

7 PRECAST CONCRETE

7.1 SCOPE

This section provides the general performance requirements specially needed for precast concrete products, which are continuously produced in well-controlled factories. Standard requirements related to construction including concrete work at site using these products, are also laid down.

Commentary:

This section provides the general performance requirements for concrete products, including not only plain and reinforced concrete products but also prestressed concrete products, to be produced continuously in large quantities in a well-controlled plant. However, provisions of this section are not applicable to plants with insufficient quality control, or precast units produced in a temporary yard near the construction site.

7.2 BASIC REQUIREMENTS

Care shall be exercised in the choice of materials used and their mix proportions, mixing, layout of reinforcement, moulding, casting, curing, etc. to ensure that the manufactured concrete products meet the required quality and performance. Also, concrete products shall be manufactured in a manner that their quality and performance are not impaired during handling, transportation, assembling and jointing, and shall be settled and assembled to satisfy the required function and performance of structures.

Commentary:

Precast concrete products shall have the following characteristics;

- 1) Control of materials, mix proportions, manufacturing in plants and site erection shall be carried out properly.*
- 2) In principle, concrete products shall be manufactured by skilled personnel.*
- 3) Use of machinery and equipment in production and handling saves labor.*
- 4) Concrete placing in the factory shall be carried out with ease and with minimal interference due to the variations in weather conditions.*
- 5) Tests using real concrete products shall be carried out.*
- 6) Some precast concrete products may have very thin sections (or parts).*
Since precast concrete products are frequently jointed at site, adequate consideration shall be given to this aspect at the design and construction stages as joints may become points of weakness.

7.3 MATERIALS

7.3.1 Quality of constituent materials

7.3.1.1 Fine and coarse aggregates

- (a) Fine and coarse aggregates shall be appropriately selected, depending on the type of the products, method of manufacture, etc. in such a manner that the required quality is imparted to the concrete product.
- (b) Maximum size of coarse aggregates shall be not more than 40 mm and shall not exceed 2/5th of minimum dimension of the finished product or 4/5th of minimum clearance between reinforcing bars. However, in cases when conditions for adequate compaction can be confirmed, this provision may be compromised.
- (c) In the case of prestressed concrete precast products, recycled aggregates shall not be used. However, in cases when the adequacy of their quality can be confirmed, this provision may be compromised.

Commentary:

- (a) *Selection of good quality fine and coarse aggregates is important because the quality of concrete used in*

precast concrete products is affected by not only conditions of manufacturing, such as mix proportions, curing, etc., but also the quality of the aggregates.

- (b) Generally, the coarse aggregates having a maximum size of 20 or 25 mm may be used in precast concrete products. For products with particularly small thickness, aggregates with a maximum size of 10mm or 15 mm may be used. Further, in cases of products with a relatively large cross section, aggregates with a maximum size of 40mm are not uncommon to be used.*
- (c) It is known that drying shrinkage and creep in concrete using recycled aggregates are larger than those using normal aggregates, and in cases that such concrete is used in prestressed concrete products, the loss of prestress can be large.*

7.3.1.2 Admixtures

Admixtures shall be used in concrete products only after appropriately considering the special methods used for mix proportion, compaction, accelerated curing, as well as the effect on the quality of the products and improvement of the production efficiency.

Commentary:

Chemical admixtures, such as air-entraining agents, water-reducing agents, air-entraining and water-reducing agents, high-range water-reducing agents, high-range water-reducing and air-entraining agents, and viscosity enhancing agent are normally used during manufacturing of concrete products. Mineral admixtures, such as expansion admixtures, admixtures for high strength concrete (mainly composed of anhydrous gypsum), ground granulated blast-furnace slag, fly ash, silica powder and coloring agents are also used.

7.3.2 Mix Proportions

7.3.2.1 General

Mix proportions for concrete products shall be determined after appropriately considering the method of moulding and curing to satisfy the required quality and performance.

