CHAPTER 13

CONSTRUCTION

Article 66. General criteria for the construction of the structure

66.1 Adaptation of the construction process to the design

The building of a concrete structure involves a series of processes that have to be carried out in accordance with what is set down in the design or, failing that, in this Code. In particular, special attention will be paid to adapting the procedures and successive construction processes to the building process foreseen in the design.

Any change to the construction processes laid down in the design shall be approved in advance by the Project Management.

66.1.1 Actions taken during the construction process

The processes used for constructing each new element in the course of the work may modify the actions having effect and the mechanical behaviour of the part of the structure already built.

Moreover, some processes, such as stripping, prestressing etc, may introduce actions that, in accordance with what is stated in Chapter 3 of this Code, should have been foreseen in the design.

66.2 Management of stocks of materials on site

The Constructor must have available a system for managing materials, products and other elements that are to be positioned in the course of construction so that their traceability is guaranteed. This system of management shall, as a minimum, have the following characteristics:

- it must include a register of suppliers, fully identifying both them and the materials and products supplied;
- it must include a system for storing the stocks on the site, and one that continues to enable every shipment or consignment that arrives at the site to be traced, if need be;
- it must include a system for registering and monitoring the constructed units that relates these to the shipments of products used and, if need be, to the consignments employed in the units so that traceability might be maintained while the construction work is in progress, and this in accordance with the level of supervision of the work defined in the design.

66.3 Environmental and promotion of sustainability considerations

Without prejudice to compliance with current environmental protection legislation, the Owners shall be able to specify that, during the construction work, account be taken of a series of environmental considerations with a view to minimising the potential impact of that work. If appropriate, this requirement should be included in an Annex forming part of the design and relating to the environmental evaluation of the structure. If the design does not provide for this type of requirement at the construction stage, the Owners will be able to enforce compliance

with such a requirement by introducing the relevant clauses into the contract with the Constructor.

In particular, the system for environmental management of the construction work shall, as a minimum, take account of the aspects dealt with in Article 77 and identify the corresponding environmental good practices to be followed while the construction work is being carried out. If the design has laid down requirements relating to the structure's contribution to sustainability, the construction work shall, in accordance with Annex 13 of this Code, be consistent with such requirements.

If some units of the construction work are subcontracted, the Constructor – understood as the principal contractor – shall ensure that the environmental requirements are complied with throughout the construction work.

Article 67. Actions to be taken prior to the start of the work

Before work is started on the structure, the Project Management will ensure that the Constructor takes the following steps:

- deposits the relevant order book, supplied by the Project Management, in the installations of the site;
- identifies the initially foreseen suppliers, as well as the rest of the agents involved in the construction work, and registers the information concerning them in the relevant directory, which is to be constantly updated until the work is completed;
- verifies the existence of the documentation guaranteeing the technical suitability of the equipment intended for use during the construction work, examples of such documentation being calibration certificates or documents defining the optimum welding parameters for welding equipment;
- verifies, if it is intended to use welding for the purpose of preparing the reinforcements for the construction work, that there are adequately qualified or authorised welders, and this in accordance with the requirements of this Code.

Furthermore, and in accordance with the criteria laid down in this Code, the Constructor shall first verify the conformity of the documentation for each of the products before they are used.

Before the work is begun, the Constructor must likewise verify that - as a consequence, for example, of the siting of new installations - there is no documentary evidence of substantial modifications that might involve alterations to the concrete structure initially planned.

With a view to securing the traceability of the materials and products employed in the construction work, the Constructor shall design and set up a system for managing the shipments and consignments received at the site, as well as the relevant stocks there.

Article 68. Processes prior to the placing of reinforcements

68.1 Siting of the structure

As the process of construction unfolds, the Constructor will ensure that the axes of the elements, the dimensions and the geometry of the sections of each structural element are in accordance with what is laid down in the design, taking into account the tolerances laid down in the design or, failing that, in Annex 11 of this Code.

68.2 Falsework and underpinning

Before using formwork in the construction, the Constructor shall be in possession of a design for it which, as a minimum:

- verifies its safety and limits the degree to which it may sustain deformation before and after the concreting;
- contains plans fully defining the falsework and its elements, and
- contains a sheet of regulations indicating the characteristics that, as required, need to be exhibited by metal sections, tubes, cramps, auxiliary elements and any other element forming part of the falsework;

Furthermore, the Constructor shall have a written procedure for assembling and dismantling the falsework or underpinning, specifying the requirements relating to its handling, adjustment, camber, load, unlocking and dismantling. It will also be verified that, with a view to its perhaps being necessary, there is a written procedure for positioning the concrete so that it is possible to limit deflection and subsidence.

Furthermore, the Project Management will have in its possession a certificate, supplied by the Constructor and signed by a natural person, guaranteeing that the elements actually employed in the construction of the falsework comply with the specifications defined in the corresponding sheet of technical requirements specific to the design.

In the case of prestressed concrete, the falsework shall be able adequately to resist the redistribution of loads that begins during the tensioning of the reinforcements as a consequence of the transfer of the prestressing forces to the concrete.

In the case of building structures, the falseworks will follow preferently the EN 12812. Distribution sills for supporting the shores will be available when the load will be transmited to the ground or to voided slabs. If the distribution sills rest directly on the ground, it will have to be ensured that they cannot subside into it. The shores will brace in both directions so that the shoring is capable of resisting the horizontal forces that may be produced when the slabs are constructed, using any of the following methods:

- Brazing the shores in both directions, i.e. with tubes or braces so that the shoring is capable of resisting the horizontal forces and at least 2% of the supported vertical-loads taking also into account the construction overload.
- Transmiting the loads to supports and walls, checking in this case that these element have enough bearing and stiffness capacity , or
- Installing falsework towers in both directions at the adequate distance.

When the floor slabs weigh more than 5 kN/m^2 or when the shores are more than 4 m high, a detailed study of the shoring, which shall appear in the design for the structure, will be carried out.

For the slabs, the secondary supports pieces will be positioned at the distances indicated in the implementation plans for the slabs, and this in accordance with what is stated in point 59.2.of the considerations prior to concreting.

On the slabs of reinforced joists will be placed the levelled shoring with the supports, and on these will be placed the joists. On the slabs of prestressed joists will be placed the joists, with the shoring being subsequently adjusted. The shores shall be able to transmit the force that they receive and, in the end, permit easy unshoring.

If case of bridges, it must be ensured that the distortions to the falsework during the process of concreting do not damage other parts of the structure that have been erected earlier. Furthermore, Annex 24 brings together recommendations relating to auxiliary construction elements in connection with the erection of structures of this type.

68.3 Formwork and moulds

The formwork and moulds must be capable of resisting the pressure to which they will be subject during the process of construction and must be rigid enough to be sure of complying with the tolerances specified in the design. Furthermore, it shall be possible for them to be withdrawn without this causing damage or abnormal shocks to the concrete.

In general, they shall present, as a minimum, the following characteristics:

- the joints between the formwork panels or in the moulds must be watertight, preventing possible leakages of water or grout through said joints;
- the formwork and moulds must be suitably resistant to the pressures exerted by the fresh concrete and to the effects of the compaction method;
- the formwork panels must be aligned and, if appropriate, vertical, with special interest attaching to the posts' continuing in a vertical direction at their junctions with the slabs in the case of building structures;
- the geometry of the mould and formwork panels must be maintained, and there must be no dents outside the tolerances laid down in the design or, if not in the design, in this Code;
- the interior surface of the moulds must be cleaned, so that there remains no type of residue from the work on assembling the reinforcements, such as the remains of wiring, trimmings, sockets etc;
- the features that permit specific textures in the surfacing of the concrete, such as bas-reliefs, impressions etc must, if appropriate, be maintained.

When it is necessary to use double formwork or formwork against the natural terrain - for example, in caisson section bridge decking, shell roofs, etc – it shall be guaranteed that the windows through which it is intended to carry out the subsequent operations of pouring and compacting the concrete are in working order.

If there are prestressed elements, the formwork and moulds shall allow the active reinforcements to be correctly sited and housed, with no impairment of the necessary watertightness.

In the case of very long elements, specific measures will be adopted to prevent undesirable movement during the phase of placing the concrete.

In the case of formwork, such as climbing formwork or sliding formwork, that is susceptible to movement during construction, it will be possible for the Project Management to require the Constructor, before the formwork is actually employed in the structure, to perform an operational test on a prototype, enabling behaviour during the construction phase to be evaluated. Such a prototype may, at the discretion of the Project Management, form part of a unit of construction.

The formwork and moulds may be of any material that does not impair the properties of the concrete. When they are of wood, they shall first be dampened to prevent them from absorbing the water contained in the concrete. Moreover, the pieces of wood will be arranged in such a way that they are able to stiffen freely, with no danger of abnormal forces or distortions being given rise to. It will not be possible to employ aluminium formwork unlessthe Project Management can be provided with a certificate, prepared by a supervisory body, to the effect that the panels employed have first been subjected to surface protection treatment to prevent them from reacting with the cement alkalis.

68.4 Stripping products

It will be possible for the Constructor to select the products used in order to facilitate form removal, unless these are specified by the Project Management. The products will be of an appropriate nature and will have to be chosen and utilised in such a way that they do not impair the properties or appearance of the concrete, do not affect the reinforcements or the formwork and do not produce effects harmful to the environment.

It will not be permitted to use diesel oil, standard grease or any other similar product.

Furthermore, the products shall not hamper the subsequent application of hardfacing or the possible construction of concreting joints.

Prior to their use, the Constructor will supply the Project Management with a certificate, signed by a natural person, stating the characteristics of the stripping product that it is intended to employ, together with its possible effects on the concrete.

The products will be applied in continuous and uniform layers to the internal surface of the formwork or mould, with the concrete having to be poured within the period of time within which the product is effective according to the certificate referred to in the previous paragraph.

Article 69. Construction, reinforcing and assembly processes for reinforcements

For the purposes of this Code, the following definitions shall apply:

- *structural ironwork:* the combined processes used to transform corrugated steel, supplied in bars or coils, as appropriate, such processes being intended for the manufacturing of passive reinforcements and, therefore, including the operations of cutting out, bending, welding, straightening etc.
- *reinforcement*: process whereby the ironwork is given its definitive geometric form through the use of constructed reinforcements or electrowelded meshes,
- *assembly*: process of positioning the reinforced ironwork in the formwork and so constituting the passive reinforcement – a process in which special attention shall be paid to the arrangement of separators and to compliance with the design's requirements regarding covers and with what is laid down to that effect in this Code.

As per 33.2, it will be possible for the reinforced ironwork to be produced, through application of the processes referred to in paragraph 69.3, either in an industrialised ironwork installation independent of the construction work or directly by the Constructor on the site itself.

The steel products employed in producing the passive reinforcements shall fulfil the requirements laid down in Article 32 in connection with said products. Likewise, reinforcements may also be produced through the transformation of electrowelded meshes, in which case the latter shall be in accordance with the relevant stipulations in this Code.

69.1 Supply of steel products for passive reinforcements

69.1.1 Supply of steel

Each consignment of steel will be supplied accompanied by the relevant supply sheet, the minimum content of which shall be in accordance with what is indicated in Annex 21 and will include the designation of the steel.

When the CE marking is in force, the steel included in each consignment will be identified in accordance with the provisions of the relevant version of UNE EN 10.080. As long as the CE marking is not in force for steel products, each steel consignment will be accompanied by a statement concerning the system of identification employed by the manufacturer, this being one of those permitted by UNE EN 10.080 and preferably registered with the Office for Harmonisation of the Internal Market, and this in accordance with Council Regulation (EC) No 40/94 of 20 December 1993 on the Community trade mark (http://oami.europa.eu).

The technical class will be specified in terms of any of the methods included in Section 10 of UNE EN 10.080 (for example, by means of a code identifying the type of steel in terms of coarsening or the lack of ribs or knurls). Furthermore, corrugated bars or wires shall, as appropriate, have the identification marks specified in the section referred to engraved, and said marks shall include information about the country of origin and the manufacturer.

If the corrugated steel product is supplied in coils or has been produced from straightening operations prior to its being supplied, this must be stated explicitly in the relevant supply sheet.

Where corrugated bars exist in connection with which, given the characteristics of the steel, special procedures - additional to or other than those referred to in this Code - are needed for the welding process, the manufacturer shall indicate what these procedures are.

69.1.2 Supply of electrowelded meshes and basic reinforcements electrowelded in a lattice

Each package of electrowelded meshes or basic reinforcements electrowelded in a lattice must arrive at the supply point (site, iron works or warehouse) accompanied by a supply sheet incorporating, as a minimum, the information referred to in Annex 21.

Likewise, each consignment shall, as long as the CE marking for steel products is not in force, be accompanied by a statement of the system of identification employed by the manufacturer, this being one of those permitted by UNE EN 10.080 and preferably registered with the Office for Harmonisation of the Internal Market, and this in accordance with Council Regulation (EC) No 40/94 of 20 December 1993 on the Community trade mark (http://oami.europa.eu).

As from the entry into force of the CE marking and in accordance with what is laid down in Directive 89/106/EEC (electrowelded meshes and basic reinforcements electrowelded in a lattice), these meshes and reinforcements shall, moreover, be supplied accompanied by the relevant documentation relating to the aforementioned CE marking, and this in accordance with what is laid down in Annex ZA of UNE EN 10.080.

The technical classes will be specified pursuant to Section 10 of UNE EN 10.080 and will consist of codes identifying the types of steel used in the meshes, with reference to the relevant coarsening or the lack of ribs or knurls). Furthermore, corrugated bars or wires shall, as appropriate, have the identification marks specified in the section referred to engraved, and said marks shall include information about the country of origin and the manufacturer.

