

KCS 11 40 05 : 2019

Reinforced Concrete Culvert

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KC CODE



국토교통부



Foreword

- This standard was organized and integrated as the code by comparing and reviewing duplicate or contradictory content within the existing construction standards (design standards, standard specifications) due to the transition of the construction standards code system.
- This standard is established by integrating and organizing the parts that are related to reinforced concrete culverts in each standard based on the existing Road Construction Standard Specifications. The history of the standards are as follows:

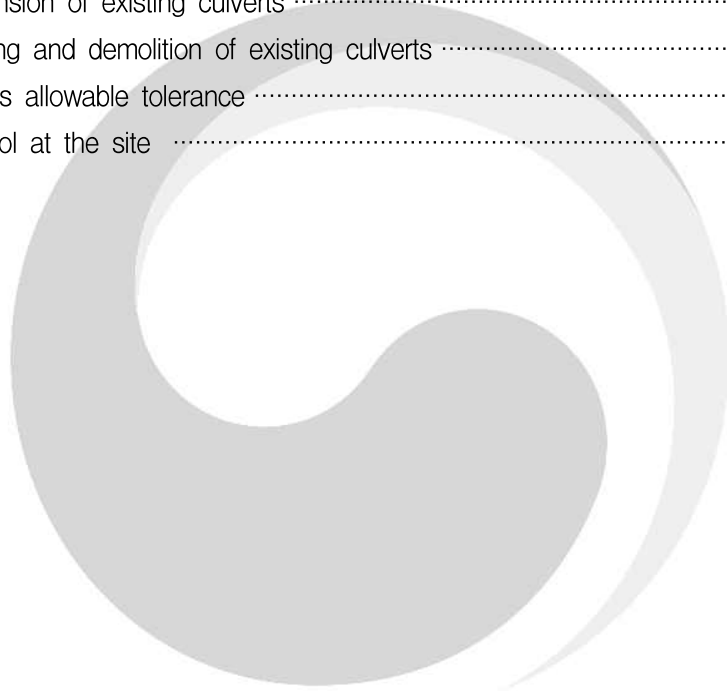
Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road Construction Standard Specifications	<ul style="list-style-type: none">• Established by the Korean Society of Civil Engineers commissioned by the Ministry of Construction	Enacted (1967.12)
Road Construction Standard Specifications	<ul style="list-style-type: none">• The specifications were improved and revised to become general specifications of overall road work by reviewing the related existing specifications and guidelines that were used and being developed.	Revised (1985.12)
Road Construction Standard Specifications	<ul style="list-style-type: none">• The specifications were improved and revised to be better specifications by advancing and complying with the currently used specifications and guidelines, along with the introduction of new theories	Revised (1990.05)
Road Construction Standard Specifications	<ul style="list-style-type: none">• The specifications were revised to enhance the international competitiveness and to promote quality improvements of road works by reorganizing the system to cope with the openness of the construction market as a result of the launch of the World Trade Organization (WTO)..	Revised (1996.07)
Road Construction Standard Specifications	<ul style="list-style-type: none">• The specifications were re-organized to establish a system of national standards and to reflect the revision of contents and other standards, such as the Korean Industrial Standard (KS) and the Standard Specification of Concrete according to the Construction Standard Organization Guideline, and to improved and revise standards to address the problems.	Revised (2003.11)

Construction Standard	Main Content	Enacted or Revised (Year.Month)
Road Construction Standard Specifications	<ul style="list-style-type: none"> The specifications were revised to improve the problems produced during the road construction and to induce reliable constructions through consistency with other standards such as the KS, Standard Specification of Concretes , and Standard Specifications of Tunnels, ensuring the prevention of shoddy and faulty construction thorough quality control. 	Revised (2009.03)
Road Construction Standard Specifications	<ul style="list-style-type: none"> The specifications were revised to reflect the recommendations from the Central Construction Technology Deliberation Committee and changed the standard specifications, specialized specifications, and design drawings. 	Revised (2015.09)
Road Construction Standard Specifications	<ul style="list-style-type: none"> Partial, revision including overview, forest and tree protection materials, and general construction works. 	Revised (2016.05)
KCS 11 40 05 : 2016	<ul style="list-style-type: none"> Integrated and organized to accommodate the code system due to the transition to the code system of construction standards. 	Enacted (2016.06)
KCS 11 40 05 : 2018	<ul style="list-style-type: none"> Modified to satisfy the Korean Industrial Standards and Construction Standards. 	Revised (2018.07)
KCS 11 40 05 : 2019	<ul style="list-style-type: none"> Modified to satisfy the Korean Industrial Standards and Construction Standards. 	Revised (2019.11)

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1. Generals

1.1 Scope of Application

- (1) This standard proposes the specification standards about the supply and installation of cast-in place concrete and precast concrete culverts.

