welding; TIG welding.
783. Drawn arc stud welding with ceramic ferrule or shielding gas.
784. Short-cycle drawn arc stud welding.

Other welding processes shall be specified explicitly in the Special Technical Specifications.

77.4. Qualification of welding procedures

77.4.1. Welding procedure

Welding must be carried out according to a qualified procedure in UNE-EN ISO 15609-1. The method for qualifying the procedure shall be one of those set out in the various parts of UNE-EN ISO 15609-1, unless explicit, details of which must be provided in every case. If so specified in the Special Technical Specifications, the welding process shall be qualified by means of advance tests in accordance with UNE-EN ISO 15614-1.

For automated sheet processes that incorporate priming at the workshop, and deep penetration welding carried out with a single pass, it is mandatory for such qualification to be carried out by means of tests prior to production. In the case of primed sheets, it must be carried out using the greatest permitted coat thickness. If a process that has been qualified through checking has not been used for more than three years, a full-size sample from a production test must be inspected in order for the process to be approved.
Where deep penetration electrodes are used, or where both sides are welded without open roots, a specimen must undergo a destructive test every six months, in addition to the qualification test prescribed for the process.

77.4.2. **Welders qualification**

Welders shall be qualified in accordance with UNE-EN 287-1; in particular, fillet weld welders must qualify through adequate fillet weld tests.

All documentation proving that welders are qualified by examination must be archived and remain available for verification. An accredited body chosen by Project Management must certify the aforementioned qualification in accordance with UNE-EN 287-1, or EN 1418 for welders.

77.4.3. **Welding coordination**

In order to ensure that sufficient attention is paid to the welding process, a specialist called a “welding coordinator” must be present during welding-related activities in structures corresponding to classes 2, 3 and 4.

The welding coordinator shall be professionally trained and experienced in the welding operations he supervises, as stated in UNE-EN ISO 14731.

77.5. **Preparation and execution of welding**

77.5.1. **Joints preparation**

The aim of preparing the edges of parts that are to be butt-welded together is to ensure complete penetration, adapting to the different technical and financial conditions existing in each specific case. The surface of parts and edges should, strictly speaking, be free of visible cracks and notches.

The surfaces that are to be welded shall be dry and free of any material that could have a negative impact on the quality of welding. Priming may be permitted if the welding process that uses such priming has been qualified.

The preparation of edges forms part of the welding process. The welding coordinator is responsible for selecting the correct type. UNE-EN ISO 9692-1 gives the most highly recommended types for various processes.

Any deviations in shape or alignment of faces should be less than the maximum permitted ones given for the welding process in question. The welding process must consider any correction of defects due to notching or geometrical errors in the assembly through welding. In all cases, the area affected must be ground, with its surface remaining smooth and flush to the rest of the part. The cutting area must always be ground for execution classes 3 and 4.

77.5.2. **Storage of welding consumables**

Input material, electrodes and wire must be stored and handled in accordance with the Manufacturer’s recommendations, particularly for basic coating that is susceptible to deterioration by moisture. Any defect or damage in the form of cracks or flaking of the wire’s oxide coating shall result in rejection. UNE-EN ISO 3834 includes a section that discusses the storage of consumables and base materials.
77.5.3. **Weather protection**

Both the welder and the working area shall be adequately protected from wind, snow and rain, particularly where the welding process is carried out using gas protection. It is usually advisable for all welding activities to be carried out at a workshop. The areas that are to be welded must be kept dry and free of condensation.

77.5.4. **Assembly for welding**

Components to be welded shall be brought into aligned and positioned correctly, and remain immobile while they are being welded. Spot welding may therefore be used between them, or even external arrangements such as patterns or reinforced members that have adequate means of fixing.

The longitudinal and transverse contraction that the welds undergo during cooling shall be taken into account. To that end, the aforementioned initial relative position between parts must be such that the final result complies with the dimensional tolerances in Chapter XVIII. In any case, straightening may be used as indicated in subsection 77.5.13.

For the purposes of fixing during assembly, joints must not be made with reinforced members or other external parts during spot welding, since this may cause residual stress owing to limited deformation during cooling. No additional welding, drilling or clipping may be done if it is not defined in the plans.

Making the dimensional tolerances compatible with the welding plan for all members may mean that execution sequences have to be established, whereby some bracing or secondary bars should be fitted last.

77.5.5. **Preheating**

The aim of pre-heating the surfaces on the members that are to be joined is to change the cooling time so as to reduce the probability that fragile elements will form in the input material and in the area affected by the heat of the base material. Preheating may be necessary for large thicknesses or for steel with high equivalent carbon content. It must form part of the welding plan in all cases where required. The welding coordinator shall be responsible for defining it.

The preheating shall extend to at least 75 mm on each side of the elements that are to be joined. It must also be considered whether it is worth pre-heating joints that are provisional or due to be spot-welded, particularly in the case of members that have very different thicknesses from each other.

The surface hardness value 380 HV10 in the area affected by the heat is a maximum limit above which the risk of fragile fractures increases. This value must be avoided in welding process tests. In some processes, such as 783 “Drawn arc stud welding with ceramic ferrules or shielding gas” and 784 “Short-cycle drawn arc stud welding” in standard UNE-EN ISO 4063, this value may be exceeded if so stipulated in the Special Technical Specifications.

77.5.6. **Temporary attachments**

If it is necessary to use temporary joints by means of spot welding, for ease of erection or assembly, such welds shall be so positioned that they may subsequently be removed without damage to the permanent steel work.
All temporary joint welds shall be executed according to specific instructions. If they are to be removed by cutting or chiselling, the surface of the parent metal shall subsequently be carefully ground smooth.

Once the temporary joints have been removed, the affected areas must be inspected in order to ensure that there are no defects.