Commentary:

Accelerated curing is adopted for many concrete products in order to raise operating ratios of factories, since formwork can be removed and re-used earlier than in case of normal curing. Since large impacting load or localized load may be applied in short period after concreting such as at removing formwork and lifting concrete products, mix proportion shall be determined taking these manufacturing requirements into account.

7.3.2.2 Workability

- (a) Workability of concrete shall be decided by taking the shape and size of the product into account, as well as the method of production.
- (b) Workability of concrete shall be checked, using the slump test, slump-flow test or any other appropriate test method.

Commentary

As concrete products are varying in their dimensions and as such methods of production are also different. Consequently it is important that workability of concrete shall be selected by taking method of production into account.

Ordinary slump of concrete is between 50 mm and 100 mm or sometimes 150 mm. Self compacting concrete is lately in use and slump flow test shall be applied for such concrete.

7.3.2.3 Strength of concrete products

- (a) The strength of concrete in precast concrete products shall, in principle, be specified on the basis of the compressive strength by taking required strength at each stage of construction into account.

- (b) Compressive strength used in concrete products, at the stage of formwork removal, application of prestressing or delivering, shall meet the required value determined for each stage of manufacture.
- (c) The test specimens shall, in principle, be prepared using similar compacting and curing condition as those of finished products.
- (d) When concrete products are manufactured in a manner similar to that of ordinary reinforced concrete members, or in cases when it is difficult to meet the provisions in (c) , the strength of concrete in the products, shall be specified in terms of Clause 5.2.1.4 (a)

Commentary:

- (a) When the quality of concrete products is specified on the basis of strength other than compressive strength, the type of strength shall be specified and it shall satisfy the requirements. Test age of the strength shall be specified taking the value at each construction stage into account.*
- (b) When the strength has not been specified even in the manufacturing process, it is important to satisfy the required value which the engineers in charge of manufacturing require if necessary.*
- (c) Since centrifugal force and strong vibration are used in precast concrete products facilities, the same method shall be applied for making test specimens. Since steam curing is used in many facilities, curing condition of test specimen shall be the same as that of the finished products.*
- (d) When adopting similar concreting and curing method as for ordinary concrete, the test method of compressive strength test shall be the same as that of the ordinary concrete.*

7.3.3 Reinforcing steel and other materials

- (a) Reinforcing steel, wires and rebar excluding prestressing steel in concrete products shall be specified in accordance with Section 4:Reinforcement.
- (b) Prestressing steel in concrete products shall be specified in accordance with Section 6.3.2.
- (c) When reinforcing steel other than (a) and (b) is used, or in cases when the reinforcing steel is re-processed or heat-processed, the qualities of the material shall be confirmed by tests. Also the appropriate strength, other design parameters and the method of use shall be determined by relevant approved methods.

Commentary:

- (a) Since precast concrete products are generally thin members, the reinforcing steel with the size of 10mm or smaller are often used. Also low carbon steel wires and rods are used for manufacturing precast products.*
- (b) Reinforcing materials which are not specified in Section 4: Reinforcement, shall be checked for their strength, parameters for design and application method with consideration of tensile and crack controlling properties which are relevant to their kinds or purposes of use.*
- (c) Steel materials which are not covered in (a) and (b) shall be used after the confirmation of their qualities. If the use of epoxy coated reinforcing bar, zinc-coated reinforcing bar, glass fiber, carbon fiber, or organic fiber is expected, the confirmation tests with proper consideration of the materials and fabrications shall be needed before application.*

7.4 WORKMANSHIP

7.4.1 Production in Factory

7.4.1.1 Mixing

Appropriate batch mixers shall be used to mix the concrete required for the manufacture of precast products.

Commentary:

Stiff consistency concrete having a low water-cement ratio is often used for concrete products. For mixing such concrete, forced mixing type mixers are suitable. Care shall be taken when tilting mixers are used, as mortar may

adhere to the inner mixer lining and the base of blades. This may adversely affect the uniformity of the concrete.

7.4.1.2 Assembly of reinforcement

- (a) The reinforcement shall be firmly assembled to prevent dislocation and excessive deformation in manufacturing process.
- (b) In cases when spacers are used, the material of the spacers and the method of use shall be selected taking into consideration the durability and appearance of the product.
- (c) The stirrups, additional steel bars, etc. shall, in principle, not be welded to prestressing tendons.