69.2 Structural ironwork installations

69.2.1 General

The production of reinforcements by means of ironworking processes requires a number of installations to be available that enable the following activities, as a minimum, to be carried out:

- storage of the steel products used;
- the process of straightening, in the event of corrugated steel supplied in coils being used;
- processes of cutting out, bending, welding and reinforcement, as the case may be;

With a view to guaranteeing the traceability of the steel products used in industrial ironworks independent of the site, it will be possible for the Project Management to demand proof of such traceability.

Moreover, the ironworks shall possess a system of production control that includes tests and inspections of the manufactured reinforcements and reinforced ironwork, and this in accordance with 69.2.4, in which connection it shall possess an internal self-control laboratory - either one of its own or one with which it has a contractual arrangement.

In the case of ironwork installations involved in the construction, the Project Management will be responsible for receiving the steel products, and the corresponding tests will be carried out by the laboratory responsible for inspecting the work.

69.2.2 Machinery

In the case of corrugated steel supplied in coils, this will be straightened using purpose-built machines that enable straightening procedures to be carried out in such a way as not to alter the mechanical and geometrical characteristics of the material to the point of causing non-compliance with the requirements laid down in this Code. It will not be possible to use bending machines to straighten the steel.

Cutting operations may be carried out using manual bench shears or automatic cutting machines. Where cutting machines are used, it needs to be possible to programme the machine in such a way as to adapt it to the dimensions laid down in the relevant design. It will not be possible to use other equipment, such as flame-cutters, that may cause significant alteration to the physico-metallurgical properties of the material.

Bending will be carried out using manual or automated bending machines that are sufficiently versatile to employ the mandrils that enable compliance with the bending radii laid down by this Code on the basis of the diameter of the reinforcement.

Welding is carried out using any equipment that permits manual or gas-shielded arc welding or electric spot welding, and this in accordance with UNE 36832.

It will also be possible for other auxiliary machinery to be employed for producing the reinforcements, for example for automatically arranging the stirrups.

69.2.3 Storage and management of stocks

Ironwork installations will have, preferably in areas protected from bad weather, specific areas for storing the shipments of steel products received and the consignments of manufactured reinforcements or ironwork, and this in order to prevent possible damage to, or contamination of, said shipments and consignments.

For any of the processes carried out for the purposes of installing the ironwork, a system for managing the stocks – and preferably a computerised one - will be available that will, in every case, enable the stocks to be traced back to the manufacturer of the steel employed.

No steel that is pitted or that has an excessive level of oxidation that might affect its bonding capacities shall be used. Such conditions are understood to have been complied with when the section affected is no less than one per cent of the initial section.

69.2.4 Production control

The industrial ironwork installations independent of the site shall contain within them a production control system that takes account of all of the processes being implemented. Such production control will have, as a minimum, the following aspects:

a) internal controlof each one of the ironwork processes,
b) tests and inspections in connection with the self-controlof the manufactured reinforcements or, as the case may be, of the reinforced ironwork,
c) the existence of a self-control document listing the types of check, the frequency with which they have been carried out and the criteria for accepting what has been produced, and
d) the existence of a register for archiving and documenting all the checks carried out in terms of production inspection.

Self-control of the processes, to which point b) refers, will include, as a minimum, the following checks:

- Validation of the straightening process through the carrying out of tension tests in respect of each straightening machine. Two monthly tests will be carried out in respect of each machine on samples taken before and after the process, and this for a diameter (small, medium or large) for each of the series, as per UNE EN 10080, with which the machine operates. If only steel with an officially recognised quality mark is used, a test may be carried out just one a month. The diameters will be alternated consecutively until all of the diameters used by each machine have been tested, specifications included in 69.3.2 have to be satisfied.
- Validation of the cutting process through the measurement of reinforcements once they have been cut. At least five weekly measurements will be taken, corresponding to each machine in the case of automatic cutting and to each operator in the case of manual cutting. The measurements obtained shall be within the tolerances laid down in the design or, in this Code, if the design does not contains these specifiations..
- Weekly validation of the bending process in respect of each machine through the application of bending templates to, at least, five reinforcements corresponding to each machine.
- Validation of the welding process, be it resistant or non-resistant, through the carrying out on a quarterly basis of the checks laid down inSection 7.1 of UNE 36832.

In the event of the reinforcements being manufactured on site, the Constructor shall carry out a self-inspection, equivalent to that defined above, on the industrial installations independent of the site.

69.3 General criteria for structural ironwork processes

69.3.1 Quartering details

In the case of manufactured reinforcements or, as the case may be, of reinforced ironwork pursuant to the stipulations in 33.2, schemes for details of reinforcements, signed by a natural person responsible for the design in the ironwork installation, will be prepared. These schemes must reflect the geometry and specific characteristics of each of the various forms, indicating the total number of similar reinforcements to be manufactured and identifying the elements for which they are intended.

In no case may the forms of details entail a reduction in the reinforcement sections laid down in the design.

If the design defines a specific distribution of forms, this must be respected in the quartering of the ironwork installation unless the Project Management or the quality control body authorises in written document alternative arrangements concerning forms of reinforcement.

In other cases, the type of dismantling considered most appropriate and complying with what is laid down in the design, may be defined by the ironwork installation. The detailing will be presented in advance to the Project Management which, as appropriate, will be able to modify it within a period agreed at the beginning of the construction work and recommended to be no longer than a week.

The simultaneous use of differently designated types of steel must be avoided. When, however, there is no danger of confusion, two different types of steel may be used in one and the same element for the passive reinforcements: one for the main reinforcement and the other for the stirrups. In those exceptional cases in which it is not possible to prevent a situation in which, in the same section, two types of steel with different limits are put in place to perform the same structural function, what is laid down in 38.3 shall apply.

In the case of girders and similar elements subject to buckling, the bars that bend shall be properly enveloped by hoops or stirrups in the area of the bend. This arrangement is always to be recommended, whatever the element in question. When, in these areas, a large number of bars bend simultaneously, it is advisable to increase the diameter of the stirrups or to reduce the gap between them.

69.3.2 Straightening

When steel products supplied in coils are used, they must be straightened with a view to giving them a straight alignment. With this in mind, machines manufactured specifically for this purpose and complying with what is indicated in 69.2.2 will be used.

As a consequence of the straightening process, the maximum variation that is produced for distortion under maximum load shall be lower than 2.5%, Taking into account the results could be affected by the sample preparation method for testing, that has to be done in agreement with Annexe 23, it can be accepted processes with variations of $\varepsilon_{máx}$ greater than the indicated value in a 0,5%, provided the fulfilment of the specifications for reinforcement included in article 33. Moreover, the variation in height of the corrugation shall be lower than 0.1mm in the case of diameters smaller than 20 mm and lower than 0.05 mm in other cases.

69.3.3 Cutting

The bars, wires and meshes used in producing the reinforcements will be cut in keeping with the plans and instructions in the design, using manual procedures (involving shears etc) or specific automatic cutting machinery.

The cutting process shall not alter the geometrical or mechanical characteristics of the steel products used.

69.3.4 Bending

The passive reinforcements will be bent in advance of their placement in the formwork, and this in keeping with the plans and instructions in the design project. This operation will be conducted at room temperature by means of mechanical bending machines of constant velocity and with the help of mandrils, so that the curvature is constant throughout the area. Exceptionally, in the case of partially concreted bars, bending will, for manual procedures, be permitted as part of the construction work.

The straightening of bends, including of those supplied, will only be permitted when this operation can be conducted without causing immediate or future damage to the relevant bar. Likewise, a high number of bars must not be bent in one and the same section of the member, and this in order to avoid creating a concentration of stresses in the concrete that might ultimately prove dangerous.

If it proves to be essential to engage in unbending operations on the site, as for example in the case of awaited reinforcements for connection with reinforcements not yet constructed, unbending will be carried out in accordance with documented processes or criteria of implementation, its having to be shown that no fissures or fractures have been produced in the reinforcements. Otherwise, steps will be taken to replace the damaged elements. If the unbending is carried out on the spur of the moment, appropriate steps shall be taken not to damage the concrete with the high temperatures.

The minimum bending diameter of a bar must be such as to prevent excessive compression and cracking of the concrete in the area of curvature of the bar, with fractures of the bar caused by such curvature needing to be prevented. Unless otherwise indicated in the design, this will be achieved using mandrils of a diameter not less than those indicated in table 69.3.4.

Table 69.3.4
Minimum diameter of the mandrils

Steel	Hooks, pins and U hooks (see figure 69.5.1.1)		Bent bars and other curved bars	
	Diameter of the bar in mm		Diameter of the bar in mm	
	ø < 20	ø ≥20	ø ≤25	ø > 25
B 400 S B400SD	4ø	7ø	10 ø	12 ø
B 500 S B 500 SD	4 ø	7 ø	12 ø	14 ø

Hoops or stirrups of a diameter equal to, or less than, 12 mm may be bent with diameters lower than those indicated above, provided that this does not cause the start of cracks in such elements. To prevent such cracking, the diameter employed shall be neither less than 3 times the diameter of the bar, nor less than 3 centimetres.

Where there are electrowelded meshes, the aforementioned limitations also apply as long as the bending takes place at a distance equal to, or greater than, four diameters, counted from the nearest junction or instance of welding. Otherwise, the minimum bending diameter cannot be less than 20 times the diameter of the reinforcement.

69.4 Reinforcement of structural ironwork

69.4.1 Distance between the bars of passive reinforcements

The reinforcement of the structural ironwork will be in accordance with the geometries defined for the ironwork in the design project, there being reinforcements that permit a correct concreting of the member in such a way that the bars or groups of bars are completely enveloped by the

concrete, with account being taken, if appropriate, of the limitations that the use of internal vibrators might impose.

When the bars are positioned in separate horizontal layers, the bars of each layer shall be situated vertically one on top of the other so that the space between the resulting columns of bars permits the passage of an internal vibrator.

The following requirements are applicable to ordinary concreted construction works *in situ*. When the construction work concerned is provisional, or in special cases of construction (for example, when there are precast elements), it will be possible, subject to special justification and on the basis of the combined circumstances in each case, to evaluate the reduction in the minimum distances that are indicated in the following sections.

69.4.1.1 Isolated bars

Except in the cases indicated in 69.4.1, the clearance – horizontal and vertical – between two consecutive isolated bars will be equal to, or greater than, the larger of the following three values:

- 20 millimetres except in the case of prestressed joists and hollow-core slabs where a figure of 15 mm will be taken;
- the diameter of the larger;
- 1.25 times the maximum size of the aggregate (see 28.3).

69.4.1.2 Groups of bars

Two or more corrugated bars placed in longitudinal contact are referred to as a group of bars.

As a general standard, groups of up to three bars may be positioned as the main reinforcement. When the members concerned are compressed, concreted in a vertical position and of dimensions such that it is not necessary to place joints in the reinforcements, it will be possible for groups of up to four bars to be put in place.

In order, where the groups of bars are concerned, to determine the extent of the covers and the clearances in respect of the neighbouring reinforcements, the diameter of each group will be considered to be that of the circular section of area equivalent to the sum of the areas of the bars constituting it.

The cover s and clearances will be measured on the basis of the actual outline of the group.

In the groups, the number of bars and their diameters will be such that the equivalent diameter of the group, defined in the form indicated in the previous paragraph, will be no greater than 50 mm, except in the case of compressed members concreted into a vertical position, where the aforementioned limit may be increased to 70 mm. In the overlap areas, the maximum number of bars in contact in the splicing area will be four.

69.4.2 Pre-reinforcement operations

On occasions, the use of systems facilitating the subsequent reinforcement of the structural ironwork, for example through the additional arrangement of bars or auxiliary wires to permit the automatic arrangement of stirrups, may be enough. In no case will it be possible for such additional elements (bars, wires etc) to be taken into account as a reinforcement section.

Furthermore, such additional elements must comply with the specifications laid down in this Code where minimum covers are concerned, and this with a view to preventing subsequent problems involving corrosion of these very auxiliary elements.

69.4.3 Reinforcement operations

69.4.3.1 General considerations concerning the reinforcement

The structural ironwork may be prepared in an industrial installation independent of the site or as a part of the assembly of the reinforcement on the Constructor’s own site, and such reinforcement will take place using tying procedures involving wires or through the application of non-resistant welding.

In any case, maintenance of the reinforcement must be guaranteed during normal operations of installing it in the formwork, as well as during the pouring and compaction of the concrete. Where reinforced structural ironwork is in an installation independent of the site, maintenance of its reinforcement must also be guaranteed during its transportation to the site.

Steel wire will be used for tying purposes and involve either manual tools or mechanical binders. Both the non-resistant welding and the tying involving wire may take place using cross unions or overlapping.