This last precaution will be particularly necessary in the case of structures that are subjected to fatigue loads. In such case, the removal of temporary joints shall be mandatory for structures of class 3 and 4.

77.5.7. **Tack welds**

This type of welding may be used to fix members together so that they maintain their position during welding. The minimum length of the tack shall be lesser than or equal to four times the thickness of the thicker part or 50 mm. In automated processes, the conditions for executing such welds shall be considered for the welding process. If they form part of a final weld, they must take a suitable shape for that purpose. For manual processes, welders who carry out this type of welding must also be qualified as stated in subsection 77.4.2, unless these welds are not included in the final weld.

In such case, these welds shall be removed.

77.5.8. **Fillet welds**

Members that are to be joined using fillet weld seams should be in the closest possible contact.

The throat thickness and chord length must not be less than those stated in the design, taking into account the use of deep penetration electrodes or partial penetration as indicated in the detail.

77.5.9. **Butt welds**

77.5.9.1. General

The finish on a surface where chords are butt-welded must be such as to ensure a sound weld with full throat thickness.

The Special Technical Specifications must state where it is necessary to use additional parts to extend the chord so as to ensure that the outside end of the chord maintains the throat thickness whilst avoiding the craters produced by striking and cutting the steel. These additional parts may be used for any destructive tests that are required.

After completion of welds, both the additional extension parts and any other additional members shall be removed.

If a flush surface is required, the excess weld metal shall be removed. This may be necessary for aesthetic reasons or in order to attenuate the effect of fatigue loads.

77.5.9.2. Single sided welds

Full penetration welds may be done on only one side, either with or without a back plate (backing). This back plate may consist of permanent backing only if the
Special Technical Specifications so permit and the approved welding process meets the corresponding requirements for it.

Backimg material shall fitted be tightly to the parent metal and should be continuous throughout the weld chord. If the back plate is made of copper, it must be removed after the welding is finished, whilst all the while taking the precaution of not priming the arc on it so that there is no copper inclusion, which may cause cracks.

The disadvantage of welding on only one accessible side using a back plate is that it may produce notching effects in the root area, so it is not suitable for fatigue loads. Although the welding is done on one side, as is the preparation of V-shaped and U-shaped edges, it is advisable to put a back chord on the root (backing chord) once it has been cleaned up.

77.5.9.3. Back gouging

For all full penetration butt welding with accessible sides in execution classes 3 and 4, the root should be cleaned up before the sealing chord or the first chord on the back is applied. This cleaning up may be done using the slot for the arc air torch, or chiselling with rounded tools and honing.

This must be done to a sufficient depth to ensure that input material deposited previously penetrates the cleaned metal. Cleaning up should follow a U-shaped groove, with the sides easily accessible for the welding.

77.5.10. Slot welds

Slot welding is used to join sheets using angle chords placed at the edges of button holes made in the outstanding sheet. The arrangement and dimensions of such button holes shall be specified.

The slots may be square, oval or circular in shape. The recommended width must not be greater than double the thickness of the sheet, nor greater than seven times that thickness within reasonable bounds, depending on the number of button holes, any mutual separation, and the edges that allow the welding to be executed easily.

It is not recommended to use this type of joint in structures that are subjected to fatigue or dynamic loads (classes 3 and 4).

Unless otherwise specified, not all of the free space needs to be filled by the weld after the angle chord has been applied to the contour. This type of finish, which is called plug welding, is more harmful, if such a thing is possible, than fatigue or dynamic loads, and may only be applied once the angle chord on the contour has been inspected.

77.5.11. Stud welding

Studs (connectors) shall comply with UNE-EN ISO 13918 and be located in areas without rust, lamination scale and grease. Where the surface is painted, the paint is to be taken off and removed completely, unless the welding process has been qualified by this special protection system.

The studs may be welded through cold-formed, corrugated sheet steel on beams that meet the following requirements:
– non-galvanised corrugated sheets shall have a nominal thickness of less than 1.5 mm;

– galvanised corrugated sheets shall have a nominal thickness of less than 1.25 mm and a nominal galvanised thickness of no more than 30 microns on each side;

– the areas where the studs are to be welded, including beneath and between corrugated sheets, must be dry and free of any condensation;

– the sheets must be in the closest possible contact with the beams when they are welded. The welding process must be qualified for a maximum limit clearance. Clearances in excess of 2 mm are not acceptable under any circumstances;

– unless the welding process provides for this option, welding done in areas where sheets overlap or if it affects the edges of such areas is not acceptable;

– studs shall be concentrated within a sheet or even alongside it, as an alternative, if there is a small stiffening rib in the middle.

77.5.12. Treatment after welding

For structures that are subject to fatigue loads, it may be beneficial to apply attenuation procedures for residual stress by means of heat treatment. In this case, the Builder must show in the welding plan that the proposed treatment is in accordance with the Special Technical Specifications.

77.5.13. Straightening

In order to comply with the tolerances, or for aesthetic reasons, distortion may be corrected, both under cold conditions using a stamp or roller machines, and under hot conditions by using flames to apply heat locally. In this case, the maximum temperature that the steel will achieve and the cooling procedure must be established beforehand.

77.5.14. Execution of welding at the workshop

The projection of erratic sparks from striking the arc must be avoided and, where such sparks are produced in classes 3 and 4, the surface affected must be ground and inspected. Weld projection and spatter must also be avoided, and removed if it does occur. For each run, dross shall be removed and any defects that emerge on the surface must be rectified before deposition of further runs.

The welding plan must consider what steps to take in order to repair defective welds and to rectify and grind the weld surface finish.

77.6. Welding acceptance criteria

Members that comprise welds shall comply with the requirements specified in Section 80.

