

DEP SPECIFICATION

REINFORCED CONCRETE STRUCTURES

DEP 34.19.20.31-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and execution of reinforced concrete structures. It applies to both in-situ work and construction using manufactured/ prefabricated concrete elements.

This DEP is a revision of the DEP with the same number dated December 2007.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, LNG, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP or its published Amendments, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1. General Definitions

The terms and definitions used in this DEP are as noted below.

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The **Principal** may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets ().

This DEP includes generic specifications names (for example the General Concrete Specification (7.1) that refers to the EN 206-1, ACI 301-05 or CSA A23.1-09 / A23.2-09). The specification applied to any specific project depends on the location of the project. Mixing of region specifications as defined in the normative reference section of the DEP (7) within a project shall not be permitted.

Documents referenced in this DEP are listed in (7.2).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated December 2007. The main changes are driven by:

1. Integration of the Shell Americas concrete standards;
2. Upgrading of the construction and quality aspects of concrete execution;
3. The requirement to split the content into Specification and an Informative DEP.

There were major changes to the content of this DEP. All changes are the result of segregating the DEP in to Specification and Informative.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of “DEPs on the Web”, available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. GENERAL

2.1 PURPOSE OF THIS DEP

This DEP provides the basis for the development of specifications and supporting documentation for concrete works for major or minor projects based on the national standards supplemented by the requirements of this DEP.

Any conflicts or inconsistencies between this DEP, the design drawings, and specifications shall be brought to the attention of the Principal for resolution.

2.2 APPLICABLE CODES AND STANDARDS

The key or "lead" national standards and/or specifications (e.g. termed "General Concrete Specification") of each element of the work are referenced in the text. Reference shall be made to (7) of this DEP for an overview of the key National Standards and Specifications.

The Euronorms shall be supplemented by the National Annexes of the respective European member states for their own areas of jurisdiction.

For countries that do not adopt standards listed in (7) of this DEP then the Contractor shall propose to the Principal an alternative national standard system that shall meet the minimum requirements of those systems listed in (7). In the event of conflict between the two sets of specifications, the more stringent shall be selected and submitted to the Principal for review and comment.

3. DESIGN OF CONCRETE STRUCTURES

3.1 DESIGN BASIS

All structures shall be designed with safety as the primary consideration.

The design and calculations of reinforced concrete structures shall be based on the relevant Design of Concrete Structure Specification; see (7.1.)

The load criteria for all concrete structures shall be in accordance with DEP 34.00.01.30-Gen., Sections 3.1 to 3.20.

Pre/Post-stressing of concrete is permitted only in the following applications:

- a) walls for LNG/LPG storage tanks;
- b) bridge and culvert decks in roads;
- c) structures for buildings;
- d) piles;
- e) other structures outside the process plant area, where the risk of fire is limited subject to the approval by the Principal.

The design of pre-stressed concrete structures shall be according to the relevant design standard as presented in (7.1).

3.2 EXECUTION DOCUMENTS

The following section provides general requirements for structural concrete drawings which are in addition to the requirements of DEP 34.00.01.30-Gen. Section 2.3.

The Contractor shall propose and submit the General Notes for the review and approval by the Principal. Example concrete general notes are provided in Appendix A.

3.3 DESIGN DETAILS

3.3.1 Constructional and movement joints

Where required, constructional and/or movement joints shall be provided in concrete structures and indicated on drawing.

Isolation joints shall be placed where differential movement is anticipated between the pavement and other adjacent vertical surfaces (e.g., walls, columns, catch basins, manholes, and equipment foundations).

3.3.2 Reinforcement and embedments

In areas where reinforcing steel congestion is anticipated, manufactured embedments may be substituted to fully develop reinforcing strength at splices. The design of these manufactured embedments shall be submitted to the Principal for review and comment.

The design of anchor bolts and anchorages shall meet the requirements of the relevant Anchorage Design Criteria Specification (7.1).