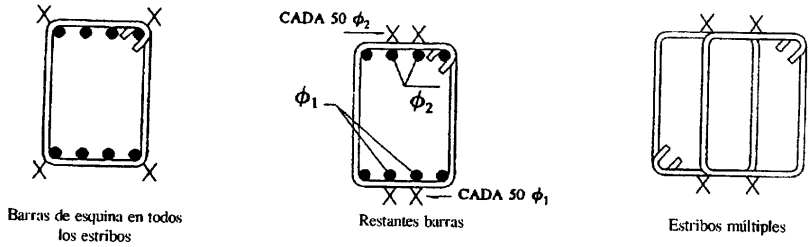
Independently of the procedure employed, the arrangement of the tying points will fulfil the following conditions, depending on the type of element:

a) Slabs and plates:

- all the bar junctions will be tied at the perimeter of the reinforcement;
- when the bars of the main reinforcement have a diameter no greater than 12 mm, the bar junctions will be tied in the rest of the panel in an alternative, staggered, manner. When the aforesaid diameter is greater than 12 mm, the tied junctions must not be at a distance from each other of more than 50 times the diameter, their being uniformly arranged on a random basis.

b) Supports and girders:

- all the corner junctions of the stirrups will be tied to the main reinforcement;
- when a bent electrowelded mesh forming the stirrups or pre-reinforced reinforcement is used for the automatic arrangement of stirrups, the main reinforcement must be tied to the corners at a distance no greater than 50 times the diameter of the main reinforcement;
- the main reinforcement bars that are not located in the corners of the stirrups must be attached to these at distances no greater than 50 times the diameter of the main reinforcement;
- multiple stirrups formed from other simple stirrups must be tied one to another.



Key to figure:
CADA: EACH; Barras de esquina en todos los estribos: Corner bars in all the stirrups; Restantes barras: Remaining bars; Estribos multiples: Multiple stirrups

c) Walls:

- the bars will be tied at their intersections in an alternative, staggered, form.

69.4.3.2 Specific considerations concerning non-resistant welding

Non-resistant welding may take place through any of the following procedures:

- manual arc welding with coated electrode,
- semi-automatic gas-shielded arc welding,
- spot welding using electrical resistance.

The characteristics of the electrodes to be used in procedures a) and b) will be those indicated in UNE 36832. In any case, the parameters of the process shall be laid down using previous tests.

Moreover, the following criteria must be taken into account:

- the surfaces to be welded shall be properly prepared and free from rust, moisture, grease or any type of dirt,
- the bars to be joined will have to be kept at a temperature higher than 0°C in the welding area and must, if appropriate, be protected so as to prevent rapid cooling following the welding, and
- welding must not take place under adverse climatic conditions such as rain, snow or high winds. If need be, screens or similar protective features may be used.

69.5 Specific criteria for anchorage and splicing of reinforcements

69.5.1 Anchorage of passive reinforcements

69.5.1.1 General

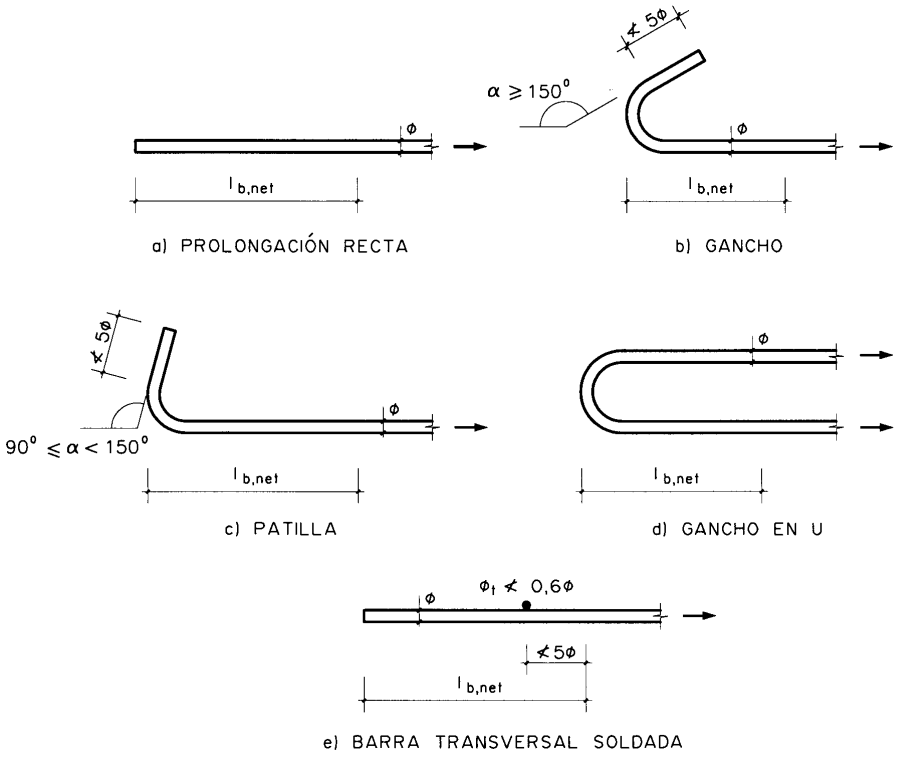
The basic anchorage lengths *(l_b)*, defined in 69.5.1.2, depend on, among other factors, the bonding properties of the bars and the position occupied by these in the concrete member.

Depending on the position occupied by the bar in the member, the following cases may be distinguished:

- Position I: good bonding, in the case of reinforcements that, during the concreting, form with the horizontal an angle between 45° and 90° or if they form an angle smaller than 45°, are situated in the lower half of the section or at a distance equal to or greater than 30 cm from the upper facing of a concreted layer.
- Position II: inadequate bonding, in the case of reinforcements that, during the concreting, do not fall within any of the aforementioned categories.
- If dynamic effects may occur, the anchorage lengths indicated in 69.5.1.2 will be increased by 10 ø.

It will not be possible for the net anchorage length defined in 69.5.1.2 and 69.5.1.4 to adopt values lower than the largest of the following three:

- a)10ø;
- b)150 mm;
- c) a third of the basic anchorage length for tensioned bars and two thirds of said length for compressed bars.



Key to figure: Prolongación recta: Straight elongation; Gancho: Hook; Patilla: Pin; Gancho en U: U hook; Barra transversal soldada: Welded transverse bar

Figure 69.5.1.1

End anchorages of the bars may take place through the standardised procedures indicated in figure 69.5.1.1 or through any other test-based guaranteed mechanical procedure capable of ensuring the transmission of forces to the concrete without danger to the latter.

In the case of girder end supports, at least a third of the reinforcement necessary for resisting the maximum positive moment shall continue as far as the supports; and at least a quarter in the case of intermediates. This reinforcement will extend from the axis of the support device at a magnitude equal to the corresponding net length of anchorage.

69.5.1.2 Anchorage of corrugated bars

This section refers to the corrugated bars that fulfil the statutory requirements laid down in this connection in Article 32.

The basic straight-elongation anchorage length in position I is that which is necessary for anchorage an $A_s f_{yd}$ force for a bar supporting an $\tau_{bd,}$, constant bonding stress in such a way that the following equilibrium equation is satisfied:

$$l_b = \frac{\phi \cdot f_{yd}}{4 \cdot \tau_{bd}}$$

where τ_{bd} depends on very many factors including the diameter of the reinforcement, the resistant characteristics of the concrete and the anchorage length itself.

If the bar's bonding characteristics are certified on the basis of the beam test described in Annex C of the UNE EN 10080, the value of τ_{bd} is that which appears in Section 32.2 of this Code, and the resultant basic anchorage length, obtained in simplified form, is:

- For bars in position I:

$$l_{bl} = m \varnothing^2 \geq \frac{f_{yk}}{20} \varnothing$$

- For bars in position II:

$$l_{bII} = 1{,}4\, m \varnothing^2 \geq \frac{f_{yk}}{14} \varnothing$$

where:

ø Diameter of the bar, in mm.

m Numerical coefficient, with the values indicated in Table 69.5.1.2.a dependent on the type of steel, obtained on the basis of the experimental results obtained for the purpose of testing the bonding of the bars

f_{yk} Guaranteed yield strength of the steel in N/mm^2.

l_{bI} *y* l_{bII} Basic anchorage lengths in positions I and II, respectively, in mm.

Table 69.5.1.2.a

Characteristic resistance of the concrete (N/mm^2)	m	
	B 400 S B400SD	B 500 S B 500SD
25	1.2	1.5
30	1.0	1.3
35	0.9	1.2
40	0.8	1.1
45	0.7	1.0
≥50	0.7	1.0

If the bonding characteristics of the bars are tested on the basis of the corrugations geometry pursuant to what is stated in the general method defined in Section 7.4 of UNE EN 10.080, the value of τ_{bd} is:

$$\tau_{bd} = 2{,}25 \eta_1 \eta_2 f_{ctd}$$

where:

f_{ctd} Tension resistance calculated in accordance with Section 39.4. For calculation purposes, no value greater than that associated with concrete of 60 N/mm^2 characteristic resistance will be adopted unless it is demonstrated by means of tests that the average bonding resistance may prove to be greater than that obtained with this limitation.

η_1 Coefficient related to bonding quality and the position of the bar during concreting.
η_1 = 1.0 for satisfactory bonding
η_1= 0.7 for any other case.

η_2 Coefficient related to the diameter of the bar:
η_2 = 1 for bars of diameter Φ≤32 mm.
$\eta_2 = \frac{132 - \phi}{100}$ for bars of diameter Φ>32 mm.

The net anchorage length is defined as:

$$l_{b,neta} = l_b \beta \frac{\sigma_{sd}}{f_{yd}} \cong l_b \beta \frac{A_s}{A_{s,real}}$$

where:

β Reduction factor defined in Table 69.5.1.2.b.

σ_{sd} Working stress of the reinforcement that it is intended to anchor, on the most unfavourable load hypothesis, in the section from which the anchorage length will be determined.

A_s Necessary reinforcement by calculation in the section from which the reinforcement is anchored

$A_{s,real}$ Actually existing reinforcement in the section from which the reinforcement is anchored

Table 69.5.1.2.b. Values of β

Type of anchorage	Tension	Compression
Straight elongation	- 1	1
Pin, hook and U hook	0.7 (*)	1
Welded transverse bar	0.7	0.7

(*) If the concrete covering perpendicular to the bending plane is higher than 3ø. Otherwise, ß = 1.

In any case, $l_{b,neta}$ will not be lower than the value indicated in 69.5.1.1.

69.5.1.3 Special rules in the case of bundles of bars

Wherever possible, the bars of a group will be anchored by straight elongation.

When all the bars of the bundle cease to be necessary in the same section, the minimum anchorage length of the bars will be:

1.3 l_b for groups of 2 bars

1.4 l_b for groups of 3 bars

1.6 l_b for groups of 4 bars

the anchorage length corresponding to an isolated bar being l_b.

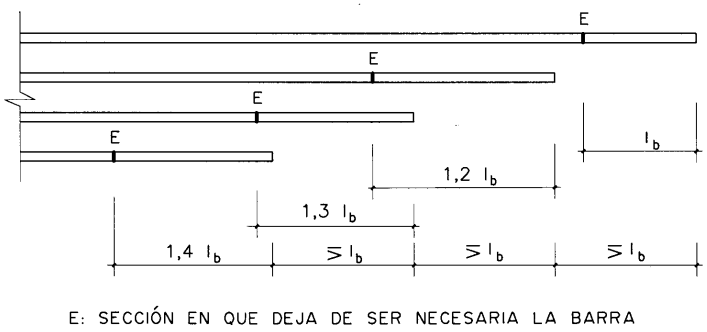
When the bars of the bundle become unnecessary in different sections, the appropriate anchorage length, calculated in accordance with the following criterion, will be given to each bar:

1.2 l_b if accompanied by 1 bar in the section in which it ceases to be necessary;

1.3 l_b if accompanied by 2 bars in the section in which it ceases to be necessary;

1.4 l_b if accompanied by 3 bars in the section in which it ceases to be necessary;

taking account of the fact that in no case may the very ends of the bars be closer than length l_b (figure 69.5.1.3).



Key to figure:
Sección en que deja de ser necesaria la barra: Section in which the bar is no longer necessary

Figure 69.5.1.3

69.5.1.4 Anchorage of electrowelded meshes

The net anchorage length of the electrowelded meshes will be determined in accordance with the following formula:

$$l_{b,neta} = l_b \, \beta \, \frac{\sigma_{sd}}{f_{yd}} \cong l_b \beta \frac{A_s}{A_{s,real}}$$

the value indicated in the formulas given in 69.5.1.2 being l_b.

If there is at least one welded transverse bar in the anchorage area, the net anchorage length will be reduced by 30%.

In any case, the net anchorage length will not be lower than the minimum values indicated in 69.5.1.2.

69.5.2 Splicing of passive reinforcements

69.5.2.1 General

The splices between bars must be designed in such a way that the transmission of forces from one bar to the next is ensured, without spalling or any other type of damage to the concrete close to the joint area taking place.

No splices in addition to those indicated in the plans and those authorised by the Work Management will be available. It will be ensured that the splices are away from the areas in which the reinforcement is operating at its maximum load.

It will be possible to produce either lapped splices or soldered splices. Other types of splices are also accepted provided that the tests carried out on them demonstrate that these splices have a permanent resistance to breaking not less than that of the smaller of the two joined-on bars and that the relative slippage of the joined-on reinforcements does not exceed 0.1 mm for service loads (an unlikely situation).

As a general standard, the splices for the various tension bars of a member will be placed at such distance from each other that their centres are separated, in the direction of the reinforcements, by a length equal to, or greater than, l_b (figure 69.5.2.1).

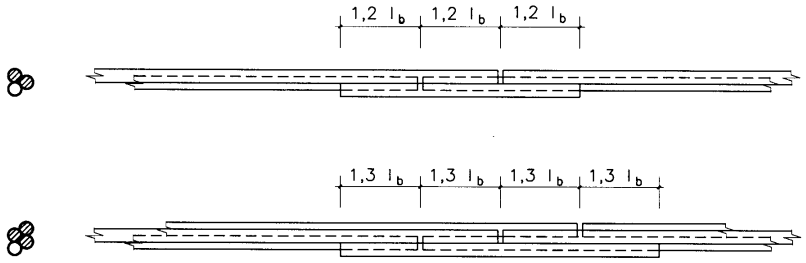


Figure 69.5.2.1

69.5.2.2 Lap splices

Splices of this type are made by positioning the bars one beside the other, leaving a gap of no more than 4ø between them. In the case of tension reinforcements, this separation will not be less than that laid down in 69.4.1.