Unless otherwise stated in the Special Technical Specifications, the welding approval criteria shall be based on UNE-EN ISO 5817. The quality levels in that standard are D (moderate), C (intermediate) and B (high), and depend on the severity and extent of the defects found. Table 77.6.a sets out the following levels for each execution class.
Table 77.6.a. Weld quality levels for the different execution classes

<table>
<thead>
<tr>
<th>EXC 1</th>
<th>Level D</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXC 2</td>
<td>Level C, in general, except level D for: undercut (5011, 5012), overlap (506), stary arc (601) and end crater pipe (2025)</td>
</tr>
<tr>
<td>EXC 3</td>
<td>Level B</td>
</tr>
<tr>
<td>EXC 4</td>
<td>Level B and additional requirements</td>
</tr>
</tbody>
</table>

The additional requirements for execution class 4 are given in Table 77.6.b; this is because aspects relating to fatigue must be taken into account for this execution class. There is also a set of more stringent requirements that must be applied to bridge decks, both for welding executed at the workshop and welding executed on site. Such requirements are set out in EN 1090-2.

Table 77.6.b. Additional requirements for execution class 4

<table>
<thead>
<tr>
<th>Imperfection designation</th>
<th>limit for imperfections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undercut (5011 and 5012)</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Excessive surplus thickness (502)</td>
<td>&lt; 2 mm</td>
</tr>
<tr>
<td>Incorrect toe (505)</td>
<td>&lt; 165 °</td>
</tr>
<tr>
<td>Internal pore or gas pores (2011 to 2014)</td>
<td>&lt; 0.1 throat thickness; max. 2 mm</td>
</tr>
</tbody>
</table>
| Solid inclusion (300)    | Width smaller than 0.1 throat thickness; max. 1 mm  
|                          | Length smaller than throat thickness; max. 10 mm |
| Linear misalignment (507) | < 0.05 t; max. 2 mm                          |
| Root concavity (515)     | Not permitted                                 |

If any of the limits above are exceeded, a special evaluation should be performed. It will consider the function and stress level of the member affected, and the characteristics of the defect (type, size, location) in order to decide whether the weld may be acceptable or if it needs to be repaired. Such an evaluation may be done by means of a calculation in order to decide whether the weld is either acceptable or shall be repaired.
CHAPTER XVII. EXECUTION ON SITE

Section 78. Assembly

78.1. Site conditions

Assembly of the structure shall begin when the requirements in the safety plan are met. Among other things, these include the following items:

– car parks and loading bays, machinery in general and warehousing;

– access routes to the site and within the site;

– installation of cranes;

– preparation of ground with regard to soil, surface drainage and slope stability conditions, if relevant;

– checking of services affected, including underground pipes, aerial cables and any other physical determining factors;

– checking to see whether the largest and heaviest parts can be delivered onto the site;

– adjacent zones affected by assembly;

– weather and environmental conditions;

– checking of ground conditions that allow any movement to be predicted or corrected, such as settling of column bases or turning of wall facings during erection Activities before or after assembly should also have a compatible safety plan, irrespective of their nature (excavation, concreting, finishing, covering, flooring, installations, etc.). Coordination of the various activities must in particular taking the following into account:

– availability of services;

– the value of construction loads during the various phases of the work, including possible warehousing areas;
control of concrete placement.

78.2. Assembly programme

The assembly programme shall be prepared by the Builder, and must be approved by Project Management before commencement. However, the Special Technical Specifications must include a preliminary assembly method that is adequate for the resistance properties of the structure during the various phases. This will help the Builder to draw up the final assembly programme.

This preliminary programme should take the following into account:

- the location of nodes and splices;
- maximum bar lengths;
- sequence of erection;
- provisional stability, including shoring and restraints;
- conditions for removal of shoring and restraints;
- parts with reduced lateral non torsional stability and moment during assembly, which require special hoisting or handling;
- execution of column bases and supports with regard to tamping base plates with mortar;
- cambers and alignments in expansion joints;
- use of profiled steel sheets to ensure stability;
- the possibility that execution loads will exceed those in the design.

When drawing up the final assembly plan, the Builder may modify the indications in the preliminary plan and introduce other methods or systems that it did not consider, wherever this is justified to Project Management using calculations or references to similar works. In any case, it must be ensured that the plan is compatible with the other stipulations in the Special Technical Specifications and that adopting such a programme would not entail any financial deviation from the estimated budget.

In addition to the requirements listed above, the programme should also provide details on the following points:

- sequence of erection, with activity times and dates based on the start and end of each one, including the necessary coordination for preparation at the workshop and transportation to the site;
- equipment for each phase, including cranes;
- personnel, specifying their professional qualifications;
- special precautions against weather conditions that could prevail during assembly.

This document shall be consistent with the health and safety plan. It must include
the blank assembly executed at the workshop so as to ensure that all the parts are as intended, as well as all auxiliary construction members that are necessary for assembly, such as provisional centring, shoring or restraints.

78.3. Supports

78.3.1. Setting out and suitability of supports

All foundations, both column foot and slabs or anchor blocks, must have been inspected beforehand, including anchor bolts that are embedded in them, so as to ensure that their position and alignment are in accordance with the drawings.

It is advisable that embedded bolts should have a certain clearance so as to allow for slight displacement thus making it easier to insert them into support base plates. To this end, boxing or sleeves may be used in the upper part of the foundation, with a width three times greater than the diameter of the bolts that they house.

Care must be taken to ensure that the position of supports is not modified in excess of the tolerances, throughout assembly (see Section 80).

Both the actual anchor bolts and the levelling blocks or wedges for base plates must be capable of supporting the assembled structure, before they are tamped with levelling mortar. If the temporary members are embedded, it must be ensured that their durability is equal to that of the structure and that they retain a minimum coating of 25 mm.