1.2 Reference standards

1.2.1 Related laws

No contents.

1.2.2 Related standards

- KCS 10 10 10 Public administration requirements
- KCS 11 20 00 Earthworks
- KCS 11 20 05 Clearing and grubbing and topsoil removal
- KCS 11 20 15 Excavation
- KCS 11 20 25 Refilling and backfill
- KCS 11 50 00 Foundation work
- KCS 14 20 00 Concrete construction
- KCS 14 20 10 General concrete
- KCS 14 20 11 Reinforcement construction
- KCS 21 50 00 Forms and temporary shore construction
- KS D 7002 PC steel wire and PC strand
- KS F 2444 Test method of bearing capacity static load
- KSM 3805 Polyvinylchloride waterstop

1.3 Definition of Terms

- Waterstop: It refers to a copper plate, stainless steel plate, or artificial rubber plate that is inserted into a concrete joint portion for watertightness. It is made of materials with high watertightness and durability, and adaptability to extension.
- Lap joint: It refers to an increase in stress of reinforcing bars by having good adhesion of concretes by lap splice of reinforcing bars.
- Form tie: It refers to a tension member that ties the form plate by preventing it from being spread by fluid pressure of fresh concrete immediately after concrete placement.

1.4 Submission documents

1.4.1 Requirements and procedure of documents to be submitted

- (1) The requirements and procedure of document submission follow the corresponding requirements in KCS 10 10 10.
- (2) The contractor shall create a construction plan document and submit it to the construction supervisor.

1.4.2 Product material

- (1) The manufacturers of expansion joint filler and sealant and dowel bar shall submit product data and installation manuals.
- (2) The manufacturers shall submit confirmation documents that their products satisfy the specified requirements.

1.4.3 Detailed construction drawings

The detailed construction drawings that display the following items shall be submitted.

- (1) Enlarged portion of culvert section
- (2) Pipeline connecting portion and opening portion
- (3) Expansion joint installation cross-section
- (4) Concrete one-layer placement height and placement rate
- (5) Detailed installation diagram of scaffolding and temporary shore and structural calculation sheet
- (6) Others
 - ① Detailed drawings of temporary shore and scaffolding and structural calculation sheets verified by professional engineers (if required)
 - ② Documents that investigate site conditions, such as construction scale, location, and inclination
- (7) The drawings required by the construction supervisor shall be created and submitted.

1.5 Transportation, storage, and handling

- (1) The reinforced concrete built-up culverts shall be stored by always maintaining a horizontal position to avoid damage and deformation.
- (2) The manufacturers must check whether the bearing support plates are placed in the right positions and ropes are firmly tied considering the possible damage of products or vehicle accidents during transportation or loading prior to the vehicle departure.

2. Materials

2.1 Materials

2.1.1 Reinforced concrete built-up culvert blocks

- (1) The concrete materials shall follow the corresponding requirements of KCS 14 20 10.
- (2) The reinforcing bars shall follow the corresponding requirements of KCS 14 20 11.
- (3) The concrete strength, water-cement ratio, and slump follow the corresponding requirements in KCS 14 20 10.
- (4) In the block, title name, manufacturer name, manufacturing date, or abbreviations shall be marked.

2.1.2 PS strand

- (1) PS strands shall meet the corresponding requirements of KS D 7002.
- (2) No defects or damage shall be found in the PS strands. Note that surface rust, without pitting corrosion may be permissible.

2.1.3 Grout mortar

- (1) The grout mortar material shall be non-contractible, and the 28-day compressive strength shall satisfy 60 MPa or higher. The injection work shall be easy and highly fluid material that can be completely filled via natural pressure.

2.1.4 Waterstop in the joint portion 3

- (1) It shall follow KS M 3805 or the construction supervisor.