Commentary:

- (a) *Reinforcing bars shall be carefully tied and assembled by tying with annealed steel wire or appropriate clips at the intersections of reinforcing bars, or by spot welding.*
- (b) *Using spacers is effective for fixing reinforcing steels into a position; however, care must be exercised to prevent weak points in the structure and to avoid deterioration of the concrete products due to the harmful effect of corrosion of the reinforcing steel which may be caused by the unsuitable spacers. Spacers made of the same properties of concrete or mortar as the concrete products are preferred over plastic spacers when used in severe condition..*
- (c) *Prestressing steel shall not be welded. But only under proper quality-controlled condition the reinforcing steel can be spot welded to the prestressing steel.*

7.4.1.3 Formwork

The formwork shall have a rigid structure, accurate in shape and size, and be easily assembled and removed.

Commentary:

During compacting, moulds for concrete products are subjected to strong vibration and high pressure. In addition, the moulds are repeatedly used and steam curing usually generates thermal stress in the moulds. Accordingly, the moulds shall be strong and convenient to be assembled and disassembled. Steel moulds are usually used for concrete forms, and synthetic resin moulds are also used. When using moulds, adequate consideration must be given to handling, cleaning, application of form releasing agents, maintenance and so on. For production of precast products with accurate dimensions, it is necessary that the tolerances for mould dimensions be less than that for the dimensions of concrete products.

7.4.1.4 Casting

- (a) Casting shall be appropriately done by using mechanical compaction methods in order to have concrete products of the required quality.
- (b) Surface of concrete products shall be smoothly finished by taking their required performances into consideration.

Commentary:

- (a) *Compaction methods generally used for concrete products include vibration compaction, centrifugal compaction, pressing compaction, vacuum compaction or their combination. It is essential that a suitable mechanical compaction method relevant to the manufacturing conditions be adopted and that casting be performed with care.*

Of late, self compacting concrete is sometimes used in order to avoid the vibration or noise.

- (b) *In general, surface finishing is done after compaction by using finishing tools such as rulers, trowels and external vibrators with a bottom plate. In the case that the concrete products have an apparent limitation of the size in their design specification, the surface finishing shall be done with those considerations.*

The exposed concrete surface shall be flat and dense for improving durability and water-tightness of

concrete products, as well as its fine external appearance. Therefore, it is necessary to compact concrete carefully.

7.4.1.5 Curing

- (a) The method and duration of curing of concrete products shall be determined such that the required quality is met, taking into consideration the type and method of manufacture.
- (b) In cases when accelerated curing is used, the curing process shall not cause defects such as crack, peeling, and deformation. Also, it shall not affect long-term strength and durability. Therefore, attention shall be especially paid to the heat generation and cooling down speed in accelerated curing.
- (c) Control of curing temperature shall be specified in a manner as shown in Table 7.4.1.

Table 7.4.1 Control of curing temperature

Item	Check	Frequency	Criterion
Curing temperature	- Heat generation speed - Cooling down speed - Maximum temperature and its holding time	Anytime	Satisfaction with the specification of designation

Commentary:

- (a) Concrete shall be cured adequately after casting in order to avoid harmful effects on quality such as those caused by low temperatures, drying, sudden temperature variations or loads and impact. It is necessary that proper curing methods such as wet curing and insulated curing be applied for the specified period even after de-moulding.
- (b) Steam curing at atmospheric pressure is widely used for high productivity. Therefore, there are many examples of steam curing applications stipulated as follows;
 - 1) Concrete products cast in moulds are put into steam curing rooms and the curing room temperature is raised uniformly.
 - 2) Steam curing shall be started 2-3 hours or more after mixing.
 - 3) The rate of temperature rise shall be no more than 20 °C per hour and the maximum temperature shall not be higher than 65 °C.
 - 4) The temperature of the curing room shall be lowered slowly, and concrete products shall be removed from the room when the temperature difference between the curing room and the outside atmosphere approaches zero.