78.3.2. Concreting

The space between the base plate and foundation must be concreted using cement mortar or special non-shrinking mortar. A minimum thickness of 25 mm is recommended, as well as ensuring that filling can be done easily and that there is sufficient space to position and handle the wedges or lower nuts for levelling.

The mortar shall be poured in as quickly as possible once the columns and beams immediately above them are correctly plumbed and aligned. The material must not be mixed or used at temperatures lower than 0°C unless the Manufacturer has instructed otherwise. In any case, adequate fluidity for filling all the space completely must be obtained.

Any residual grease, ice or dirt must be removed beforehand. For base plates with dimensions in excess of 400 mm, it is advisable to have ventilation openings of 50 mm to facilitate penetration of the product.

In the case of fixed-ended supports in column foot with calyx-type receptacles, the concrete or filling mortar must have a characteristic strength not less than that of the foundation. In its initial position, the concrete must cover two-thirds of the fixity length. It must not be subjected to any additional loads as long as the concrete does not reach half its characteristic resistance. Final execution shall be completed by concreting for the last third.

78.4. Erection

78.4.1. Erection drawings

The assembly drawings for the structure shall be drawn up on the basis of the
workshop drawings. They shall be prepared showing the drawings and elevations at such scale that the erection marks for all components can be shown on them. Drawings shall show the members and their joints, as well as any special tolerances. Foundations drawings must provide details of the position and orientation of the base plates and any other members that are in direct contact with the concrete.

They shall show the setting out of each plane. The number, type, diameter and position of the anchor bolts shall be shown in the base plates, as well as the clearance to be filled by levelling mortar.

Any temporary members, such as bracing, ladders or temporary access, must be included in the assembly drawings.

Drawings shall show the weight of all components or assembly over 50 KN and centre of gravity of all large irregular pieces.

78.4.2. Marking

Marking methods must comply with subsection 75.3.1. In some cases where the orientation cannot be deduced or where there is a risk of error caused by inversion of forces in the parts or structural subsets, they should be marked with its erected orientation (internal/external; face up/down; upper/lower, etc.).

For serial production using identical members in all respects, the assembly marking may be repeated.

78.4.3. Handling and storage on site

Handling and storage on site must be carried out so as to minimise the risk of damage to members. Particular attention should be paid to lifting for unloading and hoisting operations.

Any damage that may be sustained by any member affected by its tolerances, protective coating or joints should be repaired.

Bolts, fixing members, covers and accessories must be adequately packaged and identified.

78.4.4. Trial erection

For complex structures, or even where there is desire to ensure proper, adjusted assembly on site, the Special Technical Specifications may require blank assemblies to be made at the workshop, in accordance with subsection 75.4. The Builder may include the blank assembly in the final assembly programme mentioned in subsection 78.2, in order to evaluate the time required for or the duration of complex assembly operations.

78.4.5. Erection methods

The erection of the steel structure shall be assembled in conformity with the assembly programme mentioned in subsection 78.2. The resistance and stability of the site must be ensured throughout the process.

For buildings, it is advisable to start assembly with the rigid cores that make the whole structure immovable and give stability to the parts that are assembled afterwards.
Anchor bolts at column bases that do not have fixed ends must be considered ineffective. This is in order to avoid overturning, unless it has been checked using a calculation.

The effect of execution loads, including the weight of personnel and equipment, must be anticipated during assembly, as well as the action of wind on the unfinished structure.

Provisional bracing or stiffening must be maintained until the assembly is sufficiently advanced, so that they may be removed without compromising safety.

It may be necessary, in very tall buildings or structures, to release the bracing from the effects of heavy loads so that construction may progress. In such cases, which must be stated explicitly in the Special Technical Specifications and considered in the structure's design, it is possible to release only one panel each time and use other provisional, alternative bracing where necessary.

The Special Technical Specifications apply to temporary member joints. Such joints must be made so that they do not limit either resistance or the service capacity of the final structure.

If the erection procedure involves rolling or otherwise moving the structure or part thereof to its final position, provision shall be made to control braking of the moving mass, and preferably to take action by reversing the direction of movement may need to be considered.

All temporary anchoring devices shall be secured against unintentional release.

The Builder shall be responsible for ensuring that no part of the structure is overstressed or distorted by the warehousing of materials or assembly loads throughout construction.

78.4.6. Alignment

Each part of the structure must be aligned, levelled and adjusted as soon as possible after they have been assembled; their joints must be made immediately afterwards.

If such joints are final, it must be ensured that their execution does not compromise the adjustment, levelling or plumb of subsequent members.

Levelling nuts, wedges and lining may be used to align and adjust the structure. Where there is a risk of wedges being displaced, they may be welded. In such case, they must be made of steel and have a minimum thickness of 4 mm where they are used externally.

Where it is not possible to correct assembly or adjustment errors by means of wedges in the form of blocks or lining, the manufacture of members must be adequately modified, and the changes must be made in the assembly drawings.

Particular attention should be paid to ensuring that the adjustment is not forced if this would introduce forces in bars that have not been considered by the structure design.

The possibility of having oversized or pierced holes in order to facilitate assembly must be considered.
Section 79. Surface treatment

79.1. General

This Section shall apply both to structures treated off-site and on site. The Special Technical Specifications must define the corrosion resistance protection system and the additional requirements for achieving service conditions according to the working life of the structure (see subsection 5.1) and the maintenance plan (see Section 94), considering the level of atmospheric corrosion and the class of exposure of the different members.

With regard to the type of members and the detail of joints, the design must avoid areas where moisture and dirt may be deposited, both in internal members and in external structures.

Particular care should be taken with drainage for covers and fronts, so that the structure is protected as well as possible.

The Special Technical Specifications shall consider an adequate protection system for the members on the outside.