The overlap length will be equal to:

$$l_s = \alpha\, l_{b,neta}$$

being $l_{b,neta}$, the value of the net anchorage length defined in 69.5.1.2 and α the coefficient defined in table 69.5.2.2, a function of the percentage of overlapped reinforcement in a section in relation to the total steel section of this same section, the transverse distance between splices (as per the definition in figure 69.5.2.2) and the type of force on the bar.

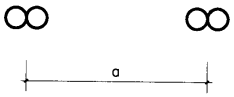


Figure 69.5.2.2

Table 69.5.2.2. Values of α

Distance between the nearest splices (figure 69.5.2.2.a)	Percentage of overlapped tension bars in relation to the total steel section					Overlapped bars operating on a normal, compresssed basis in any percentage
	20	25	33	50	>50	
a ≤ 10 ø	1.2	1.4	1.6	1.8	2.0	1.0
a > 10 ø	1.0	1.1	1.2	1.3	1.4	1.0

69.5.2.3 Lap splices for bundles of bars

In the case of the lapped splice of a bundle of bars, an additional bar will be added throughout the zone concerned for the splices of a diameter equal to the largest of those forming the group. Each bar will be abutted against the bar to be joined on. The separation between the various splices and the elongation of the additional bar will be 1.2 l_b or 1.3 l_b according to whether the bundles concerned are of two or three bars (figure 69.5.2.3).

Lapped splices are prohibited in the four-bar groups.

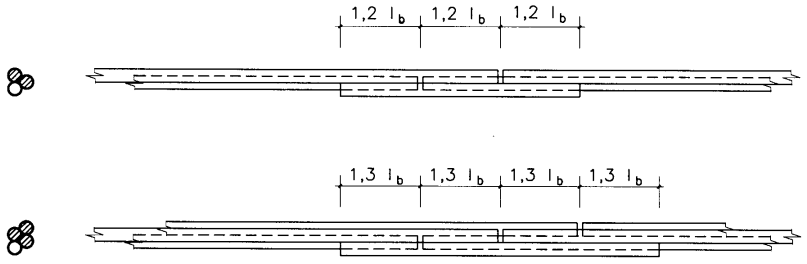


Figure 69.5.2.3

69.5.2.4 Lap splices for electrowelded meshes

Two overlap positions are considered, according to the way in which the meshes are arranged: coupled (figure 69.5.2.4.a) and overlapping or in layers (figures 69.5.2.4.b and 69.5.2.4.c).

A) Coupled lap meshes:

The overlap length will be *a* $l_{b,neat}$, the value quoted in 69.5.1.4 being $l_{b,neta}$ and the coefficient indicated in table 69.5.2.2 being α.

In the case of predominantly static loads, 100% overlap of the reinforcement in the same section is permitted. In the case of dynamic loads, 100% overlapping is only permitted if the entire reinforcement is in layer form; otherwise, 50% is permitted. In the latter case, the distance between the overlaps will be length $l_{b,neta.}$.

B) Overlapping lap meshes:

The length of the overlap will be 1.7 l_b when the separation between overlapped elements is greater than 10ø, increasing to 2.4 l_b when said separation is lower than 10ø.

In any case, the minimum overlap length will not be lower than the greater of the following values:

a) 15ø
b) 200 mm

Matters will be so arranged that the overlaps will be situated in areas in which the stresses on the reinforcement do not exceed 80% of the maximum possible stresses. The proportion of elements that may be overlapped will be 100% if just one mesh layer is arranged and 60% if various layers are arranged. In this case, the minimum distance between overlaps shall be 1.5l_b. With double bars of ø>8.5 mm, it is only permitted to overlap, as a maximum, 60% of the reinforcement.

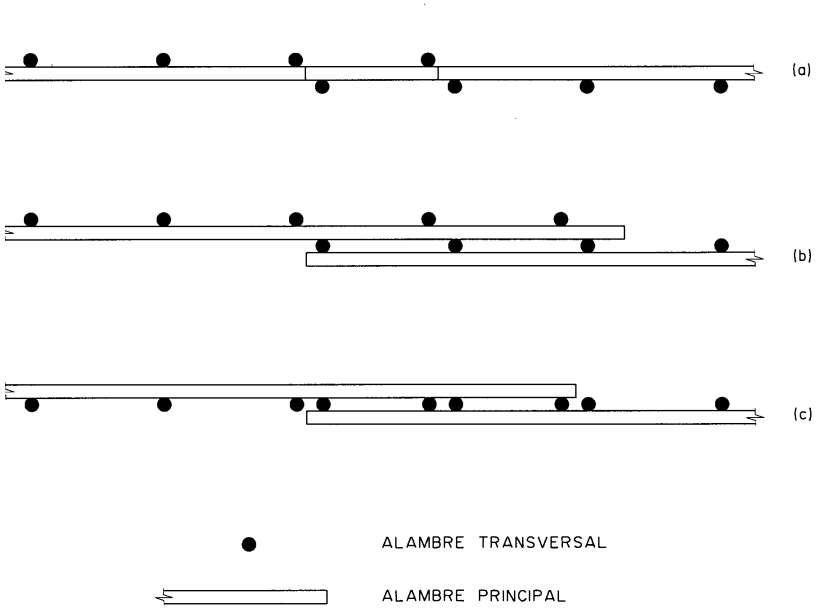


Figure 69.5.2.4

[**Key to figure:** alambre transversal – transverse wire; alambre principal – main wire]

69.5.2.5 Splices for resistant welding

Splices for resistant welding shall be produced in accordance with the welding procedures described in UNE 36832, and implemented by duly qualified workers.

The surfaces to be welded shall be dry and free from any material that might affect the quality of the welding, and all the criteria indicated in connection with the non-resistant welding in point 69.4.3.2 will also apply.

The welding of galvanised reinforcements or of reinforcements with epoxy coatings will be explicitly prohibited.

It will not be possible for welded splices to be arranged on deeply curved sections of the routing of the reinforcements.

It will be possible for bars of various diameters to be flush-welded as long as the difference between diameters is less than 3 millimetres.

It will not be possible for welding to take place in periods of high wind or when it is raining or snowing, unless due precautions are taken, such as the installation of protective screens or covers and unless the welding is adequately protected so as to prevent rapid cooling. Under no circumstances will welding take place on a surface that is at a temperature equal to, or lower than, 0°C immediately prior to the welding.

69.5.2.6 Mechanical splices

Splices produced by mechanical means must be so in accordance with the specifications of the design and the procedures indicated by the manufacturers.

The purpose of the requirements made of these types of splices is to guarantee that the behaviour of the joint area, both during and after it is in service, is similar to that which each one of the joined-up bars would produce in isolation.

In this respect, it is required that the splicing devices:

- have, as a minimum, the same resistant capacity as the smallest of the bars that are joined on;

- do not present a relative displacement greater than 0.1 mm under operating stress;
- join bars of the same diameter or, failing that, of consecutive diameters in the series of diameters, provided that the difference between the diameters of the jointed bars is less than, or equal to, 5 mm.
- are so employed that, after applying tension to the bars corresponding to 60% of the guaranteed unit failure load of the smallest bar, the residual elongation of the splicing device shall be less than, or equal to, 0.1 mm.

With joints of this type, there is no requirement to add a supplementary transverse reinforcement or to increase the covers (even if, for this purpose, the diameter of the joint or pipe joint is taken as the diameter of the reinforcement), since the concrete is not subject to additional requirements. It is therefore permitted to concentrate all these joints in one and the same section, as long as this does not affect the siting of the concrete.

69.6 Supply of assembled reinforcements and reinforced structural ironwork

The assembled reinforcements and, if appropriate, the reinforced structural ironwork must be supplied free from paint, grease or any other harmful substance that might have a harmful effect on the steel or concrete or on the bonding between the two.

They will be supplied to the site accompanied by the corresponding labels that render the steel unequivocally traceable and enable its characteristics to be identified, together with the component for which they are intended, and this in accordance with the dismantling to which point 69.3.1 refers.

Furthermore, they shall have to be accompanied by the documentation to which Article 88 of this Code refers.

69.7 Transport and storage

Both during its transport and during its storage, the constructed reinforcements, the reinforced structural ironwork or, if appropriate, the bars or coils of corrugated steel shall be protected adequately against the rain, dampness of the ground and possible agresivity of the surrounding atmosphere. Until such time as they are constructed, reinforced or assembled, they will remain duly classified so as to guarantee their necessary traceability.

69.8 Assembly of reinforcements

69.8.1 General

The reinforced structural ironwork will be assembled on site free from paint, grease or any other harmful substance that might have an effect on the steel or concrete or on the bonding between the two.

If the steel for the reinforcements has an excessive level of oxidation that might affect its bonding conditions, it will be verified that these have not been significantly altered. With this in view, brushing will take place involving a wire-pronged brush, and it will be verified that the reinforcement's loss of weight does not exceed 1% and that the bonding conditions are within the limits laid down in 32.2.

The reinforcements will, within the formwork or moulds, be secured against any type of displacement, their position being checked before the concreting is carried out.

The post hoops or girder stirrups will be fastened to the main bars through simple tying or another suitable procedure, with fastening by means of welding spots being explicitly prohibited when the structural ironwork is already situated within the moulds or formwork.

69.8.2 Arrangement of spacers

The specified position for the passive reinforcements and, especially, the nominal covers indicated in 37.2.4 shall be guaranteed through the arrangement of the corresponding elements (spacers or wedges) positioned on the site. These elements will comply with what is laid down in 37.2.5, their having to be arranged in accordance with the requirements set out in table 69.8.2.

Table 69.8.2 Arrangement of spacers

Component		Maximum distance
Horizontal surface elements (slabs, floor slabs, footings and foundation slabs, etc.)	Lower grid	50 ø ≤ 100 cm
	Higher grid	50 ø ≤ 50 cm
Walls	Each grid	50 ø or 50 cm
	Separation between grids	100 cm
Girders [1)]		100 cm
Supports [1)]		100 ø ≤ 200 cm

[1)] As a minimum, three planes of spacers per bay will be arranged in the case of the girders, and per length, in the case of the supports, coupled to the hoops or stirrups.

ø Diameter of the reinforcement to which the separator is coupled.

Article 70. Placing and tensioning of active reinforcement

70.1 Prestressing application systems

70.1.1 General

There are three distinct types of active reinforcement, according to the way in which they are positioned in the members:

a) bonding reinforcements;
b) bonding reinforcements in sheaths or ducts with bonding grout;
c) non-bonding reinforcements in sheaths or ducts with non-bonding grout.

For the purposes of this Code, application of the prestressing is understood to mean the combined processes carried out during construction with a view to place and tensioning the active reinforcements, independently of whether the reinforcements concerned are pre-tensioned or post-tensioned. All the elements of the system shall comply with what is laid down in their regard in Chapter 6 of this Code.

It will not be possible for prestressed steel with different characteristics to be used in one and the same tendon unless it is proved that there is no risk at all of electrolytic corrosion in such steel.

When they are put in place, the active reinforcements shall be very clean and without traces of rust, grease, oil, paint, powder, earth or any other material prejudicial to their proper conservation or bonding. They will not present any indications of corrosion, visible surface defects, welding spots, dents or other indentations.

Straightening of the active reinforcements on the site is forbiden.

70.1.2 Prestressing application equipment

If post-tensioned active reinforcements are applied, equipment and systems for their application shall bear the CE mark, within the compass of Directive 89/106/EEC, in accordance with what is laid down in the corresponding European Technical Approval (ETA) document, which satisfies the requirements of the ETAG 013 Guide.

In the case of prestressed reinforcements anchored by bonding, the tensioning shall be carried out on specific benches and by means of duly tested and calibrated devices.

70.2 Processes prior to the tensioning of active reinforcements

70.2.1 Supply and storage of prestressing elements

70.2.1.1 Prestressing units

The wires will be supplied in coils whose interior diameter will not be less than 225 times that of the wire and, being left free on a flat surface, will present a deflection of not more than 25 mm on a base of 1 m, at any point of the wire.

The coils supplied will not contain welds produced following the thermal treatment prior to the drawing out.

The bars will be supplied in straight pieces.

The cords of 2 or 3 wires will be supplied in coils whose interior diameter will be equal to, or larger than, 600 mm.

The cords of 7 wires will be supplied in coils, bobbins or reels which, unless otherwise agreed, will contain a single length of manufactured cord; and the interior diameter of the roll or of the core of the bobbin or reel will not be less than 750 mm.

The cords will have a deflection no greater than 20 mm on a 1 m base at any point of the cord, being left free on a flat surface.

The active reinforcements will be supplied protected from grease, dampness, deterioration, contamination etc, its being ensured that the body of the method of transport is clean and that the material is covered with canvas.

The prestressing units, together with the systems for applying them, shall be supplied to the site accompanied by the documentation to which point 90.4.1 refers.

To eliminate the risks of oxidation or corrosion, the prestressing units will be stored in ventilated premises and sheltered from the dampness of the earth and walls. The relevant precautions will be adopted in the store to prevent the material from getting dirty or any deterioration of the steel from taking place due to attack by chemicals or welding operations carried out nearby etc.