In addition to the above method, autoclave curing and pressure curing are generally used as accelerated curing methods, for example, autoclave curing for PC poles or piles. Using these curing methods, sufficient strength can be obtained at an early age.
- (c) High productivity by the acceleration of curing and de-moulding is a special requirement. However, rapid heat generation or rapid cooling down causes porous and low durable concrete products. Since the quality of concrete depends on the curing temperature and time, control of temperature must be carefully done in manufacturing process of concrete products.

7.4.1.6 Demoulding and prestressing

- (a) Demoulding of concrete products shall be done after the attainment of sufficient concrete strength for handling.
- (b) Prestressing shall be carried out after confirming that the required strength has been reached.
- (c) Concrete products using extremely dry concrete and moulded by compacting with strong vibration or by applying pressure may not cause problems for transportation, curing and other works and may not be affected qualitatively even if demoulding is immediately done after casting. Therefore, these concrete products can be immediately demoulded even if concrete were not hardened.

Commentary:

(a) *The demoulding time of concrete products shall be scheduled with the consideration not only of the concrete strength, but also creep or drying shrinkage.*

Checking of relation between quality of concrete products and strength property by the compressive strength test at early age is useful for quality control in manufacturing process of material, mix proportion, curing, and so on.

(b) *The time of prestressing of concrete products shall be decided by referring to the requirement in Section 6: Prestressed Concrete.*

7.4.1.7 Handling, transportation and storage

- (a) Handling and transportation of concrete products shall be safely done without affecting their qualities.
- (b) In cases when concrete products are stored in a yard of a factory, any extraordinary stress and plastic deformation shall not be caused to the concrete products by their self weight or stacking.

Commentary:

Since concrete products are easily cracked and damaged during handling and transporting, preventive measures shall be carried out, if necessary. Especially when long concrete products such as bridge girders, poles, piles and sheet piles are handled, transported and stored, great care shall be taken of the suspension points and the method of support so as to avoid generating any large bending moments in these products. When stacking concrete products for storage, stacking methods shall be determined by taking into account the strength and the dead load of the concrete products, as well as the stacking conditions. When stacking bridge girders, preventive measures shall be taken to prevent tumbling down caused by earthquakes or by other unexpected loads.

Furthermore, since concrete products are usually demoulded, transported and stored at an early age, deformation may be caused by drying shrinkage, creep, etc., therefore, adequate consideration shall be given to support positions during transportation and storage.

7.4.2 Assembly and erection of concrete elements

7.4.2.1 General

Assembling and erection of concrete elements shall be based on the instructions of work procedure according to scheme of execution. Concrete elements shall be assembled with specified accuracy shown in drawings and specification. Assembly and erection of concrete elements shall be executed according to the instructions given by the designated engineer.

Commentary:

As assembly and erection are significant process to affect quality of structures, detailed instruction of work procedure shall be prepared before the work. Main subjects to be examined under instruction of work procedure are as follows,

- 1) *Total process of works*
- 2) *Cycle process of works*
- 3) *Temporary work for assembly*
- 4) *Operation standard for assembly*
- 5) *Arrangement of workers*
- 6) *Adjustment of chain of conducting*
- 7) *Instruction of inspection and standard of accuracy of assembly*
- 8) *Attention to safety of works*

7.4.2.2 Temporary work for assembly

Planning of temporary work for assembly and erection of concrete elements shall be conducted to satisfy the

required quality of concrete structures and safety of assembly and erection.

Commentary:

Planning of temporary work for assembling and erection of concrete elements is classified as follows,

- a. Machines for assembly such as crane and other related facilities such as traveling lane and stock yard*
- b. Hanging jig for assuring safety and quality of works*
- c. Temporary construction to support or fix members*
- d. Safety facilities such as safety ropes, balustrade and protection net*

7.4.2.3 Construction machine and workmanship for assembly and erection

- (a) Construction machine and temporary facilities shall have sufficient capabilities to perform in accordance with the purpose of construction plan.
- (b) Operator and workman shall be certified in accordance with corresponding laws and ordinances on labours and shall be skilled in the related work.