In conjunction with this, fire protection treatment (see Chapter XII) shall also be considered, since the requirements for this may define a degree of corrosion protection that is much higher than is strictly necessary, particularly in the case of intumescent coatings and grouting.

In case of painting, the Special Technical Specifications must define the treatment system, and provide details of at least the following aspects:

- preparation of surfaces;
- type and thickness of the against corrosion prime coat;
- type and thickness of intermediate coats;
- type and thickness of the top coat and retouching.

The project budget should state clearly whether the cost of the steel structure includes the protection system.

If so, the list of unit prices must state the specific protection system for each item (particularly on sites where preparation and painting are done off-site).

For coats of paint applied on site, it is possible to estimate them according to their area, instead of using the total weight of the steel; in this case the estimate shall be made according to the surface of each specific section.

79.2. Preparation of steel substrates

All surfaces to which paints of are to be applied shall be prepared cleaned and prepared for treatment with the corresponding paint. In principle, dirt, lamination scale, residual dross from welding, grease and surface moisture must be removed. If there are any previous coats, they must also be removed.
The applicable standard is UNE-EN ISO 8504-1, and UNE-EN ISO 8504-2 for blast cleaning and UNE-EN ISO 8504-3 for mechanical and manual cleaning.

The preparation methods should achieve the degree of roughness defined in the Special Technical Specifications in accordance with UNE-EN ISO 8503, parts 1 to 5. Permanent blast-cleaning facilities should be inspected on a regular basis. In order to facilitate such inspections, it is necessary to know the initial state of the surface, in accordance with UNE-EN ISO 8501-1.

Surfaces on site must be prepared under environmental conditions that do not compromise the quality of the finish. It should therefore be avoided, when relative humidity exceed than 85 % or low temperatures that may produce condensation. The temperature of the substrate to be painted must be 3 ºC above the dew point temperature. Suitable precautions must be taken to ensure that other surfaces are not damaged.

Where surfaces are prepared at the workshop using abrasive methods, this must be followed by scrupulous removal of dust, in accordance with UNE-EN ISO 8502-3, and the application of a quick-drying primer that does not change the following phases.

79.3. Protection methods

79.3.1. Metalising

This protection method is used by projecting pulverised zinc or aluminium in accordance with UNE-EN ISO 2063.

Metalised surfaces must be treated with a special anti-corrosion primer that acts as a sealant and filler to avoid the formation of blisters before the paint is applied.

79.3.2. Galvanizing

Protection through galvanizing consists of the formation of a zinc coating or zinc/iron alloys, by immersing parts and members made of iron and steel in a cast zinc bath at a temperature of 450 ºC. Such coatings are governed by standard UNE-EN ISO 1461.

When designing a member that is to be protected by galvanizing, it is important to consider of certain requirements that may be the dimensions of such members, which must adhere to the size of the galvanisation bath, although in some cases where the size of the part is greater than that of the baths available, the part may be partially submerged and then turned round so that the untreated portion may be treated.

Preparation of the surfaces of the members that are to be galvanised must include cleaning all surface contaminants that cannot be removed by descaling, as is the case for grease, paint, welding dross, etc.

UNE-EN ISO 14713 (Annex A) discusses various design questions in detail, which must be taken into account in order to achieve an adequate, good-quality coating.

In the event that members have to be welded once they have been galvanised, or have been restored if they have minor galvanisation defects, it is possible to restore the area affected by the coating by means of thermal projection of zinc (in accordance with UNE-EN ISO 2063) or using a zinc-rich paint with a high content of metallic zinc in
the dry film (minimum 80 % by weight). The most suitable types of paint for this purpose are those that have epoxy binders of air-drying polyurethane (1 element) and air-drying ethyl silicate (1 element).

If the protection system specifies any subsequent painting of galvanised surfaces, it is necessary for them to be adequately treated through degreasing followed by priming treatment to ensure adherence of the paint, in accordance with UNE-EN ISO 12944-4. Finally, base coat and top coat are applied, depending on the environmental corrosion, in accordance with UNE-EN ISO 12944-5 (Table A9).

As a supplement to galvanisation, painting with powder and polymerisation in a furnace may be used in accordance with standards UNE-EN 13438 and UNE-EN 15773.

Members made from continuously galvanised steel sheets (thickness of up to 3 mm; in accordance with UNE-EN 10346) must be specified at a thickness or mass of coating that is adequate for the environmental corrosion category in accordance with UNE-EN ISO 14713.

79.3.3. **Paint systems**

Paint must be applied in accordance with the data sheet supplied by the product’s manufacturer.

Check should be carried out beforehand to ensure that the surface state is as anticipated by the preceding phase, i.e. both the degree of cleaning and roughness in the case of a primer coat, and the sealing, compatibility and nature of the previous coat for subsequent coats.

The separate paints that make up a painting system must be mutually compatible.

It is advisable to use products from the same manufacturer.

The site plan must set out the phases for applying the protection, paying due regard to the other activities. If painting is done on site, the members must be primed at the workshop to a minimum thickness that impedes incipient oxidation before assembly where there is a chance of prolonged warehousing or storage.

In order to facilitate checks, it is advisable for each coat to have a different colour or shade, in accordance with UNE 48103.

Once the surface has been executed and retouched, the drying and hardening period advised by the manufacturer must be observed strictly, preventing any contact with water.

79.4. **Special requirements**

Surfaces that are to be embedded in concrete do not require protection starting from 30 mm below the level of the concrete, wherever the surface of the concrete is in turn safe from carbonation processes. Only brushing is required to remove lamination scale, dirt and grease. If it is delivered primed from the workshop, no additional operations are required.
Surfaces that are to transmit forces by friction and those that house pre-loading bolts shall satisfy the requirements for contact surfaces mentioned in subsection 76.8.