The minimum edge distance of anchor bolts shall be six times the anchor bolt diameter.

The minimum concrete cover on the outer reinforcement and minimum clear distance between individual bars shall be per the relevant Concrete Design Specification (7.1). For minimum clear distances and requirements for ties/stirrups and other reinforcing see DEP Standard Drawing S19.012.

3.4 SPECIAL FOUNDATIONS AND STRUCTURES

3.4.1 Liquid-retaining structures

Liquid retaining structures should be water tested under atmospheric pressure conditions. Acceptance criteria for these tests shall be submitted to the Principal for review and comment.

Environmental structures (structures that hold solids but could have liquids entrained e.g. Sludge Pits) and structures required to be liquid tight shall meet the requirements of Design of Liquid Retaining Structures (7).

3.4.2 Foundations and structures subject to vibration

Foundations and structures subject to vibration shall be isolated from adjacent structures. A detailed design and vibration assessment or analysis shall be performed for these foundations to model foundation performance. This analysis shall be performed in accordance with DEP 34.00.01.30-Gen., Section 3.10.

The static deformation for rotating equipment foundations shall be evaluated and shown to be within the limits stated by the Manufacturer/Supplier of the equipment. The calculations when required shall include, but not be limited to, the following causes of deformation:

- a) shrinkage and creep of concrete or grout;
- b) temperature effects caused by radiation and convection of heat or cold generated by machinery, piping and ducting;
- c) temperature effects due to winter, summer / daylight
- d) elastic deformation caused by changing vapour pressure in condensers;
- e) elastic deformation caused by soil settlement or elastic compression of piles.

3.4.3 Foundations and structures subject to temperature effects

All critical foundations and structures subject to temperature effects shall be designed for any temperature difference that may occur in parts of structural members and/or the whole structure.

3.4.4 Box-outs and curbs

All holes in table tops which have equipment underneath shall be enclosed by concrete, grout and/or a suitable elastomeric caulk after installation of piping, equipment, or other items.

All edges of table top slabs shall have a curb of minimum 100 mm (4 inches) height with a designated drain.

3.4.5 Skirted process column pedestals

The pedestals of the foundation for skirted process vessels shall be provided with a slope and drain. Reference DEP Standard Drawing S19.014 for typical drainage details.

4. MATERIALS AND COMPONENTS

All materials (shown below in alphabetical order) shall conform to the requirements of the relevant General Concrete Specification (7.1) and related Standards.

4.1 ADMIXTURES

Only one Manufacturer of each admixture (except air entrainment) shall be used. The relevant Admixtures shall be submitted to the Principal for review and comment.

4.2 AGGREGATES

Aggregate used by each Manufacturer/Supplier shall be obtained from a single source throughout the course of the job.

4.3 ANCHOR BOLTS AND EMBEDMENTS

Anchor bolt materials shall be based on standard bolt assemblies and galvanised according to DEP 34.28.00.31-Gen., Section 4.3.

Anchor bolts and assemblies shall meet the requirements of DEP Standard Drawings S10.045 or S28.020.

Other embedded steel material shall be standard grade or low grade steel materials and galvanised in accordance with DEP 34.28.00.31-Gen., Section 4.3.

Aluminium items are not permitted to act as concrete embedments.

Concrete anchors shall be per the drawings and specifications and the following requirements:

- Expansion anchors are not to be used where structural tension or moment loads are to be resisted.
- Fully threaded rod is acceptable as long as the net area of the bolt is used for design and anchor bolt pre-stress.
- Epoxy anchor bolts that are installed into hardened concrete with an engineered proprietary system are acceptable. Epoxy anchor bolts used for sustained structural loads shall be seismically qualified. These bolts shall not be installed in overhead applications.
- Wet dipping of anchor bolts is not permitted.

4.3.1 Anchor bolt sleeves

Anchor bolt sleeves should be used for equipment cast-in-place anchor bolts where a template is not provided.