Commentary:

Cranes to be used in precast concrete assembly could be classified as traveling type and fixed type. Type of crane shall be selected in accordance with site conditions and shape of structures to be built. Fixed type crane would be suitable for a square plan and high rise structures. Traveling type crane would be suitable for long and slender plan. On the selection of type of cranes, setting up point, operation range and weight of members, as well as site conditions and shape of structures shall be examined. Operator of crane shall be skilled in operation of machine and handling of loads. Inspection and adjustment of machinery shall be performed to avoid accidents.

7.4.2.4 Assembly and erection

- (a) Assembly and erection of concrete elements shall be conducted in accordance with the instruction of work procedure.
- (b) Assembly and erection shall be performed to satisfy required accuracy of assembly. Concrete elements shall be assembled to avoid inclining or irregular joint.
- (c) Assembly and erection shall not be carried out under the condition of excessive wind.
- (d) Inspection on accuracy of assembly shall be conducted in accordance with specified methods and standards.

Commentary:

Instruction of work procedure shall be made to examine arrangement of supports considering shape and weight of members. Wind and rain could affect assembly and erection work. An anemometer shall be set near working area and measurement of wind velocity shall be available at all times. In case of occurrence of excessive wind velocity such as that faster than 10m/sec or a gust of wind, work shall be suspended.

7.4.3 Jointing of concrete elements

7.4.3.1 General

Type and method of jointing of elements shall be in accordance with particular specifications and drawings. Jointing of concrete elements shall be performed according to instruction of work procedure, scheme of construction process and quality control.

Commentary:

Method and procedure of jointing of elements are recommended to be indicated on particular specifications and drawings to avoid excessive strain at joint.

7.4.3.2 Jointing of reinforcing bars and steel element

7.4.3.2.1 Welded joint

- (a) Welded joint shall be performed by welder qualified for particular method, materials, thickness and so forth.
- (b) Welding shall be performed immediately after assembling of the elements.
- (c) Welding part and welding materials shall be dried sufficiently.
- (d) Working environment shall not be affected by rain, wind and low temperature conditions.

7.4.3.2.2 Mechanical joint

- (a) Mechanical joint for reinforcing bars shall be made in accordance with the instruction of work procedure.
- (b) Sleeve joint shall be made to avoid insufficient grouting.
- (c) Screwed mechanical joint shall be made to avoid inadequate tightening.

7.4.3.2.3 Gas pressure welding joint

Gas pressure welding shall be conducted by qualified welder having qualifications specified on national standard.

7.4.3.2.4 Other joints

Other jointing shall be conducted in accordance with corresponding specification.

Commentary:

Welder for welded joints shall be qualified for the specific type of welding. Welding shall be performed immediately after assembling of the elements to assure stability of structure especially in the event of an earthquake. Under rain or excessive wind condition, welding shall not be performed to avoid defects.

Mechanical joint with proper assessment or certified by proper organization shall be used. Instruction of work procedure shall be made according to specification of manufactures.

Other frequently used joints are friction type high strength bolted connections and other bolted connection.

7.4.3.3 In-filled concrete

- (a) In-filled concrete using ready mixed concrete shall satisfy the quality of concrete as specified in Section 5: Concrete.
- (b) Formwork for in-filled concrete shall be rigid to avoid excessive deformation at placing and leakage of paste or mortar at joint of formwork.
- (c) Cleaning and moisturizing the inner surface of formwork and joint shall be performed before placing concrete.
- (d) Placing concrete shall be conducted to ensure in-filling concrete in the formwork.

Commentary:

Before placing concrete to infill joint, spraying proper amount of water would be necessary to assure good jointing, or to prevent defects such as honeycomb which may appear because of water absorption by the concrete elements. Surface of joint shall be cleaned before placing concrete.

7.4.3.4 Placing mortar for jointing

7.4.3.4.1 Laying mortar

- (a) Mixture of laying mortar shall be such as to have required strength and workability.
- (b) Placing of laying mortar shall be such as to ensure good joint filling for concrete elements.