Before storing the active reinforcements, it will be checked that they are clean and without spots of grease, oil, paint, powder, earth or any other material harmful to their proper conservation and subsequent bonding. Furthermore, they must be stored carefully classified according to their types and classes and the batches they come from.

The condition of the surface of all the steel items may at any time be subject to examination before they are used, especially following prolonged storage on site or in a factory, and this with a view to ensuring that they do not show harmful alterations.

70.2.1.2 Anchorage and splicing devices

The anchorage and splicing devices will be positioned in the sections indicated in the design and shall be in accordance with what is indicated specifically for each system in the documentation accompanying the system's European Technical Approval (ETA) document.

The anchorages and splicing elements must be submitted properly protected so that they do not suffer damage during transport, handling on site and storage.

The manufacturer or supplier of the anchorages will confirm and guarantee their characteristics by means of a certificate sent by a specialist laboratory independent of the manufacturer, specifying the conditions in which they must be used. In the case of wedge

anchorages, the magnitude of the joint movement of the reinforcement and the wedge, through adjustment and penetration, shall, in particular, be shown.

They shall be accompanied by the corresponding documentation, enabling the original material and the treatments undergone by it to be identified.

They shall be kept properly classified according to size, and the necessary precautions will be taken to prevent them from corroding, becoming dirty or coming into contact with grease, non-soluble oil, paint or any other damaging substance.

Each consignment of anchorage and splicing devices supplied to the site shall be accompanied by the documentation for the CE marking in connection with the relevant prestressing system.

70.2.1.3 Sheaths and prestressing accessories

The characteristics of sheaths and prestressing accessories must be in accordance with what is specifically indicated for each system in the documentation accompanying the system's DITE (Document of Technical Suitability)

The sheaths and their accessories will be supplied and stored through the adoption of precautions similar to those indicated for the reinforcements. The acceptable level of corrosion must be such that the friction coefficients are not altered. Adequate means of provisional protection against corrosion will therefore be adopted.

70.2.1.4 Grouting materials

The product must be delivered bagged or in containers, with the identification and instructions for its use (type of product, security of handling etc) prepared by its manufacturer.

Compatibility and suitability need to be checked when various different products are used in the same grout.

The dosage used in the grouting grout shall be sanctioned by a number of assessment tests carried out in accordance with the following criteria:

- they will be carried out in respect of products, with the methods of manufacture and the thermal conditions being identical to those used to produce compounds for the construction work, and
- they will be carried out without any change to the way in which the cement is manufactured, and in respect of types and routings of tendon that are representative of those used in the construction work.

In the case of cables with significant dislevelment (vertical cables, for example), it is recommended that, in order to characterise on a real-size basis the exudation and filtration due to the spiral form of the strands and in order to validate the grouting procedure, the grouting test be carried out on a sample tendon in a transparent plastic tube in accordance with what is stated in paragraph C.4.3.3.2.1 of document ETAG 013.

In the case of construction work of modest size, use of a dosage of grout based on tests and previous references may be justified as long as the materials are not modified and that the conditions of use are comparable.

When a non-bonding product is used for the grouting, the correct means of transport, and injection, of the product shall be adopted in order to guarantee the safety of the operations and in order to ensure correct filling in the liquid phase without altering the physical and chemical properties of the product.

70.2.2 Placing of active reinforcements

70.2.2.1 Placing of sheaths and tendons

The actual path of the tendons will be adjusted in accordance with what is stated in the design, with the support points necessary for maintaining the reinforcements and sheaths

placed in their correct positions. The distances between these points will be such as to ensure compliance with the routing regularity tolerances indicated in Article 96.

The supports available for maintaining this routing shall be of such a kind that they do not give rise to fissures or leaks once the concrete has hardened.

Moreover, proper control will be exercised over the active reinforcements or their sheaths to prevent them from moving during the concreting and vibration, its being expressly prohibited to use the welding for this purpose.

The bending and positioning of the sheath and its fixing to the passive reinforcement must guarantee smooth routing of the tendon and, in order to prevent ripple, must follow the theoretical axis of the latter so as not to increase the coefficient of parasitic friction or cause unforeseen pressure on the vacuum.

The position of the tendons within its sheaths or ducts shall be appropriate, with recourse had, if need be, to the use of spacers.

When prestressed reinforcements are used, a small amount of prior stress needs to be applied to them and it needs to be verified that the spacers, end plates and wires are properly aligned and that the latter have become neither entangled nor snagged.

Before authorising the concreting and once the reinforcements have been put in place and, if need be, tensioned, it will be verified whether the position of the reinforcements, like that of the sheaths, anchorages and other elements, is in accordance with what is stated in the plans and whether the fastenings are adequate to guarantee their invariability during the concreting and vibration. If necessary, the appropriate corrections will be made.

The prestressing operator shall, in the case of each type of tendon, check the thicknesses and sheath diameters indicated in the design, together with the minimum radii of curvature, in order to prevent denting, guarantee that the frictional coefficients considered in the calculation are not exceeded and prevent ripping and crushing during tensioning, especially in the case of plastic sheaths.

70.2.2.2 Positioning of deflectors

The deflectors used in the exterior pre-tensioning systems have to satisfy the following requirements:

- support the longitudinal and transverse forces transmitted to them by the tendon and, in turn, transmit these forces to the structure, and
- ensure continuity between two straight sections of the tendon, without there being unacceptable angular discontinuities.

The deflectors will be positioned in such a way that the supplier’s instructions are followed strictly.

70.2.2.3 Distance between pre-tensioned active reinforcements

The separation between the pre-tensioned ducts or tendons will be such as to enable the proper positioning and compaction of the concrete and will guarantee correct bonding between the tendons or sheaths and the concrete.

The pre-tensioned reinforcements shall be positioned separately. The minimum free separation of the individual tendons, both horizontally and vertically, will be equal to, or greater than, the largest of the following values (figure 70.2.2.3):

a) 20 millimetres for the horizontal separation in all cases, except in the cases of pre-tensioned joists and hollow-core slabs where 15 millimetres will be taken, and 10 millimetres for the vertical separation;
b) the diameter of the larger;
c) 1.25 times the maximum size of the aggregate for the horizontal separation and 0.8 times for the vertical separation (see 28.3).

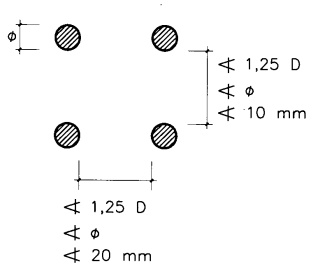


Figure 70.2.2.3

Where there are one-way floor slabs, the wires may be grouped in a vertical position as long as they are of the same quality and diameter, in which case the real perimeter of the reinforcements will be considered for the purpose of determining the extent of the covers and the clearances in respect of the neighbouring reinforcements.

70.2.2.4 Distance between post-tensioned active reinforcements

As a general standard, it is acceptable to position a variety of sheaths that form a group in contact with each other, the number concerned being limited to two horizontally and to no more than four in all. In this connection, the sheaths must be corrugated and, at each side of the sheaths as a whole, enough space must be left for a normal internal vibrator to be introduced.

The clearances between sheaths or groups of sheaths in contact with each other, or between these sheaths and the other reinforcements, must be at least equal to the greatest of the following values:

in the vertical direction:

a) the diameter of the sheath;
b) the vertical dimension of the sheaths or group of sheaths;
c) 5 centimetres;

in the horizontal direction:

a) the diameter of the sheath
b) the horizontal dimension of the sheath
c) 4 centimetres;
d) 1.6 times the largest of the dimensions of the individual sheaths that form a group of sheaths.

70.2.3 **Bonding of active reinforcements to concrete**

The length of transmission of a given reinforcement is defined, as is what is necessary for transferring to the concrete for bonding the prestressing force introduced into said reinforcement and, where the anchorage length is concerned, what is necessary for guaranteeing the resistance of the anchorage by bonding, until the steel breaks.

The lengths of transmission and anchorage depend on the bond stress between the steel and the concrete, such stress being in general determined on an experimental basis.

70.2.4 **Splices for active reinforcements**

The splices will be made in the sections indicated in the design and will be arranged in special sockets with enough length to enable them to move freely during the tensioning.

When the design assumes the use of pre-tensioning couplers, these will be situated away from the intermediate supports, its being avoided positioning them in more than half the tendons in the same cross-section.

70.3 Tensioning processes for active reinforcements

70.3.1 General

The tensioning shall be carried out in accordance with a previously established plan in which the recommendations of the manufacturer of the system used shall be taken into account. In particular, care will be taken to ensure that the jack rests perpendicularly and centrally on the anchorage. The tensioning will be carried out by qualified operators who have the necessary skills and experience. This operation will be carefully supervised and inspected, with the necessary safety measures being adopted to prevent any personal injury.

The tensioning, carried out at one or both ends of the element, in accordance with the established programme, will be such that the stresses increase slowly and progressively until they achieve the value stablished in the design.

If in the course of the tensioning one or more of the elements constituting the reinforcement should break, it will be possible to reach the necessary total tensioning force, increasing the stress on the remaining elements provided that to do this it is not necessary to increase the stress in each individual element more than 5% of the value initially plannedvalue. The application of greater stresses requires further study of the original design – study that will have to be carried out on the basis of the mechanical characteristics of the materials actually used. In all these cases, it will be necessary to carry out the relevant check on the piece or structural element that is being tensioned, taking account of the new conditions to which it is subject.

The total loss of prestressing force caused by the breakage of irreplaceable elements of the reinforcement should never exceed 2% of the total prestressing force indicated in the design.

70.3.2 Tensioning programme

The following must be explicitly stated in the tensioning programme:

A) Pre-tensioned reinforcements

- the tensioning order of the reinforcements and, if need be, the successive partial prestressing stages;
- the pressure or force that must not be exceeded in the jacks;
- the value of the tensioned load in the anchorages;
- the elongation that must be obtained, taking into account, if need be, the movement caused by wedge penetration;
- the method and sequence that shall be followed in order to release the tendons;
- the resistance required of the concrete at the time of the transfer of prestressing..

B) Post-tensioned reinforcements

- the tensioning order for the reinforcements;
- the pressure or force that must be exercised in the jack;
- the elongation provided for and the maximum wedge penetration;
- the time for removal the falsework during the tensioning, if appropriate;
- the concrete strength required befor e tensioning;
- the number, type and location of the couplers;
- the modulus of elasticity assumed for the active reinforcement;
- the theoretical coefficients of friction taken into account.

The tensioning will not begin without the prior authorisation of the Work Management, which will verify the suitability of the proposed tensioning programme, as well as the concrete strength,

such resistance having to be equal to, or higher than the stablished in the design to begin this operation.

70.3.3 Maximum initial stress permissible in reinforcements

In addition to other limitations that may be laid down in point 20.2.1, for the purpose of reducing various risks during construction (breakage of active reinforcements, low-stress corrosion, personal injury etc), the maximum value of the initial stress introduced into reinforcements σ_{p0} prior to anchorage them shall produce stresses that comply with the following conditions:

- 85% of the guaranteed characteristic maximum unitary load provided that, in anchorage the reinforcements in the concrete, a reduction in stress is caused, so that, following this reduction, the maximum value of the stress in reinforcements σ_{p0} does not exceed 75% of the guaranteed characteristic maximum unitary load, in the event of both the steel for active reinforcements and the prestressing operator possessing an officially recognised quality mark, and
- in the remaining cases, 80% of the guaranteed characteristic maximum unitary load provided that, in anchorage the reinforcements in the concrete, a reduction in stress is caused, so that, following this reduction, the maximum value of the stress in reinforcements σ_{p0} does not exceed 70% of the guaranteed characteristic maximum unitary load.

70.3.4 Re-tensioning of post-tensioned reinforcements

Re-tensioning is understood as any tensioning operation carried out on a tendon subsequent to the initial tensioning on it.

It is only justified when it is considered necessary for standardising the stresses on the various tendons in the same element or when, in accordance with the programme laid down in the design, the tensioning takes place in successive stages.

Re-tensioning with the only objective of reducing the deferred stress losses, must be avoided, unless required by special circumstances.

70.4 Processes subsequent to the tensioning of the active reinforcements

70.4.1 Grouting of sheaths in post-tensioned reinforcements

70.4.1.1 General

The main objectives of injecting the tendons are to prevent corrosion of the prestressed steel and to bring an effective bonding between the concrete and the steel.

In order to achieve this, it is a basic condition that all the cavities of the sheaths or ducts and anchorages be filled by an appropriate grouting material (Article 35) that fulfils the necessary requirements in terms of resistance and bonding.

The grouting must be carried out as soon as possible after the tensioning. If, for constructive reasons, it has to be deferred, the reinforcements will be protected on a provisional basis, using a method or material that does not hinder the tendons' subsequent bonding to the grouting product.

In order, moreover, to ensure that the tendons are injected correctly and safely, it is necessary:

- to have qualified and appropriately trained staff;
- to have sound and safe equipment, properly checked, calibrated and ready to be used;
- to have written instructions and a previous organisation of the materials to be used and the grouting procedure to be followed;
- to adopt the safety precautions appropriate to each case.

70.4.1.2 Preparation of the mixture

The solid materials used to prepare the grouting product shall be proportioned by weight.

The materials in question will be combined in a mixer capable of preparing a grouting product of uniform consistency and, if possible, of colloidal character. Mixing by hand is forbidden..

The period of the mixing depends on the type of mixer, and the mixing must be done in accordance with the manufacturer's instructions. At any event, it will not be less than 2 minutes or more than 4 minutes.