Damage to or contamination of such surfaces must be avoided during transportation and assembly by using adequate cover of impermeable protection.

Bolted joints must be inspected before paint is applied on site.

Joints made by welding must be done on unpainted strips with a width of 150 mm or a coat of compatible primer. The weld and the adjacent part must be painted once all dross has been completely removed and the joint has been accepted.

Areas and surfaces that are difficult to access after assembly should be treated before assembly. Surfaces made of self-weathering steel, which is resistant to atmospheric corrosion by self-oxidation, must have an acceptable appearance after they have been exposed to bad weather. It may therefore be necessary to blast-clean them using pressurised water, in order to ensure a similar texture and uniform colour. It must be borne in mind that the self-protection mechanism that develops in steel of this type only works in alternating dry and wet cycles, and wherever there is no acidic or saline atmospheric pollution. The design must adopt the construction details necessary to prevent any runoff of oxide due to rainwater from affecting the rest of the construction. It must be taken into account that this type of steel may use different passive fire protection systems as steel in UNE-EN 10025.

The Special Technical Specifications shall state whether or not closed beams or hollow sections require internal treatment. In the event that water tightness is ensured by structural welding or even by seal welding at ends, it shall be considered that the internal space will be protected once such welding has been accepted. Seal welding only requires a visual inspection. Special precautions must be taken concerning the water tightness of fixing members that may go through members in box girders or sealed sections.

Closed beams and sections are also protected by their internal surfaces where they are protected by galvanizing, which also renders it unnecessary to seal the extremities.

79.5. Protection of fixing members

Fixing and anchor members must be supplied with adequate protection for their environmental exposure class.

The most suitable protection for fixing members that are to be used in structures protected by galvanisation or thermal projection of zinc is also galvanizing in accordance with UNE-EN ISO 1068, so as to ensure there are no joints with possible signs of corrosion caused by galvanic couples.

Any additional protection that is to be applied on site shall be applied once the joint has been inspected. Anchor bolts do not require any treatment unless otherwise stipulated in the Special Technical Specifications.
CHAPTER XVIII. TOLERANCES

Section 80. Tolerance types

Tolerances are classified as:

- normal tolerances; (functional)
- special tolerances. (essential)

Normal tolerances are those that are specified in this Code. The permitted deviations given must not be exceeded under any circumstances, since doing so would compromise the resistance and stability of the structure, bearing the essential tolerances in mind.

The tables further on show other, stricter, deviations within the maximum permitted deviations, compliance with which would allow 1.00 instead of 1.05 as the partial safety factor for $\gamma_{M0}$ and $\gamma_{M1}$ for all types of structure other than bridges.

The special tolerances are stricter, and apply to cases where requirements relating to adjustment, finish, aesthetic appearance or operating conditions have to be met. In special cases for assembly, or in order to increase safety or serviceability of structural members, it may be necessary to use special tolerances.

The Special Technical Specifications must give the design tolerances. In the case of special tolerances, it is necessary to stipulate to which members the tolerances apply.

80.1. Normal tolerances. General

The normal tolerances are given in the tables in this Chapter. It must be understood that these are requirements for final acceptance of the structure; the tolerances of pre-fabricated members that are fitted on site are therefore subject to the final check on the executed structure.

If the permitted deviation limits (the tolerance value) result in non-compliance, they should be dealt with in accordance with Chapters XIX to XXII of Title 8, “Controls”, of this Code.
An uncorrected deviation from the essential tolerances may be justified by redesigning the structure, explicitly including the deviation value.

Tolerances for measurements or dimensions and the shape of flat steel products obtained from cold-forming are given in UNE-EN 10131:2007.

The deviations permitted for straight sections of hot-finished structural members are those specified in the following standards: UNE-EN 10024, UNE-EN 10034, UNE-EN 10051, UNE-EN 10056-2, UNE-EN 10079, UNE-EN 10279, UNE 36559, UNE-EN 10210-2.

The deviations permitted for straight sections of cold-finished structural members are those specified in standard UNE-EN 10219-2.

80.2. Normal tolerances. Manufacturing

Where standard products are added to a member, the stricter tolerances shall apply to the assembly. Every single product must comply with its own relevant standard:

a) the standards for beams in the case of reinforced sections welded to rolled profiles;

b) standard UNE-EN 10162 for cold-formed profiles. Table 80.2.a applies to press manufacture;

c) Tables 80.2.b and 80.2.c for manufactured members;

d) shells of revolution in accordance with the specific execution classes for this type of structure in accordance with EN 1993-1-6 shall have the tolerances given in Annex D to EN 1090-2;

e) the permitted deviation is 2 mm for the position of bolt-holes, both individually and as a group;

f) Table 80.2.d for cold-formed ribbed sheets.
### Table 80.2.a. Essential manufacturing tolerances cold-formed profiles

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
</table>
| 1  | Internal elements width | Width A between bends | $-\Delta = A/50$  
   (note negative sign)  
   Stricter deviation:  
   $|\Delta| = A/80$ |
| 2  | "outstand element width | Width B between a bend and free edge | $-\Delta = B/80$  
   (note negative sign)  
   Stricter deviation:  
   $|\Delta| = B/100$ |
| 3  | Flatness | Convexity or concavity | $|\Delta| = D/50$  
   Stricter deviation:  
   $|\Delta| = D/80$ |
| 4  | Straightness of compressed parts | Eccentricity $\Delta$ | $|\Delta| = L/750$  
   Stricter deviation:  
   $|\Delta| = L/1000$ |
### Table 80.2.b. Essential manufacturing tolerances Welded profiles