2.1.5 Filling materials in the joint portion

- (1) The joint sealer for concrete pavement can be divided into heating construction type, room-temperature construction type, and special performance construction type.
- (2) The joint sealer shall be adapted to concrete expansion and contraction, adhered well to concrete, be not soluble in water, and be waterproofed. It shall also not be lost at high temperature and resistant to impact at low temperature, while blocking infiltration, such as earth and sand and durable. It shall be approved by the construction supervisor before the use.
- (3) The primer for the joint sealers shall satisfy the quality suitable to joint sealers.

2.1.6 Waterproof cover

- (1) It is a processing material such as asphalt-based, rubber-based, or vinyl-based, and shall be used after obtaining the approval of the construction supervisor.

2.1.7 Waterstop for culvert

(1) Types and dimensions of waterstop plates are presented in Table 2.1-1, and quality criteria are presented in Table 2.1-2.

Table 2.1-1 Types and dimensions of waterstop plate for culvert

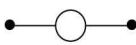

Type	Thickness (mm)	Width (mm)	Application
A type	5 or higher	200 or higher	 
B type	7 or higher	300 or higher	same as above

Table 2.1-2 Quality criteria of waterstop plate for culverts

Test item			Unit	Test criteria
Proportion				Below 1.4
Longitude			HDA	65 or higher
Tensile strength			MPa	11.8 or higher
Tensile strain			%	250 or higher
Aging resistance			%	Within ± 5
Flexible temperature			$^{\circ}\text{C}$	Below -30
Chemical resistance	Alkali	Tensile strength change rate	%	Within ± 20
		Tensile strain change rate	%	Within ± 20
		Weight change rate	%	Within ± 5
	Saline solution	Tensile strength change rate	%	Within ± 10
		Tensile strain change rate	%	Within ± 10
		Weight change rate	%	Within ± 2

2.1.8 Foundation materials

- (1) The refilling materials shall follow the corresponding requirements of excavation and filling in KCS 11 20 00.
- (2) The materials for the foundation shall be natural stones or crushed stone of 100mm to 150mm diameter, and shall not contain thin, flat or soft stones.
- (3) The sands for foundation are river sand, sea sands, or crushed sands, and shall not contain clay, silt, or other harmful substances. All sands shall pass a through a 10mm sieve, and a passing percentage of 0.08mm (No. 200) sieve shall be less than 10%.

2.1.9 Piles

- (1) The pile used in the foundation of culverts shall follow the corresponding requirements of KCS 11 50 00.

2.1.10 Floor leveling concrete

- (1) The floor leveling materials shall follow the corresponding requirements of KCS 14 20 00.

2.2. Equipment

2.2.1 Crane

- (1) The capacity specification of cranes for culvert laying shall be three to five times more than the culvert weight.

2.2.2 Mixer for grout injection

- (1) A mixer for grout injection shall be capable of continuous injection work at least at one place.

2.3 Assembly allowable tolerance

- (1) The allowable tolerance of reinforced concrete culvert blocks shall follow the values in Table 2.3-1.

Table 2.3-1 Allowable tolerance of culvert block dimensions (unit: mm)

Category	Inner width	Thickness	Evenness	Diagonal angle	Note
Allowable tolerance	± 3	± 3	± 10	± 3	

3. Construction

3.1 Verification of construction conditions

- (1) Abnormal conditions such as the compaction level at the bottom surface and water conditions shall be checked prior to installation of reinforced concrete culverts.
- (2) The site assembler shall check the accessibility of equipment and transportation vehicles at the site prior to the culvert installation work.

3.2 Work preparation

- (1) The leveling of the foundation bottom is inspected and if the bottom is not even, sands or mortars for leveling shall be prepared.
- (2) The capacity of installation equipment, entry method, work location, and installation work shall be selected.

3.3 Construction standards

3.3.1 Excavation

- (1) The excavation shall follow the corresponding requirements of KCS 11 20 15.

3.3.2 Foundation

- (1) Foundation material laying and the verification of bearing capacity
 - ① The allowable bearing capacity shall be verified in accordance with KS F 2444 after laying the foundation material, and if the bearing capacity is difficult to meet, it shall be reinforced.
 - ② If pebbles are laid as foundation materials, voids between the pebbles shall be filled sufficiently with filling materials such as pit run gravel or crushed stones, and compacted fully by small rollers or rammers to be finished with the required thickness.
 - ③ If pit run gravels or sands are laid as foundation materials, they shall be compacted thoroughly by small rollers or rammers to be finished with the required thickness.
- (2) The use of foundation piles shall follow KCS 11 50 00.
- (3) The floor leveling concretes shall be placed after laying the foundation materials and the foundation bottom shall be evenly finished unless instructed otherwise.