7.4.3.4.2 Infilled mortar

- (a) Placing of infilled mortar shall be carried out after confirming the finishing of jointing reinforcing bars and steel element.
- (b) Cleaning and moisturizing the inner surface of formwork and joint shall be performed before placing mortar.

Commentary:

Laying mortar could be dried out in case that dried surface of joint elements would absorb moisture from the laying mortar. That would lead to improper hydration of cement and insufficient workability of mortar. Proper moisturizing and cleaning of joint shall be performed before placing laying mortar.

Placing of infilled mortar shall be performed after confirming that other corresponding works had been completed. Proper moisturizing and cleaning of joint shall be performed before placing infilled mortar.

7.4.3.5 Grouting for jointing

- (a) Cleaning and moisturising of joint and removal of unwanted substances from joint shall be performed before joint grouting.
- (b) Grouting shall be performed to ensure good joint filling for concrete elements.
- (c) Grouting shall be performed after confirming the finishing of jointing reinforcing bars and steel element.

Commentary:

Before grouting, removal of unwanted substances from joint such as by using blower and moisturizing jointing would be necessary to ensure infilling of grout. Consecutive grouting would be needed to infill grout and avoid air voids in joint.

7.4.4 In-situ reinforced concrete elements

7.4.4.1 General

In-situ reinforced concrete is applied to basement of precast concrete buildings, joint of precast concrete elements and topping of composite slab.

7.4.4.2 Formwork

Selection of materials, design, workmanship and quality control of formwork for in-situ reinforced concrete elements shall be conducted in accordance with Section 3: Formwork.

Commentary:

As the construction of formwork is done in parts, the formwork system shall be so devised that it can be easily and swiftly erected and removed by a few all-round workers. It is desired that the supporting system is used separately for precast concrete elements and in-situ reinforced concrete elements. If the supporting system is used for both, it shall be more tightly assembled than conventional one.

7.4.4.3 Reinforcement work

- (a) Selection of materials, workmanship and quality control of reinforcing bars used for in-situ reinforced concrete elements shall be conducted in accordance with Section 4: Reinforcement Work.
- (b) Jointing steels shall be accurately placed at the positions prescribed in the drawing within an acceptable tolerance and sufficiently installed on the formwork against displacement which may be caused by concrete placing. Reinforcing steels for jointing shall be guarded to avoid mortar and concrete adhering.

Commentary:

(a) *Reinforcing bars which have contact with precast concrete elements shall be more accurately placed than those in the case of general construction work because they are usually jointed or complicated with reinforcing bars embedded in precast concrete elements. As the length of laps and joints are generally short at the junction of precast concrete elements, welding and mechanical connection are usually used. It is not desirable to use various types of jointing steels.*

(b) *Shop drawing of the formwork system, which shows the attached state of jointing steels, shall be provided before placing concrete because their incorrect positioning make repair work difficult. After*

constructing the formwork, the jointing positions are precisely measured and determined, and the jointing steels shall be fastened by means of appropriate devices such as a template.

7.4.4.4 Concrete work

Selection of materials, mix proportioning, workmanship and quality control of concrete used for in-situ reinforced concrete elements shall be conducted in accordance with Section 5: Concrete Work.

Commentary:

The surface of precast concrete elements shall be damped because the surface-dried condition of precast concrete elements easily absorbs water and is liable to cause defects in adjoining in-situ concrete. At the junction of precast concrete elements, where concrete filling and aggregate segregation may occur due to the insufficient clear spacing of reinforcing bars and shear cotters, procedures and methods shall be sufficiently investigated. Special attention and careful control shall be given to the placing of concrete in the case that precast concrete elements are used as formwork because any defects cannot be inspected after concrete placement.

7.4.5 Waterproofing of joint

7.4.5.1 Waterproofing materials

- (a) Sealants shall conform to the corresponding ISO standards or national standards.
- (b) Sealants, which do not conform to the corresponding national standard, shall be tested for satisfactory performance before being adopted for use.
- (c) Materials for waterproofing other than sealants, if used, shall be tested and their design properties and application methods shall be decided accordingly.