Anchor bolt sleeves shall be installed when specified by the mechanical or other equipment drawings. These sleeves shall be designed to accommodate the pretension requirements of the design anchor bolts according to DEP Standard Drawing S10.045.

For large prefabricated skids and equipment anchor bolt sleeves shall be provided to allow for minor field adjustments.

4.4 CEMENT

Blended Portland blast furnace cement shall be used for general applications. This material shall be in accordance with the relevant General Concrete Specification (7.1).

The number of cement types and design mixes in a project shall be minimized to simplify execution and quality control.

Portland Cement shall conform to the relevant Portland Cement Specification (7.1).

High early strength concrete may only be used if the relevant data is submitted to the Principal for comment. This type of cement shall not be used for compressor foundations.

High-alumina cement shall not be used for structural applications.

Only one brand of cement shall be used.

Cement older than 6 months shall not be used.

Cement which has been in storage for more than 3 months from the date of manufacture shall be tested to verify that its quality is still in accordance with the relevant General Concrete Specifications (7.1).

Cement containing lumps shall be rejected.

4.5 JOINT FILLER

Remoulded expansion joint filler shall conform to ASTM D994 or ASTM D1751.

4.6 JOINT SEALANT

Sealer shall be a two component polysulfide compound.

Sealer for downhand application shall be liquid self-levelling grade. Application shall conform to:

- EU: BS 6093 and BS 6213;
- US/CA: ASTM D6690.

Sealer for vertical joints or for overhead application shall be trowel grade. Application shall conform to:

- EU BS 6093 and BS 6213;
- US/CA: ASTM C881/C881M Type IV Grade Grade-3, Class-B/C.

4.7 MIXING WATER

The water used for mixing water, ice, curing, or any other function relating to the placement of concrete shall be clean and fresh, and free from harmful matter in accordance with the relevant Mix Water Specification (0.1).

4.8 REINFORCING STEEL

Reinforcement for general concrete work shall be in accordance with the relevant Reinforcement Steel Specification (7.1).

Reinforcement for general concrete work shall be hot rolled high yield deformed bars.

Reinforcing bars shall be uncoated deformed billet steel.

Welded wire fabric shall be flat (unrolled) plain wire fabric.

Tie wire shall be black annealed wire, binding wire of approximately 1.5 mm (16 BWG).

When rebar is used as part of the earthing/grounding installation and the grounding connection is required to be welded, weldable rebar shall be specified to facilitate grounding wire installation; see also (5.4.1).

Prestressing steel shall be in accordance with the relevant Design of Concrete Structure Specification.

4.9 SPACERS

Reinforcement bar supports, bolsters, chairs, spacers and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place shall be manufactured and installed according to CRSI Reinforcement Manual. For concrete surfaces exposed to view where legs of wire bar supports contact forms and where rust stains in the concrete finish are objectionable, CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports shall be used.

4.10 VAPOUR BARRIER/ BUILDING PAPER

Vapour barrier/ building paper shall be a virgin heavy-duty polyethylene film, with the following characteristics:

- Minimum thickness of 0.15 mm (6 mils);
- Uniform thickness throughout;
- Overlap shall be not less than 150 mm (6 inches) at all joints and intersections;
- Flexible to enable construction at temperatures down to the lowest possible site temperatures;
- Moisture transmission of less than 0.45 metric perms (0.3 US perms) determined in accordance with ASTM E96/E96M;
- Free of pinholes, nozzle scars, or other imperfections.

5. EXECUTION OF CONCRETE STRUCTURES

5.1 EXECUTION MANAGEMENT

The execution management of the structural concrete works shall be outlined in a concreting execution plan.

In addition to providing a plan on how the work will be managed, a method statement shall be provided which describes how the works will be performed and how the HSSE issues during all phases of the concreting execution will be addressed.

A concreting execution plan shall address (or reference) the following information for each subset of the work:

A. Organisation:

- Personnel;
- Plant and equipment.