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Depth</td>
<td>Overall depth</td>
<td>$-\Delta = \frac{h}{50}$ (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$-\Delta = \frac{h}{100}$</td>
</tr>
<tr>
<td>2</td>
<td>Flange width: B1 or b2</td>
<td>B1 or b2</td>
<td>$-\Delta = \frac{b}{100}$ (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$-\Delta = \frac{h}{150}$</td>
</tr>
<tr>
<td>3</td>
<td>Squareness at bearings</td>
<td>Total web eccentricity</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for components without</td>
<td>but $</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bearing stiffners</td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>4</td>
<td>Section dimensions</td>
<td>External or internal</td>
<td>$-\Delta = \frac{b}{100}$ (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dimensions</td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>where $b=b_1 b_2 b_3$ or $b_4$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$-\Delta = \frac{b}{150}$</td>
</tr>
</tbody>
</table>
### Table 80.2.b. Essential manufacturing tolerances for reinforced beams

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Edge</td>
<td>Total edge h:</td>
<td>-Δ=h/50 (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Δ=h/100</td>
</tr>
<tr>
<td>2</td>
<td>Width</td>
<td>Flange width:</td>
<td>-Δ=b/100 (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Δ=b/150</td>
</tr>
<tr>
<td>3</td>
<td>Perpendicularity of supports</td>
<td>Total web eccentricity for members without stiffened supports</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Width</td>
<td>External or internal dimensions</td>
<td>-Δ=b/100 (note negative sign)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Δ=b/150</td>
</tr>
<tr>
<td>5</td>
<td>Plate curvature</td>
<td>Plate curvature</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
</tr>
</tbody>
</table>
| ![Plate curvature diagram](image) | Deviation over plate height b | $|\Delta| = b/100$
|  |  | but $|\Delta| \geq t_w$
|  |  | Stricter deviation: $|\Delta| = b/150$

<table>
<thead>
<tr>
<th>6</th>
<th>Web distortion</th>
<th>Web distortion</th>
</tr>
</thead>
</table>
| ![Web distortion diagram](image) | Deviation $\Delta$ on gauge length $L$ equal to plate length web $b$ | $|\Delta| = b/100$
|  |  | but $|\Delta| \geq t_w$
|  |  | Stricter deviation: $|\Delta| = b/100$

<table>
<thead>
<tr>
<th>7</th>
<th>Web undulation</th>
<th>Web undulation</th>
</tr>
</thead>
</table>
| ![Web undulation diagram](image) | Deviation $\Delta$ on gauge length $L$ equal to plate length $b$ | $|\Delta| = b/100$
|  |  | but $|\Delta| \geq t_w$
|  |  | Stricter deviation: $|\Delta| = b/150$

N.B. Notations such as $|\Delta| = b/100$ but $|\Delta| \geq t_w$ mean that the larger of the two values is permitted.
Table 80.2.b (continued). Essential manufacturing tolerances Flanges of welded profiles

<table>
<thead>
<tr>
<th>No</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Flange distortion of I sections</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>Deviation on gauge (\Delta) length (L) (\text{where } L = \text{flange width } b)</td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>9</td>
<td>Flange undulation of I sections</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>Distortion on gauge (\Delta) length (L) (\text{where } L = \text{flange width } b)</td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>10</td>
<td>Out of plane imperfection of plate panels between webs or stiffeners (general case)</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>Distortion (\Delta) perpendicular to the (t) plane of the plate (\text{if } a \leq 2b) (\text{if } a &gt; 2b)</td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>11</td>
<td>Out of plane Imperfections of the plate panels between webs or stiffeners (special case with transverse compression) The general case applies unless this special case is specified</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>Distortion (\Delta) perpendicular to the (t) plane of the plate (\text{if } b \leq 2a) (\text{if } b &gt; 2a)</td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>No</td>
<td>Criterion</td>
<td>Parameter</td>
</tr>
<tr>
<td>----</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
<td>Straightness of longitudinal stiffeners in longitudinally stiffened plating</td>
<td>Deviation perpendicular to the plate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Straightness of transvers stiffeners in Transversely and longitudinally stiffened plating</td>
<td>Deviation parallel to the plate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Straightness of transvers stiffeners in Transversely and longitudinally stiffened plating</td>
<td>Deviation perpendicular to the plate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8.0.2.d. Essential manufacturing tolerances for cold-formed profiled sheets

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flatness of unstiffened or stiffened flanges or webs, Deviation $\Delta$ from flatness of nominally flat element</td>
<td>$</td>
<td>\Delta</td>
</tr>
<tr>
<td>2</td>
<td>Curvature of flanges or webs Deviation $\Delta$ from intended shape of each web or flange over curve width $b$</td>
<td>$</td>
<td>\Delta</td>
</tr>
</tbody>
</table>

80.3. Normal tolerances.

Erection Deviations in fitted members should be measured relative to a grid of predetermined fixed points.

No deviation more than $\pm 6$ mm is permitted for the centre of a group of anchor bolts or other type of support base.

The centre of a pillar or column may not deviate by more than $\pm 5$ mm from its theoretical plane position.

It is advisable to have bolt-holes in the base plate with adequate clearance (pierced or of larger diameter) in order for this requirement to be met more easily. In such case, larger washers must be used.
The level of the base plates may not deviate by more than ± 5 mm.

The tolerances for the assembly of pillars are given in Tables 80.3.a and 80.3.b.

The arithmetical mean value of 6 contiguous pillars in a building with several planes must comply with Table 80.3.b in both directions (orthogonal frames).

In a group of 6 pillars that comply with this tolerance, an individual deviation of h/100 may be permitted.

The deviation between lines of adjacent pillars shall be within the tolerance of ± 5 mm of theoretical dimension.

This theoretical grid shall be set out before assembly commences.

Where it is anticipated that the groups of bolts will be displaced or misaligned from the theoretical lines, the deviation of ± 6 mm shall apply to displacement in relation to the network of pillars thus formed.