3.3.3 Installation of temporary shore and forms

- (1) The installation of the temporary shore and forms shall follow the corresponding requirements of KCS 21 50 00.
- (2) For form tie holes after the removal of forms, only the outer side of the backfilling portion is filled in case of box culverts for passing, and the inner and outer sides are filled with non-contractible

mortar in case of box culverts for water transfer.

- (3) If a pattern engraved form is used, the reinforcement coating is reduced by as much as the engraving depth. Thus, a measure to take this into consideration shall be investigated before construction.

3.3.4 Reinforced concrete

- (1) The concrete placement shall follow the corresponding requirements of KCS 14 20 10.
- (2) The processing and assembly of reinforcing bars shall follow the corresponding requirements of KCS 14 20 11.
- (3) Concrete shall be compacted thoroughly immediately after placement, so that concrete is fully filled around the reinforcing bars and burials as well as the forms to make compacted concrete.
- (4) If wall concrete is placed, construction shall start after the bottom slab of the culvert is fully hardened, the laitance in the concrete joint is completely removed, and the surface is made rough by high pressure water or chipping, thereby making the old and new concretes joint convenient.
- (5) If the culvert height is less than 1.2 m, side walls and upper slab concretes shall be placed simultaneously.
- (6) If the culvert height is more than 1.2 m, upper slab concrete may be placed after the side wall concrete is hardened. Here, the interlocked reinforcing bars shall be left for the joint of the side wall and upper slab concrete, and it shall be approved by the construction supervisor before the side wall concrete is poured.
- (7) If the culvert is a syphon structure, particularly water-tight concrete shall be used.
- (8) If possible, concrete for wing walls shall be poured simultaneously with the concrete poured for the main body of the culvert.

3.3.5 Precast concrete

- (1) The manufacturing, transportation, storage, foundation work at the installation place, and laying order shall follow the pre-set procedures and drawings.
- (2) The required specifications and quantities shall be pre-ordered according to the construction plan. In particular, branch pipes, curve pipes, manholes, and water pipes shall be manufactured after thorough prior consultation according to the installation layout plan.
- (3) The road conditions and unloading places are inspected prior to product shipment and products are shipped according to the culvert installation order while the shipment amount is adjusted considering the daily installation amount, storage capacity at the site, and entry road conditions.
- (4) For the foundation of the place where the culvert is to be installed, prior work required to install the culvert, such as uniform support bearing capacity required by the design precedent pre-loading or soft groundsoil improvement, the use of temporary drainage facilities if the underground water level is high, sufficient compaction of the foundation ground, and bottom surface leveling using concrete or

mortars shall be conducted.

- (5) Prior to placing the culvert, the joint surface shall be cleansed with brushes and a clean dried cloth to remove impurities, such as dust and soil, and dry conditions shall be maintained.
- (6) The culvert shall be laid from the downstream to upstream side in principle. Care should be taken about required items during culvert laying, such as the safety inspection of equipment, prevention of safety accidents, prevention of unbalanced loads, and product damage and deformation.
- (7) After joint laying, the joints are bound using mortars or caulking, and the inner surface of the culvert is finished flatly.
- (8) Water is sprayed over the joint surface and wet conditions shall be maintained to fill the micro voids tightly and making grouting work convenient. Here, excess water shall be removed.
- (9) The anchorage to anchor PS steel wires shall be cleanly finished with stiff paste of non-contractible mortars.

3.3.6 Construction joint

- (1) The construction of culvert joints shall be done according to the design drawings and instruction of the construction supervisor.
- (2) The cast-in place concrete culvert shall place extension joint or expansion joint.
- (3) The joint portion shall have durability and elasticity, and equipment that can block the inflow of underground water and sewage leakage inside the culvert. A waterstop plate shall be installed vertically to the concrete structure section.
- (4) The waterstop shall be constructed without interruption in the middle.
- (5) The construction joint shall be installed at proper spacing to play a role as an expansion joint.
- (6) Filling sealants in the joint portion shall be applied only on the inside in the case of culverts for passing and on both of the inside and outside in the case of culverts for water transfer, considering the prevention of water leakage and aesthetics.
- (7) PVC waterstop plates shall be installed to have no twist or bending at the specified position in the design drawings, and the joint of the waterstop plates shall have no water leakage with the method approved by the construction supervisor or the PVC welder.
- (8) When PVC waterstop plates are buried in concretes, foreign substances such as oils, grease, and dried mortars shall not be left on the surface. The entire waterstop plate shall be tightly filled with concretes so that it can be fixed firmly, and the joint portion shall have more than 60% of tensile strength of the original material.
- (9) Since the controlled expansion waterstop plate is constructed after concrete curing, the construction surface shall be maintained to be clean and dry. The concrete surface that is attached shall have no unevenness and no gaps shall be found when it is joined at the joint portion or crossed with the waterstop. The length of the cross shall be more than 50mm.