B. Requirements:

- Permits and required documents;
- Description of work and planning (including all HSSE concerns during execution);
- Construction schedule and sequence, complete with manpower, plant and equipment;
- Logistics of the concrete mixing transport and pouring including:
 - contingency plans for construction joints and pumping,
 - Testing and schedule readiness of placement equipment;
- Relevant drawings of rebar/post-tensioned tendons;
- Inserts and cast items;
- Concrete placing requirements including:
 - Maximum thickness of mass concrete layers,
 - How concrete segregation will be avoided particularly when placing concrete in tall walls and columns, etc.,
 - Vibration and re-compaction plan,
 - Concrete curing and protection schedule and plan,
 - Preventative measures to avoid settlement of the formwork;
- Formwork:
 - schedule for design, placement (and re-use),
 - requirements for removal;
- Joint preparation requirements;
- Pour abandonment procedure.

C. Concrete Testing Inspection and Quality Plan (0).

D. Safety, Health and Environmental issues:

- Construction site risk inventory;
- Toolbox meetings;
- Safety and health risk inventory.

E. Long and short term weather expectations.

F. Contingency plans regarding weather and equipment spares.

The above documents shall be submitted to the Principal for comment prior to commencing the works.

5.2 PREPARATORY WORK

5.2.1 Setting out and tolerances

Setting out shall be in accordance with the relevant General Concrete Specification (7.1) and the following:

Tolerances for concrete surfaces which are not listed in Table 1 shall be the same as those specified in:

- EU: EN13670;
- US: ACI 117, Section 4, Cast-in-Place Concrete for Buildings.

Embedments shall be installed in accordance with the tolerances shown in Table 1. The term "bolt group" used in Table 1 is defined as the set of anchor bolts for a single fabricated steel shipping piece, or a single piece of equipment or skid.

Table 1 Tolerances for Embedments

Measurement	Tolerance
Anchor bolt projection	+ 6 mm (1/4 inch), – 0.00 mm (0 inch)
Elevation of the top of bolts.	+ 6 mm (1/4 inch), – 0.00 mm (0 inch)
Anchor bolt plumpness	4 mm in 1 meter (1/8 inch in 3 feet)
Centre of bolt group	+ or – 6 mm (1/4 inch)
Centre to centre of any two anchor bolts within a bolt group without sleeves.	+ or – 3 mm (1/8 inch)
Centre-to-centre of any two bolts in a bolt group with sleeves	+ or – 6 mm (1/4 inch)
Centre to centre between bolt groups	+ or – 6 mm (1/4 inch))
Centre-to-centre of adjacent bolt groups that receive structural steel columns with interconnecting members.	+ or – 6 mm (1/4 inch)
Plate insert horizontal and vertical location	+ or – 6 mm (1/4 inch) horizontal and + or – 1 mm (1/32 inch) vertical
Maximum accumulation per 30.5 m (100 ft) along line of bolt groups receiving structural steel columns with interconnecting members	+ or – 6 mm (1/4 inch)
Maximum total accumulation along line of bolt groups receiving structural steel columns with interconnecting members.	25 mm (1 inch)
From the centre of an anchor bolt group to the column line through that group.	+ or – 6 mm (1/4 inch)

5.2.2 Foundation preparation

A layer of blinding concrete (seal slab) of 50 mm (2 inches) minimum thickness shall be placed under foundations in order to avoid disturbance of soil by rain or ground water.

In regions where frost susceptible soil is present and the concrete foundations anchored by piles are in direct contact with soil, void form material that remains compressible for the specified design temperatures shall be used to minimize the possibility of loading of the concrete due to swelling of the soil due to ice lens build-up.

Foundations shall be inspected in accordance with the ITPs (6).

A 75 mm (3 inches) course of sand or gravel shall be placed above the vapour barrier/building paper when interior grade slabs require a vapour barrier/building paper.