The length standing out from an anchor bolt (in its optimal adjustment position, if it can be adjusted) shall be vertical to within a range of 1 mm to 20 mm. A similar requirement shall apply to a set of horizontal bolts and other angles.

Holes for settling and fixing plates shall be designed bearing in mind the clearances consistent with the permitted deviations for the bolts.

Pillars adjacent to lift shafts may require special tolerances.
Table 80.3.a Essential erection- Single storey columns tolerances

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inclination of any column that supports a crane gantry a track</td>
<td>Inclination from floor level to bearing of crane beam</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>2</td>
<td>Inclination of pillars for frames without bridge cranes</td>
<td>Most unfavourable inclination of the pillars for each frame Δ=(Δ1+Δ2)/2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No more stringent deviation is required.</td>
</tr>
<tr>
<td>3</td>
<td>inclination of single-storey columns generally</td>
<td>Overall inclination in storey height h</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>straightness of a single storey column</td>
<td>Location of the column in plan, relative to a straight line between position points at top and bottom: Generally structural hollow sections Deviation Δ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 80.3.b. Essential erection – Multi-storey columns tolerances

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Combined inclination</td>
<td>Overall inclination in relation to their base</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>2</td>
<td>Inclination of a column between adjacent storey levels</td>
<td>Overall inclination in relation to the bottom</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No more stricter deviation is required.</td>
</tr>
<tr>
<td>3</td>
<td>Straightness of a continuous column between adjacent storeys</td>
<td>Maximum eccentricity in relation to the directrix</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>4</td>
<td>straightness of a spliced column with links between adjacent storeys levels</td>
<td>Eccentricity in the link in relation to the directrix</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stricter deviation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>

#### 80.3.1. Total contact supports

Where a total contact support is specified, the surfaces shall be arranged so that when the support and bars that are in contact are aligned locally within an angular deviation of $1$ in $1\,000$, the maximum clearance between the contact surfaces shall not exceed $1$ mm locally, nor shall it exceed $0.5$ mm throughout at least two-thirds of the contact area, as shown in Table 80.3.1.a.
Where the size of the clearance exceeds the specified limits but is not less than 6 mm, wedges or blocks may be used to reduce such clearance to the permitted deviation limits. The wedges shall be made of rubber tyres or strips of mild steel (with low carbon content).

Table 80.3.1.a tolerances contact

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Local angular misalignment where h is the height of the storey</td>
<td>$</td>
<td>\Delta \theta</td>
</tr>
<tr>
<td>2</td>
<td>Gap at x</td>
<td>$</td>
<td>\Delta</td>
</tr>
</tbody>
</table>

80.4. Normal tolerances for bridges

Supports/piles for bridges shall comply with a tolerance of ± 5 mm on the vertical and the plane.

The webs of main beams shall comply with a tolerance of edge verticality/300.

Other tolerances specific to bridges are given in Table 80.4.
### Table 80.4. Functional erection tolerances for bridges

<table>
<thead>
<tr>
<th>No</th>
<th>Criterion</th>
<th>Parameter</th>
<th>Permitted deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Span length</td>
<td>Deviation $\Delta$ of distance between two consecutive supports, measured on top of upper flanges</td>
<td>$\Delta = \pm 3 \frac{L}{1000}$</td>
</tr>
<tr>
<td>2</td>
<td>Elevation or plan profile bridge</td>
<td>Deviation $\Delta$ from nominal profile adjusted for as-built levels of supports $L \leq 20 \text{ m}$: $</td>
<td>\Delta</td>
</tr>
<tr>
<td>3</td>
<td>Fit-up of orthotropic decks of thickness $T$ after erection</td>
<td>Difference in level at junction: $T \leq 10 \text{ mm}$: $V_e = 2 \text{ mm}$ $10 \text{ mm} &lt; T &lt; 70 \text{ mm}$: $V_e = 5 \text{ mm}$ $T &gt; 70 \text{ mm}$: $V_e = 8 \text{ mm}$ Slope at junction $T \leq 10 \text{ mm}$: $D_r = 8 %$ $10 \text{ mm} &lt; T &lt; 70 \text{ mm}$: $D_r = 9 %$ $T &gt; 70 \text{ mm}$: $D_r = 10 %$ Flatness in all directions: $T \leq 10 \text{ mm}$: $P_r = 3 \text{ mm over 1 m}$ $10 \text{ mm} &lt; T &lt; 70 \text{ mm}$: $P_r = 4 \text{ mm over 3 m}$ $T &gt; 70 \text{ mm}$: $P_r = 5 \text{ mm over 5 m}$ General case: $P_r = 5 \text{ mm over 3 m}$ Lengthwise: $P_r = 18 \text{ mm over 3 m}$</td>
<td>(*) gauge length</td>
</tr>
<tr>
<td>4</td>
<td>Orthotropic deck welding</td>
<td>Protusion kness $A_r$ of weld above surrounding surface</td>
<td>$A_r = +1 / -0 \text{ mm}$</td>
</tr>
</tbody>
</table>
80.5. Special tolerances

For special tolerances, it is recommended that the supplementary tolerances in Annex D to EN 1090-2 be followed. These set out two levels or classes for manufacture and assembly.

It should be stated to which members the tolerances apply, since they may be used for a single member or also a set.

In some cases where Annex D is cited without specifying the tolerance class, it is to be understood as meaning tolerance 1, which is less strict than class 2.

An example of tolerance class 2 being applied is where a glazed facade is assembled, so as to reduce clearances and improve adjustment.

It should be keep in mind that, in order to specify the supplementary tolerance class (especially class 2), the beams and lintels of moving frames may have relatively large deflection and shift.

Apart from bars that are subjected to dynamic forces, the applicable tolerance may be one five-hundredth of its length.