Following the mixing, the product must be kept in continuous movement until the time of grouting. It is crucial that the product be free from lumps at that time.

In the case of vertical sheaths or ducts, the water/cement ratio in the mixture must be somewhat higher than in mixtures intended for grouting in horizontal sheaths.

70.4.1.3 Grouting programme

The grouting programme must include, as a minimum, the following:

- the characteristics of the grout to be used, including the period of use and the period of hardening;
- the characteristics of the grouting equipment, including pressures and speed of grouting;
- cleaning of the ducts;
- sequence of the grouting operations and tests to be carried out on the fresh grout (fluidity, segregation, etc.).
- preparation of samples for tests (exudation, shrinkage, resistance etc).
- volume of grout that has to be prepared.
- instructions concerning actions to be taken in the case of incidents (for example, failure during grouting), or harmful climatic conditions (for example, during and after periods with temperatures lower than 5°C).

70.4.1.4 Implementation of the grouting

Before carrying out the grouting, it has to be shown that the following prior conditions have been met:

a) the grouting equipment is in operation, and an auxiliary grouting pump is available to prevent interruptions in the event of malfunctioning.
b) there is a permanent supply of water under pressure and of compressed air.
c) there are more than enough materials for mixing the grouting product;
d) the sheaths are free from harmful materials, for example water or ice;
e) the openings of the ducts to be injected are fully prepared and identified;
f) the tests for supervising the grout have been prepared;

In the event of the prestressing application equipment being in possession of an officially recognised quality mark, the Project Management will be able to dispense with the condition referred to in point a).

The grouting must be continuous and uninterrupted and with an advance velocity of between 5 and 15 metres per minute. The maximum length of grouting and the length of the nozzles will be defined by the relevant Document for European Idoneity for the prestressing system.

As general rule, for standard grouting a speed of 5 to 15 metres per minute; maximum lengths of 120 m will be injected, and bleed valves will be placed at the high points with a maximum separation of 50 m. In the case of special grouting, other parameters that will have to be justified through tests may be used.

It is prohibited to carry out the grouting using compressed air.

If possible, the grouting must be carried out from the lowest anchorage or from the lower pipe of the duct.

The grouting must be continued until the consistency of the mixture running out of the open end of the duct is equal to that of the injected product and, once the process has been concluded, the necessary measures must be taken to prevent losses of the mixture in the duct.

In the case of vertical sheaths or ducts, a small deposit must be placed in the upper part, which must be kept constantly full of paste in order to offset the reduction in volume that is produced. It is important that this deposit be situated in a centralised position above the duct in order to enabling the water ascending by exudation to mix with the mixture contained in the deposit and not to remain at the upper end of the sheaths – what would be dangerous in terms of protecting the tendon and the corresponding anchorage.

In cold weather and, especially, in freezing conditions, special precautions must be taken to ensure that, when the grouting commences, there is no ice in the ducts. With this in view, warm water – but never steam – must be injected.

If the temperature is not expected to fall below 5°C in the 48 hours following the grouting, the procces may continue, with the use of a product that is less sensitive to frost, that contains from 6% to 10% of occluded air and that fulfils the conditions laid down in Article 35; alternatively, the structural element can be heated in such a way that its temperature does not fall by 5°C during this period.

When the surrounding temperature exceeds 35°C, it is advisable to cool the water in the mixture.

Once the grouting has been concluded, the openings and bleed pipes must, in all cases, be hermetically sealed in such a way as to prevent water or any other agent likely to corrode the reinforcements from entering the ducts. Likewise, the equipment must be cleaned as quickly as possible after the grouting has been concluded, with the pump, mixer and pipes continuing to be dried carefully.

If there is the possibility of there being large non-injected areas, appropriate steps must be taken to have these areas injected subsequently. In case of doubt, a check using an endoscope may be carried out, or a vacuum created.

70.4.1.5 Safety measures during the grouting

During the grouting of the ducts, the operators who work nearby must be provided with protective glasses or transparent visors, half masks for the mouth and nostrils and gloves - all this in anticipation of possible escapes of the pressure-injected mixture.

The tubes used as breather pipes or weirs must not be looked through in order to check the progress of the grouting product.

When the grouting takes place on site, and there are people moving about in nearby areas, the appropriate precautions will be taken to prevent damage possibly being caused if the grouting product escapes.

70.4.2 De-tensioning of pre-tensioned reinforcements

De-tensioning is the operation through which, in the case of pre-tensioned reinforcements, the prestressing force is transmitted from the reinforcements to the concrete, and it takes place by releasing said reinforcements from their provisional end anchorages.

Before carrying out the de-tensioning, it must be checked that the concrete has achieved the strength necessary to support the stresses transmitted by the reinforcements, and all the obstacles capable of hampering the free movement of the concrete members shall be eliminated.

If the de-tensioning is carried out element by element, the operation must be conducted in a pre-established order with a view to preventing asymmetries that might prove harmful to the prestressing force.

Appropriate arrangements shall be made, enabling the de-tensioning to take place slowly, gradually and uniformly, with no sudden jolts.

Once the reinforcements have been freed from their end fastenings and once, too, the constraints that may exist between the successive members of each prestressing bed have been released, the end parts of the reinforcements that project from the heads of such members will be cut if these would otherwise be exposed, rather than embedded in the concrete.

Article 71. Manufacture and placing of concrete

71.1 General requirements

The structural concrete needs to be manufactured in plants with installations for:

- storing the component materials
- batching these, and
- mixing.

The concrete not manufactured in plants may only be used for non-structural purposes, in accordance with what is stated in Annex 18.

The component materials will be stored and transported in such a way that any type of intermixing, contamination, deterioration or other significant alteration to their characteristics will be prevented. Account will be taken of what is laid down in Articles 26°, 27°, 28°, 29° and 30° for such cases.

The batching of cement – of the aggregates and, if appropriate, of the additions – will be done by weight. The batching for each material shall be adjusted to what is specified in order to bring about appropriate uniformity between mixes.

The component materials will be mixed in such a way that an integrated and homogeneous mix is obtained, and, as a result, the aggregate should be properly coated with cement paste. The homogeneity of the concrete shall be verified in accordance with the procedure laid down in 71.2.4.

71.2 Installations for the manufacture of concrete

71.2.1 General

A concrete manufacturing plant will be understood to mean the combination of installations and equipment that, in compliance with the specifications contained in the following sections, extends to cover:

- storage of component materials
- batching installations
- mixing equipment
- transport equipment, if appropriate
- production control.

In each plant there will be an appropriately trained and experienced person responsible for manufacture who will be present during the production process and who will be separate from the person responsible for production control.

The plants may or may not belong to the work site own installations.

To distinguish one case from the other, prepared concrete is designated in this Code as that which is manufactured in a plant not belonging to the site's installations and that is registered in the Industrial Register in accordance with Title 4 of the Industry Act No 21 of 16 July 1992 and with Royal Decree No 697/1995 of 28 April, this registration being available to the applicant and to the competent administrations.

71.2.2 Stock management systems

The cement, aggregates and, if appropriate, the additions will comply with what is laid down in, respectively, Articles 26, 28 and 30, their having to be stored in a way that prevents their segregation or contamination.

In particular, the aggregates will be stored on an anti-pollutant base that prevents their contact with the ground. Stacks of separate granulometric fractions will be prevented from becoming mixed up by means of separating partitions or wide spaces between the fractions.

If installations exist for storing water or admixtures, they will be such as to prevent any contamination.

Powdery admixtures will be stored in the same conditions as the cement.

Liquid admixtures and powdery materials diluted in water must be stored in tanks protected from frost and possessing agitators for stopping the solids from sinking to the bottom.

71.2.3 Batching installations

The batching installations will have silos with suitable and separate compartments for each one of the necessary granulometric aggregate fractions. Each compartment of the silos will be designed and assembled in such a way that it can be unloaded efficiently, without jamming and with minimum segregation, on the hopper of the weighing machine.

The necessary means of controlshall exist to ensure that the supply of the materials to the hopper of the weighing machine can be cut off exactly when the desired quantity has been accumulated.

Weighing machine hoppers shall be constructed in such a way that they can be completely unloaded of all the material that has been weighed.

The indicator instruments shall be completely visible and sufficiently close to the operator to be read precisely while the hopper of the weighing machine is being loaded. The operator shall have easy access to all the controlinstruments.

Under static loads, the weighing machines shall have to be able to assess 0.5% of the total capacity of the scale of the weighing machine. In order to verify this, it shall have an adequate combination of standard calibration weights.

All the bearings, hinges and similar parts of the weighing machines shall have to be kept perfectly clean.

The water measurer shall be precise enough for the batching tolerance laid down in 71.3.2.4 not to be exceeded.

The equipment for measuring out admistures will be designed and marked in such a way that the quantity of additive corresponding to 50 kilograms of cement can be measured clearly. In case of installations with electronic weighting devices, in will be enough to have a computerized data base where, with a specific application, the data corresponding to the admisxtures dosing in different batches were authomaticly recorded.

71.2.4 **Mixing equipment**

Equipment may consist of fixed or mobile mixers capable of mixing the concrete components in such a way that a homogeneous and completely integrated mixture is obtained that is capable of satisfying the two requirements of Group A and at least two of the requirements of Group B, in table 71.2.4.

This equipment will be inspected with the frequency necessary for detecting the presence of concrete residue or hardened mortar, as well as imperfections in, or deterioration of, the blades or the interior surface. If need be, compliance with the aforesaid requirements will also be checked.

The mixers, both fixed and mobile, shall bear, in a prominent position, a metal plate specifying:

- in the case of the fixed mixers, the mixing speed and the maximum capacity of the drum, in terms of the volume of mixed concrete;
- in the case of the mobile mixers, the total volume of the drum, its maximum capacity in terms of volume of mixed concrete and the maximum and minimum rotation speeds;

Table 71.2.4

Verification of the homogeneity of the concrete. Satisfactory results will have to be obtained in the two tests in Group A and in at least two of the four tests in Group B

TESTS		Tolerated maximum difference between the results of the tests of two samples taken from the unloaded concrete (1/4 and 3/4 of the unloaded concrete)
GROUP A	1. Consistency (UNE-EN 12350-2)	
	If the average base is equal to, or smaller than, 9 cm	3 cm
	If the average base is greater than 9 cm	4 cm
	2. Strength (*)	
	In percentages in respect of the average	7.5 %
GROUP B:	3. Density of the concrete (UNE-EN 12350-6)	
	In kg/m^3	16 kg/m^3
	4. Air content (UNE-EN 12350-7)	
	As a percentage in respect of the volume of concrete	1 %
	5. Content of coarse aggregate (UNE 7295)	
	As a percentage in respect of the weight of the sample taken	6 %
	6. Granulometric modulus of the aggregate (UNE 7295)	0,5

(*) For each sample, two test cylinders 15 cm in diameter and 30 cm in height will be produced and tested under compression at the age of seven days. These test cylinders will be produced, preserved and tested according to the procedures referred to in Section 86.3. The measurement of each of the two samples will be determined as a percentage of the total average.

71.2.5 Production control

The prepared concrete plants must have a production controlsystem that takes account of all the processes being implemented in the plant, and this in accordance with what is provided for in the current regulations applicable.

In the event of the concrete being manufactured at a plant on the site, the Constructor shall carry out a self-inspection, equivalent to that defined above, on the prepared concrete plants.

71.3 Manufacture of concrete

71.3.1 Supply and storage of component materials

Each of the component materials used in manufacturing the concrete shall be supplied to the concrete plant accompanied by the supply documentation noted for that purpose in Annex no. 21.

71.3.1.1 Aggregates

The aggregates shall be stored in such a way that they remain protected from possible contamination by the environment and, especially, by the ground. The separate granulometric fractions must not be mixed in an uncontrolled way.

The necessary precautions shall also be adopted in order to eliminate segregation as far as possible, during both storage and transportation.

71.3.1.2 Cement

The cement will be supplied to, and stored in, the concrete plant in accordance with what is laid down in the specific regulations in force.

71.3.1.3 Additions

In the case of fly ash and silica fume supplied in bulk, equipment similar to that used for the cement shall be used, its having to be stored in waterproof receptacles and silos that protect them from dampness and contamination and its being fully identified in order to prevent possible dosing errors.

71.3.1.4 Admixtures

Powdery additives will be stored in the same conditions as the cement. When the admixtures are in liquid form or come from powdery materials, dissolved in water, the deposits shall, for storage purposes, be protected from frost. Any contamination will have to be prevented, and it will have to be guaranteed that there are no underlying deposits or material residue and that the uniformity of the entire additive is maintained.

71.3.2 Batching of constituent materials

71.3.2.1 General criteria

The concrete will be dosed in accordance with the methods considered appropriate, with respect always for the following limitations:

a) The minimum quantity of cement per cubic metre of concrete will be that laid down in 37.3.2.
b) The maximum quantity of cement per cubic metre of concrete will be 500 kg. In exceptional cases, subject to experimental justification and the express authorisation of the Works Management, it will be possible to exceed the aforesaid limit.
c) No water/cement ratio greater than the maximum laid down in 37.3.2 shall be used.

Such batching shall take account not only of the mechanical resistance and the consistency that has to be obtained but also of the type of environment to which the concrete is to be subjected, given the possible risks of damage to the concrete or the reinforcements as a result of attack by external agents.

In order to establish the dose (or doses, if various types of concrete are required), the Constructor shall have recourse, in general, to previous laboratory tests with a view to ensuring that the resultant concrete satisfies the conditions required by Articles 31 and 37, as well as what is specified in the specofic project technical specifications.