5.2.3 Placement of prefabricated concrete

When prefabricated concrete elements are placed directly on steel structures, a load bearing layer shall be placed between those elements. The layer material shall be neoprene, nylon, rubber or equivalent. When applicable the material shall be chemical resistant.

When prefabricated concrete elements are placed on soil, they shall be either bedded in a sand layer, on blinding concrete or equivalent materials.

When pre-fabricated elements are placed in in-situ concrete slots, non-shrink grout shall be used to provide a bearing surface in the slot in accordance with the Manufacturer's specifications.

5.3 FALSEWORK AND FORMWORK

5.3.1 General

All formwork, false work and re-shoring (formwork) shall be in accordance with the relevant Formwork Specification (7.1).

Vertical surfaces of sub-grade structures and pavements shall be formed.

Chamfer strips, 20-mm (3/4 inches), shall be provided at all corners on permanently exposed surfaces.

Formwork shall be kept clean and free from defects, holes, binding wire, sand, water, etc. This shall be confirmed by inspection before pouring. Formwork for column and wall shall be provided with adequate cleanout openings to permit inspection and easy cleaning after reinforcement has been placed.

Form accessories, such as ties and hangers that remain embedded in the concrete, shall be a commercially manufactured type, and shall be no closer than 25 mm (1 inch) from the finished concrete surface.

Form ties or tying methods, which can cause spalling of concrete during form stripping or create rust or discoloration on concrete exposed surfaces, shall not be used. Where the tying method requires remedial repair to maintain the liquid retention integrity of a component, such repair methods shall be submitted to the Principal for review and comment 2 weeks before formwork begins.

Spreader cones on ties shall not exceed 25 mm (1 inch) in diameter.

Form-release agents shall not be applied if concrete surfaces will receive special finishes or where the form-release agent may affect applied coverings. Alternatively, inside surfaces of untreated formwork shall be soaked with clean water and kept moist before placing concrete, but no standing water is permitted in the formwork before the concrete pour.

Unless otherwise specified, internal surface of forms shall be coated with form oil before the reinforcement is placed. Excess oil shall be removed.

Internal surface of forms for concrete surfaces that will be painted shall be coated with oil-free form sealer.

5.3.2 Removal and loading

Formwork shall be removed in accordance with the relevant Formwork Specification (0.1).

Forms for self-supporting members, and water-tight basins may be removed if the concrete strength is at least 80 percent of the specified 28 day strength.

A formwork striking plan shall be submitted to the Principal for review and comment. Forms shall not be left permanently in place.

No superimposed load shall be applied to self-supporting members until results of compression testing and calculations demonstrate that the load can be accommodated.

5.4 REINFORCEMENT AND EMBEDMENTS

5.4.1 Reinforcement fabrication

Reinforcing steel shall be fabricated (cut, bent etc.) in accordance with the relevant Steel Reinforcement Specification (7.1).

Welding of concrete reinforcing steel if permitted shall be per the relevant welding standards included in the quality plan. Any welding of reinforced steel shall be submitted to the Principal for review and comment.

Reinforcement placing drawings and bending schedules shall be prepared in accordance with:

- EU: EN ISO 3766
- US: ACI SP-66.

Drawings and schedules shall show number, grade, size, length, mark, location, and bending diagrams for reinforcing bars.

Splices in reinforcement shall be detailed, fabricated, and located as shown on the drawings. All splices not indicated or as detailed on the project drawings shall be approved by the Contractor and submitted to the Principal for review and comment.

Fabrication drawings (bend schedule) shall indicate the related purchasing identification number, release number, and design drawing number.

5.4.2 Reinforcement handling

Reinforcement shall be tagged with weather-resistant metal tags.

The tags shall indicate drawing number, release number, mark number, grade, bar quantity, bar size, and length.

Reinforcement bundles shall include material grade, bar size, and length.

5.4.3 Placing reinforcement

Exposed reinforcing bars including dowels that are vertical shall be protected using plastic protection caps.