Commentary:

- (a) *Waterproofing materials used at the junction of precast concrete elements and the connection between precast concrete and in-situ concrete shall be selected by considering the movement of the junction of the connection, the weathering resistance and their compatibility to joining surfaces.*
- (b) *Sealants are classified into the following categories according to their constituent components.*
 - *Silicone series*
 - *Modified silicone series*
 - *Polysulfide series*
 - *Polyurethane series*
- (c) *Sealants are classified into the following categories according to their shapes.*
 - *Tape type*
 - *Liquid type*
 - *Glass-fiber sheet type*
- (d) *Waterproofing materials besides sealants include backup materials, which are applied before sealing, and edging materials, which are used to satisfy required thickness when applying bond breakers and liquid sealants.*

7.4.5.2 Sealing

- (a) Cracking and chipping parts in the waterproofed concrete shall be repaired.
- (b) Dust and laitance shall be removed from the substrate.
- (c) Primer shall conform to the waterproofing material used.
- (d) Sealant shall be filled in the jointing part without any voids after coating the primer on the substrate.
- (e) Sealing tape with specified thickness shall be applied to the specified position.
- (f) Liquid-type sealing materials shall be poured into the jointing part without any voids. Waterproofing

glass-fiber sheet shall be applied without any asperity and its edge shall be attached with the liquid-type sealing materials.

Commentary:

- (a) *Impurities on the surface of substrate may cause defect in waterproof and insufficient drying of substrate may lead to adhesion failure of waterproofing materials.*
- (b) *As primer uncoated parts in the substrate, where the primer is difficult to be coated, may cause adhesion failure, their occurrence shall be prevented by devising the shape of brush for primer.*
- (c) *Two-component sealant shall be sufficiently mixed to prevent inadequate hardening and entrapped air which reduce the performance.*
- (d) *Tape type sealants, which are used at lateral joints, shall conform to seasonal temperature conditions and have the required thickness to obtain satisfactory waterproofness.*
- (e) *The liquid type sealants shall have a minimum width of 60mm wider than that of the joint and the thickness not less than 10mm including the thickness of glass-fiber sheet.*

7.5 QUALITY CONTROL AND INSPECTION

7.5.1 General

- (a) Quality assurance shall be supported by quality control and inspection.
- (b) Quality control shall be well planned and carried out at the appropriate stages of manufacturing, transportation and assembly.
- (c) Inspection shall be carried out by appropriate methods and at the appropriate stages of manufacturing and construction process in order to satisfy the required performance of precast concrete members in the structure.

Commentary:

Quality assurance of precast concrete products is supported by inspection made by the purchaser and quality control made by the manufacturer. Inspection shall be done by the objective methods prescribed in contract to judge for acceptance. Appropriate tolerance and/or criteria limit shall also be prescribed. If there is no specific requirement, the relevant national standards may be used.

The method of quality control can be determined by the manufacturer considering the planned inspections and conditions of factories.

Quality control and inspection on shape and size of products, surface condition and quality of concrete used are usually necessary. And those for formwork, reinforcement, concrete and prestressing shall refer to Sections 3.6, 4.6, 5.5 and 6.5, respectively.

Harmful defects for concrete products in service shall not be caused by cracks, flaws, warping and twists. Dimensional tolerance for concrete products shall satisfy the required performances specified in the prescribed production scheme.

Concrete products shall have the required strength in the design stage. In cases when the strength of concrete specimen can be used to represent the required strength of concrete products, compressive strength of concrete shall be generally used.

In case when the result of inspection can be used to judge the acceptance, appropriate treatment shall be specified by agreement between the manufacturing and ordering agents.

Concrete products might have hidden parts of which deterioration can not be monitored from the surface after assembly or installation. In such cases, appropriate inspection procedure shall be established to ensure the required quality and durability.

At assembling stage in construction site, inspection and quality control shall be done, and refer to in accordance with Section 5.5.