In the event of the Constructor being able to provide documentary justification that, with the materials, dosage and implementation process provided for, it is possible to obtain concrete that fulfils the requirements mentioned above and, in particular, that is of the required strength, the prior tests referred to may be dispensed with.

71.3.2.2 Cement

The cement will be batched by weight, with weighing machines and scales being used that are separate from those used in connection with the aggregates. The tolerance by weight of cement will be ±3%.

71.3.2.3 Aggregates

The aggregates will be batched by weight, account being taken of the corrections for humidity. For the purpose of measuring their surface humidity, the plant will have elements enabling this data to be obtained systematically, the method used involving the contrasting of data and being preferably automatic.

The aggregate shall be composed of at least two granulometric fractions, for maximum sizes equal to or less than 20 mm, and of three granulometric fractions for larger maximum sizes.

If a supplied total aggregate is used, the manufacturer of the aggregate must provide its particle size distribution and manufacturing tolerances, and this with a view to being able to

define a probable granulometric zone that ensures controlof the aggregates using the working formula.

The tolerance by weight of the aggregates, both in cases where separate weighing machines are used for each fraction of aggregate and where the dosing is on an accumulated basis, will be ±3%.

71.3.2.4 Water

The mixing water consists, basically, of that added directly to the mixture, that proceeding from the humidity of the aggregates and, if appropriate, that supplied by liquid admixtures.

The water added directly to the mixture will be measured by weight or volume, with a tolerance of ±1%.

In the case of mobile mixing installations (concrete mixers), any quantity of washing water kept in the tank so that it might be used in the following mixture shall be measured precisely. If this is impossible in practice, the washing water will have to be removed before the next mixture of concrete is loaded.

The total amount of water will be determined with a margin of ±3% of the pre-established total quantity.

71.3.2.5 Additions

When used, the additions will be proportioned by weight, with weighing machines and scales being used that are separate from those employed in connection with the aggregates. The tolerance, by weight, of additions will be ±3%.

71.3.2.6 Admixtures

Powdery admixtures shall be measured by weight, and admixtures in the form of paste or liquid shall be measured by weight or by volume.

In both cases, the margin will be ±5% of the weight or volume required.

Admixtures may be incorporated either in the plant or on the site. On some occasions, however, it may be appropriate to combine the two situations in order to obtain concrete with special characteristics.

71.3.3 **Mixing of concrete**

The concrete will be mixed using one of the following procedures:

- entirely in a fixed mixing installation;
- beginning in a fixed mixing installation and concluded in a mobile mixing installation, prior to its transportation;
- in a mobile mixing installation, prior to its transportation.

71.3.4 **Designation and characteristics**

Concrete manufactured in a plant may be designated in accordance with its properties or, exceptionally, in accordance with batching.

In both cases, the following shall be specified, as a minimum:

- consistency
- maximum size of the aggregate
- type of environment to which the concrete is to be exposed
- characteristic compressive strength (see 39.1), for concretes designated by its properties
- the cement content, expressed in kilos per cubic metre (kg/m^3), for concrete designated by dosage
- indication of whether the concrete will be used in plain, reinforced or pre-stressed form.

When the concrete is designated in accordance with its properties, the supplier will specify the composition of the concrete mixture, guaranteeing to the applicant the specified

characteristics of maximum aggregate size, consistency and characteristic strength, as well as the limitations derived from the type of specified environment (cement content and water/cement ratio).

Designation by properties will take place in accordance with what is stated in 39.2.

When the concrete is designated in accordance with its batching, the applicant is responsible for the consistency of the specified characteristics, namely maximum size of the aggregate and the consistency and the content of the cement per cubic metre of concrete; meanwhile, the supplier shall have to guarantee these characteristics, as well as state the water/cement ratio he has employed.

When the applicant requests concrete with special characteristics or characteristics in addition to those cited above, the guarantees and the data with which the supplier must provide him will be specified before supply commences.

Before beginning the supply, the applicant will be able to ask the supplier for a satisfactory demonstration that the component materials that are to be employed fulfil the requirements laid down in Articles 26°, 27°, 28°, 29° and 30.

In no case will additions or admixtures not included in Table 29.2 be employed without the knowledge of the applicant or the authorisation of the Project Management.

71.4 Transport and supply of concrete

71.4.1 Transport of concrete

For transporting the concrete, appropriate procedures will be used to ensure that the mortar arrives at the place of delivery in the stipulated conditions and without being subject to any appreciable variation in the characteristics it had by recent mixes.

The time that has elapsed between the addition of mixing water to the cement and to the aggregates and the placing of the concrete must not be more than an hour and a half, unless admixtures designed to delay the setting of the concrete are used. In hot conditions or in conditions that help the concrete to set quickly, the period shall be shorter unless special measures are adopted that, without harming the quality of the concrete, increase the setting time.

When the concrete is mixed entirely in the plant and is transported in mobile mixing installations, the volume of concrete transported shall not exceed 80% of the total volume of the drum. When the concrete is mixed, or completes the mixing process, in a mobile mixing installation, the volume will not exceed two thirds of the total volume of the drum.

The transportation equipment shall be free of concrete residue or hardened mortar, in which connection it will be carefully cleaned before a fresh batch of concrete is loaded. Likewise, the platforms or internal surfaces of the transportation equipment must not be damaged in such a way as possibly to affect the homogeneity of the concrete or to hamper compliance with what is stipulated in 71.2.4.

It will be possible for the concrete to be transported in mobile mixing installations, at agitation speed, or in equipment with or without agitators, as long as such equipment has smooth, rounded surfaces and is capable of maintaining the homogeneity of the concrete during transportation and unloading.

The transporting items will be cleaned in special wash basins that allow the water to be recycled.

71.4.2 Supply of concrete

Each load of concrete manufactured in a plant, whether or not it belongs to the site installations, will be accompanied by a supply sheet, the minimum content of which is stated in Annex 21.

The start of the unloading of the concrete from the supplier’s transportation equipment at the place of delivery marks the beginning of the period of delivery and receipt of the concrete, which will last until the concrete has been fully unloaded.

The Works Management, or the person delegated, is responsible for supervising receipt of the concrete and, to that end, takes the necessary samples, carries out the required controltests and follows the procedures indicated in Chapter 15.

Any rejection of the concrete based on the results of the consistency tests (and occluded air, as appropriate) shall be made during the delivery. It will not be possible to reject any concrete for these reasons unless the appropriate tests are carried out.

It is explicitly forbidden to add to the concrete any quantity of water or other substances that may alter the original composition of the fresh batch. However, if the settlement is smaller than that specified in 31.5, the supplier will be able to incorporate plasticizer or superplasticizer admixture in order to increase it until it reaches said consistency, without this exceeding the margins indicated in the section referred to and provided this operation is done following a written procedure approved by the concrete Manufaturer. With this in view, the transportation vehicle or, if appropriate, the construction plant shall be equipped with the relevant admixture dispenser system and shall re-mix the concrete until the admixture has completely dispersed. The re-mixing period will be of at least 1 min/m^3 and, at any event, of not less than 5 minutes.

The action taken by the supplier will cease once the concrete has been delivered and once the reception tests for the concrete have been completed satisfactorily.

In the agreements between the applicant and the supplier, account shall be taken of the time that, in each case, may elapse between the manufacture and placing of the concrete.

71.5 Placing of concrete

Except in cases when the reinforcements are in possession of an officially recognised quality mark and there is intense construction control, it will not be possible to place the concrete until the results of the relevant conformity verification tests are available.

71.5.1 Pouring and placing of concrete

In no circumstances will the placed batches that have begun to set be tolerated.

In the pouring and positioning of the batches, including when these operations are carried out continuously using appropriate ducts and pipes, due precautions will be taken to prevent the mixture from disintegrating.

No layers of concrete will be placed that are too thick to enable the batch to become fully compacted.

The concreting will not take place until the agreement of the Works Management has been obtained following controlof the reinforcements already placed in their definitive positions.

Each component will be concreted in accordance with a pre-established plan in which account will be taken of foreseeable distortions to the formwork and falsework.

71.5.2 Compaction of concrete

The concretes forming part of the construction work will be compacted by means of procedures appropriate to the consistency of the mixtures and in such a way that cavities are eliminated and the batch completely closed, and without segregation occurring. The compacting process shall continue until the paste flows back to the surface and air ceases to come out.

When surface vibrators are used, the thickness of the layer following compaction will not be greater than 20 centimetres.

Consideration shall be given to how best to use mould or formwork vibrators so that the vibration transmitted through the formwork is enough to produce proper compaction and to prevent the formation of less strong cavities and layers.

The revibration of the concrete will be the subject of approval by the Works Management.

71.5.3 Placing of concrete in special climatic conditions

71.5.3.1 Concreting in cold weather

The temperature of the batch of concrete, at the time of its being poured into the mould or formwork, shall not be less than 5°C.

It is forbithen to pour the concrete onto components (reinforcements, moulds etc) whose temperature is lower than zero degrees centigrade.

In general, the concreting will be suspended if it is anticipated that, within 48 hours, the surrounding temperature may fall to below zero degrees centigrade.

In cases in which, by absolute necessity, concreting takes place during frosty weather, the necessary steps will be taken to ensure that, while the concrete is setting and initially hardening, no local damage to the relevant features will occur, nor permanent appreciable impairment of the resistant characteristics of the material. If any type of damage is produced, the necessary tests on information (see Article 86°) shall be carried out in order to estimate the strength actually achieved, with the appropriate measures being taken if necessary.

The use of admixtures to speed up the setting or hardening processes or the use, in general, of any antifreezing product specific to concrete will, in every case, require explicit authorisation from the Works Management. It will never be possible to use products likely to attack the reinforcements, especially those containing chlorine ions.

71.5.3.2 Concreting in hot weather

When the concreting takes place in hot weather, the appropriate measures will be taken to prevent the mixing water from evaporating, in particular while the concrete is being transported, and to reduce the temperature of the batch. These measures shall be enhanced in the case of high-strength concretes.

With this in view, the materials constitutive of the concrete, together with the formwork or moulds designed to receive it must be protected from bleaching.

Once the concrete has been put in position, it will be protected from the sun and, especially, from the wind to prevent it from drying out.

If the surrounding temperature is higher than 40°C or if there is excessive wind, the concreting will be suspended unless, subject to the explicit authorisation of the Works Management, special measures are adopted.

71.5.4 Concreting joints

The concreting joints which shall, in general, be provided for in the design will be situated in as normal as possible a relation to the compression strengths and, hence, where their effects are least harmful, their being removed, to that end, from the areas in which the reinforcement is subject to strong tensions. They will be given the appropriate form, ensuring the most intimate as possible a link between the old and the new concrete.

When there is a need for concreting joints not provided for in the design, they will be put in places approved by the Works Management and, preferably, on the shores of the falsework. The concreting of these joints will not resume until they have first been examined and approved, if appropriate, by the Works Manager.

If a joint is not on the correct plane, the relevant portion of concrete will be demolished in order to give appropriate direction to the surface.

Before resuming the concreting, the surface layer of mortar will be removed, leaving the aggregates exposed, and any loose dirt or aggregate will be removed from the joint. In any case, the cleaning procedure used shall not produce appreciable alteration to the bonding between the paste and the thick aggregate. The use of corrosive products for cleaning joints is explicitly prohibited.

It is prohibited to engage in concreting directly on or against concrete surfaces that have suffered the effects of frost. In this case, the frost-damaged parts shall first be removed.

The project technical specifications will be able to authorise the use of other techniques for constructing joints (for example, impregnation with appropriate products), as long as it has first been verified, by means of adequate tests, that such techniques are capable of producing results that are at least as effective as those obtained when the traditional methods are used.

71.6 Curing of concrete

While the concrete is setting and initially hardening, its continuing humidity shall be maintained by means of appropriate curing. This will continue for the necessary period, depending on the type and class of cement, the temperature and level of humidity of the environment , etc. Curing will be possible by keeping the surfaces of the concrete elements damp, by means of direct watering that does not wash the concrete away. The water employed in these operations shall possess the qualities required by Article 27 of this Code.

Curing by dampening may be replaced by protecting the surfaces by means of plastic coverings, filmogenous agents or other appropriate treatments, as long as such methods, especially in the case of dry batches, offer the guarantees considered necessary for enabling the initial humidity of the batch to be maintained during the initial period of hardening and as long as the products concerned do not contain substances harmful to the concrete.

If special techniques (such as steam curing) are used, they shall, subject to authorisation by the Works Management, be used in accordance with the standards of good practice peculiar to such techniques.

Article 72. Special concretes

The Designer or Project Management shall be able to use or, if appropriate, authorise, at the proposal of the Constructor, the use of special concretes that may require specifications - additional to those indicated in the Article or specific conditions of use - such as enable the basic requirements of this Code to be satisfied.

When recycled concretes or self-compacting concretes are used, the designer or Project Management may be obliged to comply with the relevant recommendations compiled in, respectively, Annexes 15 and 17 of this Code.

Annex 14 contains a number of recommendations concerning the design and construction of concrete structures with fibres, while Annex 16 deals with concrete structures involving light aggregate.

When, moreover, there is a need to use concretes in non-structural elements, what is laid down in Annex 18 will apply.

Article 73. Formwork removal

Special attention will be paid to removing, if need be, any formwork or mould element that might hamper the free play of the retraction, seat or expansion joints, as well as of the hinges, if such exist.

The environmental conditions (for example, frost) will also be taken into account, together with the need to adopt means of protection once the formwork or moulds have been removed.