Reinforcing steel shall be secured against displacement within tolerances specified in the relevant Steel Reinforcement Specification (7.1).

Whenever conduit, piping inserts, pipe sleeves, etc. as called for on the drawings interfere with placing of reinforcement, proper adjustment or addition of reinforcement steel or the other embedment shall be approved by the Contractor before concrete is placed.

A procedure for bending or straightening of reinforcing bars partially embedded in concrete shall be submitted to the Principal for review and comment.

All reinforcing shall be in place prior to pouring concrete. No wet placing (i.e. during concreting operations) shall be permitted.

5.4.4 Placing anchor bolts and other embedments

Anchor bolts, anchors, inserts, anchor rails, sleeves, drains, curb and seat angles, nosing, and other embedded items shall be positioned in accordance with the requirements of Table 1 and secured before placing concrete. Welding of these items to the reinforcing bars shall not be permitted.

When an anchor bolt template is provided by an Equipment Manufacturer any adjustment in the position of template or anchorage locations within the template shall be indicated on the

base plate drawing supplied with the loading information from the Manufacturer. Any such adjustments shall be clearly indicated on the detail foundation drawing with the method(s) to be applied. If adjustments are required, the Manufacturer shall approve these changes before they are made.

Anchor bolt threads and the exposed surfaces of other embedments shall be kept free of concrete and be protected from corrosion and other damage until the equipment/structure is permanently installed.

Anchor bolt sleeves shall be capped and/or filled with nonbonding mouldable material to keep out water, concrete, and debris during the placement of concrete and grout.

5.5. INSTALLATION OF WATERSTOPS

Waterstops shall be installed as located according to the Manufacturer's recommendations, specifications and drawings as part of the formwork installation.

Adequate provisions shall be made for the support and protection of the waterstops during the progress of the work. Damaged waterstops shall be replaced and/or repaired before embedment in concrete.

5.6 JOINTS

5.6.1 General

All joints shall be specified, located and constructed in accordance with the drawings and specifications.

5.6.2 Control joints

Control joints shall be installed as per:

- EU: EN 13670,
- US: ACI 302.1R Guide for Concrete Floor and Slab Construction.

Control joints in slab toppings shall be located directly above and in line with the control joints in the underlying concrete slab.

5.6.3 Isolation/ Expansion joints

Dowels at expansion joints shall be properly aligned to prevent any restraint on expansion movement at the joint.

Width of expansion joints shall be 12 mm (0.5 inch) minimum and 25 mm (1 inch) maximum unless the requirement of a larger expansion joint is demonstrated by expansion calculations of the joint. Sides of joints shall be parallel. The spacing of expansion joints shall be as specified on the drawings.

Reinforcing steel shall not extend through expansion joints; dowels shall be bonded on only one side of the joint.

5.6.4 Construction joints

The surface of construction joints for structural components shall be roughened or a retarder may be sprayed immediately after placing of the concrete. The aggregate at the surface shall be exposed uniformly with no laitance and no loosened particles of aggregate or damaged concrete before the subsequent pour.

The surface of joints shall be cleaned of scale and laitance and thoroughly wetted, but be free of standing water, before placing adjoining concrete.

The surface preparation of construction joints for pavements and secondary structures (e.g. manholes, catch-basins, trenches or minor foundations) shall be as specified in the drawings.

When contingency construction joints are detailed in the drawings all materials shall be available to install these joints along with a contingency plan.

5.7 CONCRETE MEASURING, MIXING, PRODUCTION, TRANSPORTING AND WEATHER PROVISIONS

5.7.1 General

Concrete shall be manufactured and delivered to the site of placement in accordance with the relevant Concrete Mix Specification (7) supplemented by the requirements mentioned below.

The concrete may be sourced from a commercial ready mixed concrete Manufacturer/Supplier or a batch plant specifically set up for the needs of the project. The batch plant(s) shall be capable of meeting the project demands with adequate fall back provisions.