3.3.7 Removal of temporary shore and forms

- (1) The removal of the temporary shore and forms shall follow the corresponding requirements of KCS 21 50 00.

3.3.8 Refilling and backfill

- (1) The refilling and backfilling shall follow the corresponding requirements of KCS 11 20 05.
- (2) The culvert refilling shall be performed without negative effects on the structure, such as vibration and impact, etc.
- (3) Both walls of the culvert shall not be backfilled until the required curing is complete in the side walls and upper slab. When the upper slab is located within 3.5 m from the pavement finish surface, high quality pit run gravels are approved materials. When the upper slab is located more than 3.5 m away from the pavement finish surface, high quality earth and sands are used, which shall be piled to have a wedge shape behind the side walls of the culvert and compacted thoroughly. The construction of culvert backfilling shall make sure that the heights of both sides of the main body shall be the same.
- (4) Note that if one side should be refilled higher than the other side due to the site circumstance, it shall be constructed after acquiring prior approval from the construction supervisor once the required concrete strength is guaranteed based on indoor test results.
- (5) layer shall be marked every 200mm on the wall of the structures so the compaction condition of the layers can be inspected. Compaction shall be done so the 1st layer's thickness is equivalent or below 200mm.
- (6) After removing the existing base at the culverts for water transfer or the at the backfill, it with approved backfill materials and compaction shall be followed to prevent the loss of soil particles caused by river-bed water. Measures for drainage of influent water shall be considered.
- (7) Cracks at the backfill area shall be managed by producing a management register.

3.3.9 Waterproofing

- (1) The materials specified in the design drawings shall be used for waterproofing of the culvert main body, and appropriate waterproofing shall be done after prior approval from the construction supervisor.
- (2) The waterproofing work shall be done after acquiring the inspection and measurement on the concrete surface status of culvert main body by the construction supervisor.
- (3) If the waterproofing materials do not exhibit proper waterproof function, due to the exposure to sunlight for a long period of time after waterproofing, re-construction shall be done at the expense of the contractor.
- (4) Sheet-applied waterproofing may be done in special cases, such as culvert for passage.

3.3.10 Wing wall and inlet and outlet

- (1) Culvert wing walls and inlet/outlet shall be constructed in accordance with the instruction of the construction supervisor and design drawings. In particular, the right and left sides of cantilever wing wall shall be constructed simultaneously, and care should be taken not to have inclination and unequal settlement due to eccentric loads.
- (2) For wing walls, concretes shall be poured while pouring concretes for the culvert concrete structure. However, if the construction shall be separated, it can be done after obtaining the approval from the construction supervisor.
- (3) Drainage holes shall be installed in the wing walls for drainage behind the wing walls. The height of the drainage hole shall be lower than the slope in front of the wing wall.
- (4) In culverts for water transfer, canal protection facilities shall be installed according to flow velocity in the outlet and inlet portions as follows.
 - Upon $2.5 \text{ m/sec} < V \leq 4.0 \text{ m/sec}$: Installation of canal protection work
 - Upon $4.0 \text{ m/sec} < V \leq 6.0 \text{ m/sec}$: Installation of energy dissipater
 - Upon $6.0 \text{ m/sec} < V \leq 6.0 \text{ m/sec}$: Installation of setting tank
- (5) Cut off walls shall not be installed where inflow/outflow of culverts for water transfer are connected by concrete side gutters (V-Type, U-Type, open gutter), but shall be installed where connected by soil gutter (waterway).

3.3.11 Strut

- (1) The strut construction of patterned culverts shall be done prior to refilling and backfilling construction and start after the culvert main body construction according to the design drawings, and special care should be taken not to have inappropriate stress.