Article 74. Removal of falsework

The separate elements of the moulds or formwork (sides, bottoms etc), props and falsework will be removed without causing jolts or shocks to the structure, and it is recommended, when the elements are of a certain size, that wedges, gravel boxes, clamps or other similar devices be used to ensure that the supports are brought down in a uniform way.

The aforesaid operations shall not be carried out until the concrete has acquired the necessary strength to support, safely enough and without excessive distortions, the forces to which it will be subject during and after the formwork removal and stripping.

When the work concerned is on a large scale and no experience of similar cases is possessed, or when the damage that might be caused by premature fissuring is considerable, tests on information (see Article 86) will be carried out in order to estimate the actual strength of the concrete and to be able properly to establish the time of the formwork removal or stripping.

In the case of prestressed concrete elements, it is crucial for the Removal of falsework to take place in accordance with what is stated in the relevant programme that was provided for

that purpose when drafting the design for the structure. This programme shall be in accordance with that corresponding to the tensioning process. Particularly in the case of the prestressed bridges that are being stripped, at least partially, through the tensioning of the prestressed tendons, an assessment shall be carried out of the effects of the prestrained formwork on the structure in the process of dismantling that structure.

The unshoring or Removal of falsework periods indicated in this Article may only be changed if the Constructor drafts a plan in accordance with the available material resources, duly verified and establishing the appropriate means of supervision and safety. All this will be submitted for the approval of the Project Management.

The shoring will be removed, in the case of one-way slabs, starting at the centre of the span and moving out to the ends and, in the case of cantilevering, starting at the nosing and moving out to the springing. Shoring shall not be depleted or removed without the prior authorisation of the Project Management. Unshoring shall not take place suddenly, and precautions will be taken to prevent the straining pieces and shoring from having an effect on the floor slab.

Article 75. Surface finish

Once the formwork has been removed, the visible surfaces from the members or structures shall not present air pockets or irregularities that impair the behaviour of the structure or its exterior aspect.

When a particular grade or type of finish is required for practical or aesthetic reasons, the design shall specify the requirements either directly or by means of surface templates.

For the purposes of covering or filling the anchorage heads, openings, notches, mouldings etc – a process that must take place once the members have been fully dealt with – use will be made of mortar manufactured from batches similar to those used for the concreting of such members, but aggregates more than 4 mm in size will be removed from them. All the mortar surfaces will be finished appropriately.

Article 76. Precast elements

76.1 Transport, unloading and handling

In addition to the requirements derived from current transport regulation, account shall, where precast elements are concerned, be taken of, as a minimum, the following conditions:

- the support on the lorry bodies shall not exert forces on the elements not considered in the design,
- the load shall be tied so as to prevent unwanted movement,
- all the members shall be separated using appropriate elements so as to prevent the members from colliding during transport,
- if the transport takes place when the element concerned is very new, the latter shall be prevented from drying out during transportation.

For the purposes of unloading and handling on the site, the Constructor or, if appropriate, the supplier of the precast element shall use unloading methods appropriate to the size and weight of the element, taking special care that there is no loss of alignment or vertical status that could cause unacceptable stresses in the component. In any case, the instructions given by each manufacturer for handling the elements shall be followed. If any of the components is damaged in a way that might affect its bearing capacity, it will be rejected.

76.2 Stocks on site

If appropriate, matters will be arranged so that the stock areas are places large enough to enable stocks to be managed properly and without losing their necessary traceability, at the same time as its being possible for lorries and, if required, cranes to be manoeuvred.

The elements shall be stored on horizontal supports that are sufficiently rigid, given the characteristics of the ground and the dimensions and weight of the elements. Joists and hollow-core slabs shall be piled up, clean, on sleepers that will coincide in the same vertical and with, if appropriate, nosing no larger than 0.50 m and pile heights of no more than 1.50 m, unless another, higher figure is indicated by the manufacturer.

If appropriate, the joints, fastenings etc shall also be kept in a store so that their characteristics do not alter and the necessary traceability is maintained.

76.3 Assembly of precast elements

Precast elements shall be assembled in accordance with what is laid down in the design and, in particular, with what is laid down in the plans and details for the assembly schemes, with the sequence of operations of the implementation programme and with the assembly instructions supplied by the precast product manufacturer.

Depending on the type of precast element, it may have to be assembled by specialised, properly trained staff.

76.3.1 Joists and hollow-core slabs

76.3.1.1 Positioning of joists and hollow-core slabs

Shoring will take place in accordance with the relevant stipulations in Section 68.2 of this Code. Once the straining pieces have been levelled, the joists will be placed in position with the interaxle indicated in the plans and using the end beam-filling members. Once this phase is complete, the shoring will be adjusted, and the remaining hollow-core slabs will be placed in position.

76.3.1.2 Unshoring

The unshoring periods shall be those indicated in Article 74. In order to change these periods, the Constructor shall present to the Project Management for its approval an unshoring plan in accordance with the available material resources, duly verified and establishing the appropriate means of supervision and security.

The shoring will be removed, starting at the centre of the bay and moving out to the ends and, in the case of cantilevering, starting at the nosing and moving out to the springing. Shoring shall not be depleted or removed without the prior authorisation of the Project Management.

Unshoring shall not take place suddenly, and due precautions will be taken to prevent the straining pieces and shoring from having an effect on the floor slab.

76.3.1.3 Construction of partition walls

In constructing the partitioning components consisting of rigid walls, constructive solutions shall be adopted that are necessary to minimise the risk of the walls being damaged by the floor slab and the transmission of loads from the higher floors through the walls.

76.3.2 Other precast linear elements

When assembling precast girders, the appropriate measures shall be adopted to prevent the supports from slipping.

The design shall, if appropriate, include a study of the assembly of the precast elements that require provisional bracing in order to prevent possible problems of instability while the structure is being assembled.

76.4 Joints between precast elements

The joints between the separate precast members that constitute a structure or between such members and the other structural elements constructed *in situ* shall ensure that the forces between each member and those adjacent to it are transmitted correctly.

They shall be constructed in such a way that they can absorb the normal prefabrication size tolerances without giving rise to additional stresses or to the concentration of forces in the precast elements.

It will not be possible for the heads of the elements that are to be left in contact to present irregularities such as interfere with the compressions being transmitted evenly over the whole surface of the heads. The admissible limit for such irregularities depends on the type and thickness of the joint, and it is not permitted to try to correct these irregularities by filling the heads with cement mortar or any other material that does not guarantee the appropriate transmission of the forces without their being subject to excessive distortion.

Where soldered joints are concerned, care shall be taken to ensure that the heat given off does not cause damage to the concrete or to the reinforcements of the members.

Joints involving post-tensioned reinforcements require special precautions to be adopted if these reinforcements are short. The use of such reinforcements is to be recommended with a view to stiffening joints, and they are especially appropriate for structures that have to support seismic effects.

Where threaded joints are concerned, special attention shall be paid to the calibrations of the dynamometric equipment used and to ensuring that the opening stress applied to each screw corresponds to that specified in the design.

Article 77. Basic environmental aspects and good practices

77.1 Basic environmental aspects for construction

77.1.1 Generation of waste arising from the construction activity

When the construction phase generates residue classified as dangerous, the Constructor shall, in accordance with what is laid down in Order MAM/304/2002 of 8 February, separate it from the harmless residue, store it separately and identify clearly the type of residue and its date of storage, since it will not be possible for the dangerous residue to be stored for more than six months on the site.

The residue shall be removed from the site by authorised managers who, if appropriate, shall take responsibility for its recovery, re-use, controlled disposal etc.

Special attention shall be paid to the pouring away or disposal of chemical products (for example, battery liquids) or oils used in the site machinery. Equally to be prevented is the spilling of sludge or residue in connection with the washing of the machinery – sludge or residue that, frequently, may also contain solvents, grease and oils.

The residue shall be separated and stored separately, and the type of residue and its date of storage shall be identified clearly, it not being possible to keep the dangerous residue on the site for more than six months.

77.1.2 Atmospheric emissions

Particularly when the construction work is carried out close to urban areas, the Constructor will see to it that no dust is generated in any of the following circumstances:

- land movement associated with excavations,
- aggregate crushing or concrete manufacturing plants located on the site,
- stocks of materials

With this in view, the tracks and roads used by the machinery will be irrigated frequently, the speed of the machinery will be limited and, if appropriate, the consignments and stocks will be covered by suitable canvases. Where aggregate crushing installations are concerned, their activity will be planned in such a way that their period of use is kept to a minimum. The belts used for transporting the aggregate will be covered and, whenever possible, dust-collecting

elements or water sprayers will be used. In the case of concrete plants, the cement silos will have to contain filters that prevent the generation of dust as a consequence of pneumatic transport.

- Arrangements will be made to minimise the generation of gases proceeding from the combustion of fuels, and this by refraining from running the site machinery at excessive speeds, maintaining the machinery properly and, preferably, using machinery with catalysers.

Welding processes generate gases that, particularly if they are generated in confined places, may be toxic, which is why periodic analyses of the gases should be carried out. In any case, welding must be carried out where there is adequate ventilation.

77.1.3 Generation of waste waters from the cleaning of plants or elements for the transport of concrete

In the case of concrete-manufacturing plants, the water that has been used for washing their installations or the elements used for transporting the concrete will be poured onto specific, impermeable and adequately signposted areas. It will be possible for the water thus stored to be re-used as mixing water for the manufacture of the concrete, as long as it complies with the requirements to that effect set down in Article 27 of this Code.

As a general principle, there will be no cleaning on site of the elements used for transporting the concrete. If such cleaning is unavoidable, a procedure similar to that referred to previously in connection with construction plants shall be followed.

77.1.4 Generation of noise

The construction of concrete structures may generate noise, basically from one of the following sources:

- the machinery used during the construction,
- operations involving the loading and unloading of materials,
- aggregate treating or concrete manufacturing operations,

Noise usually has an impact that is difficult to prevent in the building of normal structures, and it affects both the staff on the site itself and those who live or engage in activities in its vicinity. Particularly when the construction in question is close to urban centres, the Constructor will therefore plan his activities in such a way as to minimise the periods in which they may generate noise and, if appropriate, in such a way that they are in accordance with the relevant bye-laws.

77.1.5 Consumption of resources

The Constructor will, if appropriate, arrange to use recycled materials, especially in the case of aggregate for the manufacture of concrete, and this in accordance with the criteria laid down in Annex 15 of this Code. Likewise, he will, whenever possible, have installations that permit the use of recycled water that has been employed for washing the elements used for transporting the concrete, and this under the terms indicated in Article 27.

77.1.6 Potential effects to soil and aquifers

Activities connected with the building of the structure may accidentally bring about situations in which environmental damage is caused both to the soil and to nearby aquifers. Such incidents may basically consist in the accidental spillage of concretes, oils, fuels, stripping

products etc. If such an incident occurs, the Constructor shall clean the affected ground and arrange for the relevant residue to be removed by an authorised manager.

If an accidental spillage should occur, it will, in particular, be ensured that the material concerned does not reach aquifers and hydrological catchment basins, the sea and drainage systems, and the necessary prior or subsequent measures will be taken to prevent this from happening (for example, the ground of the areas in which stocks of residue are kept might be made impermeable, or the necessary absorbent material might be laid). If a spillage does occur, the residue generated will be managed in accordance with point 77.1.1.

77.2 Use of environmentally sound products and materials

All the agents involved in building the structure (Constructor, Project Management etc) shall ensure that environmentally sound products and materials are used. The criteria for selecting these include the following:

- the materials concerned should be as durable as possible,
- require as little maintenance as possible,
- be simple, consist preferably of a single component,
- be easy to deploy and, if appropriate, to recycle
- be as energy efficient as possible,
- the materials concerned should be as healthy as possible both for those involved in the construction and for the users,
- the materials concerned should come from locations or stores as close as possible to the site, and this with a view to minimizing the impact of transportation.

77.3 Good environmental practices for the construction

In addition to the criteria established in the sections above, a series of good environmental practices may be identified, among which the following might be emphasised:

- it will be ensured that all the staff and subcontractors involved in the construction comply with the environmental requirements defined by the Constructor,
- the environmental criteria will be included in the contract with the subcontractors, and said contract will also define the liabilities to be incurred by the subcontractors if they fail to comply with the criteria,
- residue will be kept to a minimum and its re-use encouraged and, if appropriate,
- the storage of residue will be managed,
- plans will be made to employ, as soon as the construction work begins, an authorised manager to collect residue with a view to preventing unnecessary storage,
- there will be proper management of energy consumption on the site, with systems immediately put in place for measuring consumption, enabling the extent of this to be known as soon as possible; furthermore, the use of generator sets, which have a major environmental impact, will be avoided,
- if demolition of any part of the construction has to be resorted to, this shall take place through the use of deconstruction criteria that encourage classification of the corresponding residue and, thus, its subsequent recycling,
- fuel consumption will be minimised by restricting the speeds of the machinery and transportation elements on the site, by carrying out appropriate maintenance and by encouraging the use of low-consumption vehicles,

- the deterioration of materials contained in paper sacks, such as cement, will be prevented by means of a system of storage under cover that prevents their weathering and subsequent conversion into residue,
- the members comprising the formwork and falsework will be properly managed, and a situation prevented in which subsequent operations involving earth-moving machinery cause said members finally to be incorporated into the ground,
- stocks for the construction work will be organised in such a way that they are used as soon as possible and located as close as possible to the areas in which they are to be used in the construction work,
- the reinforcements will be assembled in specific areas so as to prevent the uncontrolled appearance of wires in those facings of the concrete element that correspond to the formwork bottoms.