The Manufacturer/Supplier providing measuring, mixing, production and transportation of ready-mix concrete shall be registered and certified in accordance with local requirements. This applies to both commercial and dedicated project facilities. The certifications shall be current for the duration of the concrete supply.

The following pre-concreting operations shall be met:

1. A concreting and inspection test plan including all actions to be dealt with relevant to the execution;
2. Equipment made from aluminium or aluminium alloys for pump lines, tremies or chutes to transport shall not be permitted;
3. The initial testing of concreting by trial casting, documented before the start of execution when specified;
4. Documented inspection and approval of all preparation works according to the Project Inspection Test Plan (6.2).

5.7.2 Manufacturer/Supplier

Irrespective of the types of concrete to be produced, an inspection report of the proposed concrete Manufacturer/Supplier shall be provided to the Principal for review and approval. The report shall address that:

- the batching plant operation, materials testing, complies with the project requirements;
- the certification and calibration of all necessary equipment takes place at the correct intervals in accordance with this DEP and the relevant ITP.

Ongoing inspections of the ready mixed concrete Manufacturer/Supplier, ensuring continual compliance with the project requirements, shall be performed.

5.7.3 Dedicated project batch plant

When a concrete mixing plant is required to be provided (e.g. on site) full details of the fully automated concrete mixing plant(s) and devices, material storage etc. shall be submitted to the Principal for review and comment.

5.7.3.1 Facility requirements

The continuation of supply of concrete shall be guaranteed by the provision of redundancy of plant, equipment and utilities as required by the project.

A minimum of two sets of concrete batching trains in each batch plant shall be provided.

The plant shall be provided with suitable utility support to enable simultaneous operation of the trains. The plant design shall assume 75% continuous daily (8 hour days) usage of both trains.

The plant area shall be adequately paved with concrete or gravel, and surrounded by a fence. The plant construction works shall meet the project HSE, quality and construction requirements for temporary facilities.

All components utilised in the construction of the facility shall be either new or refurbished to as new condition and shall be maintained as such throughout the duration of the works. All

equipment, structures and components including supporting structures shall be of such a design to adequately withstand the local environmental conditions. All equipment installed or utilised shall be specifically designed for the production and delivery of high quality, temperature controlled concrete despite variations in ambient temperature.

The functionality of the facilities within the batching plant shall be as follows:

- Two drum type mixer trains, with a average capacity as designated by the Contractor;
- Laboratory including temperature controlled curing basin;
- Provision for a free draining aggregate stock yard sufficient for two months supply at peak capacity of two trains. Depending on the project requirements, concrete or gravel may be used for paving in this area;
- Cement bag storage for two months supply at peak capacity of two trains;
- Cement silos for one day's supply at peak capacity of two trains;
- Curbed, concrete paved area for storage of additives and admixtures;
- Wash out pit and concrete disposal area;
- Facility to ensure quality of any discharged water shall comply with national requirements;
- Parking spaces for concrete trucks as defined by the Contractor;
- The plant shall be designed for day and night time production of concrete as required by the project;
- Offices.

Before the commencement of erection of the batching plant, the full design and construction drawings supported by specifications and operational procedures, all in accordance with the batch plant Manufacturer's instructions, shall be provided to the Principal for review and comment. The documentation shall also include a construction and demolition schedule for the facilities along with a site renovation plan.

The batch plant shall be inspected in accordance with the ITP specifically developed for the project.

The functionality of the batch plant facility shall be demonstrated during the full scale batch plant trial mixes. Certification and registration of the facilities shall be carried out as required under local regulations prior to the commencement of production of concrete for the project.