3.3.12 Expansion joint

- (1) The concrete temperature expansion joint shall be installed to prevent cracks due to concrete temperature expansion according to the culvert size.

3.3.13 One-side cut, one-side filling section

- (1) Culverts that are located in one-side cut or one-side banking section shall prevent unequal settlement due to a difference in bearing capacity of foundation ground. Foundation materials shall be laid according to the wire cylinder construction specifications and allowable bearing capacity shall be verified. If the required bearing capacity is not ensured, it shall be reinforced.

3.3.14 Approach slab

- (1) General construction
 - ① The reinforced concrete slab (approach slab) shall be reinforced at the joint portion of culvert

for culverts whose backfilling thickness is thin, and steps generated between the culvert concrete structure and backfilling joint portion shall be minimized.

(2) Approach slab structure

- ① The length of approach slab shall follow the design drawings.
- ② The width of approach slab is the width that includes a road width and both marginal strips at the inner and outer sides. If it is adjacent to wing walls, the edges shall be cut after installing joint materials.
- ③ The support of approach slab shall be installed in the rear side of the culvert, and dowel bars shall be installed at the support.
- ④ Joint materials shall be inserted between approach slab and support, and side walls of the culvert, and special support structures shall be installed at the banking side of the approach slab.

(3) Approach slab construction

- ① The place where the approach slab is installed shall be compacted naturally by construction vehicles, and then construction shall start after backfill section is compacted and stabilized.
- ② The foundation bottom of the approach slab shall have bottom leveling, and the same finish shall be applied with that of slab gradient.
- ③ The concrete placement shall follow the corresponding requirements of KCS 14 20 10.

3.3.15 Expansion of existing culverts

- (1) Culverts that are located in cut or banking section shall prevent unequal settlement due to a difference in bearing capacity of foundation ground. Foundation materials shall be laid, and the allowable bearing capacity shall be verified. If the required bearing capacity is not ensured, it shall be reinforced. The voids are filled with rubble stones when foundation materials are laid, and small rollers or hammers are used to compact it fully. Then, the construction shall be finished with design thickness.
- (2) The smashing of existing culvert joint portions shall not damage existing facilities, and the contractor is fully responsible for the damage, which shall be repaired and restored to the original state at the expense of contractor.
- (3) Existing concrete surfaces shall be cut vertically not to damage the reinforcing bars buried in existing concrete, and foreign substances including concrete residue around the reinforcing bars shall be cleanly removed.
- (4) Lap joint length with existing reinforcing bars shall be guaranteed, and lap joints shall be reinforced via welding if needed.
- (5) Concrete shall be poured in the concrete joint surface to ensure the adhesion of old and new concretes.
- (6) At the outer walls of the joint portion, waterproof sheets are constructed to prevent water

leakage.

- (7) Forms shall be firmly installed to be closely contacted with existing concretes so that no steps shall occur between the new and old concrete surfaces.

3.3.16 Closing and demolition of existing culverts

- (1) If the demolition of existing culverts whose load carrying capacity is deficient is inevitable, the upper end of the culvert is cut, and then type 5 concrete or filling materials that do not affect settlement or stress adversely (e.g., concrete $\{ \geq 16 \text{ MPa} (160 \text{ kgf/cm}^2), 40 \text{ mm} \}$ are used to fill or reinforce it.
- (2) Existing culvert demolition shall follow the specifications of KCS 11 20 05 (3.3.2), and waste concrete generated during demolition shall be recycled in principle, but it can be adjusted depending on local site conditions.

3.4 Construction's allowable tolerance

- (1) The allowable tolerances of cast-in place culvert are presented in Table 3.4-1.

Table 3.4-1 Allowable tolerance of cast-in place culvert

Item		Allowable tolerance (mm)	Measurement criteria	Note
Cast-in place	Reference level	± 30	Construction at both ends Every joint	
	Thickness $t1, t2, t3, t4$	-20		
	Width $a1$	-30		
	Height $h1$	± 30		
	Length $l < 20 \text{ m}$ $l > 20 \text{ m}$	-50 -100		

Note 1) t : Base metal plate thickness. In case of butt welding where plate thickness is different, it is set to a thinner side thickness.

3.5 Quality management at the site

- (1) Non-destructive inspection of concrete, or tests on specimens cut from the structure shall be conducted upon the request from the construction supervisor after construction completion. The test results shall be reported immediately.