5.7.3.2 Transport and storage of cement

The Batch Plant storage shall meet the following requirements:

- i. The cement shall be delivered to the site in ply bags or in bulk carriers. Bags transported by sea shall be packed in plastic and stored to prevent moisture ingress. The name and brand of the Manufacturer, including batch number and date of manufacture, shall be clearly marked on the bags.
- ii. The cement shall be stored in such a way that the date of manufacturing is clearly visible so that it is used in sequence by the date of manufacture, oldest first.
- iii. The height of storage of the bags shall be safe and structurally sound with a ventilated space between the floor and lowest bags. In tropical and subtropical areas the outside of the cement storage shall be painted white.
- iv. A cement storage shall be provided with the following:
 - concrete floor;
 - waterproof walls and roof;
 - ventilation in the building to prevent condensation;

- adequate drainage system;
 - air-conditioning system to control the temperature between 0 °C and 40 °C.
- v. The bulk cement shall be stored in a silo. The silo shall comply with the following:
- in hot climates the silo shall be painted white;
- vi. in all areas the temperature shall be maintained between 0 °C and 40 °C The cement shall be suitably protected during storage to avoid deterioration in quality.

5.7.3.3 Severe climate requirements:

Should the plant be located in a severe climate, then the following requirements shall also be included:

In cold climates:

- warm mixing water supply;
- heated aggregate storage for three days' supply at peak capacity of two plants;
- adequate covers to prevent snow ingress, (e.g. covered conveyer belts);
- snow clearance programs etc.

In hot climates:

- Sheltered aggregate storage for three days' supply at peak capacity;
- Provision to minimise the temperature of fresh concrete on mixing and transportation to site, for example by provision of a water chiller, or the use of ice as mixing water.

5.7.4 Laboratory facilities

An independent testing agency shall be employed to inspect and test the concrete and its constituents. The testing agency may either be locally available (e.g. commercial testing facilities), or dedicated project facilities may be provided.

All concrete testing shall be independent of the concrete production facilities.

Laboratory, equipment and personnel and quality systems shall comply with the relevant General Concrete Specification (7.1) and be registered, certified and in accordance with local or national government as required. Calibration of equipment shall be performed in accordance with the frequencies and to the standards stipulated by national authorities, or as specified by the project, whichever shall be more stringent. Laboratory test equipment shall be maintained in good condition and subject to routine servicing and inspection. This shall be described in the Laboratory Testing Facility Quality Plan which shall be available for review in the laboratory.

The laboratories shall be able to cope with all required testing and the peak project work load. Adequate spares shall be provided to prevent delays to inspecting and testing

All documentation, such as Codes and Standards as well as project procedures, required to perform the inspection and testing work, shall be available within the laboratory facilities.

5.7.5 Concrete mix design

The optimum design mix shall be developed to address, amongst other issues, the proposed application, travel time from batching location to point of pour, workability, placing equipment, climatic conditions, sequence for placing concrete including the limits of individual pours and the height of lifts, heat of hydration, aim to minimize thermal and shrinkage strains and durability.

The concrete mix design shall be submitted to the Principal for review and comment.

The compressive strength of the concrete mix shall be in accordance with the drawings and specifications, which as a minimum shall specify 28 day compressive strengths as listed in Table 2:

Table 2 Concrete mixing and strengths

Item	Design Compressive Strength of Concrete	
	Per ACI 318	Per EN 206-1
Slabs, area paving, roads, watertight concrete, machinery foundations, and concrete exposed to severe freezing and thawing conditions	28 MPa (4000 psi),	Grade C25/30
Structures and their foundations and for stationary equipment foundations except jetties	28 MPa (4000 psi),	Grade C25/30
Seal Slab or Blinding concrete, and miscellaneous non-structural concrete fill	14 MPa (2000 psi)	Grade C16/20
Concrete envelopes for underground electrical ducts and cover slabs for direct-buried cables	14 MPa (2000 psi)	Grade C16/20
Pre-stressed concrete structures and reinforced concrete of marine structures	41 MPa (6000 psi)	Grade C35/45

The required concrete mixes shall be designed in accordance with the relevant Concrete Mix Specification (0.1)

The maximum Water Cement Ratio (WCR) shall be according to the relevant Concrete Mix Specification (7.1) as listed in Ratio Table 3.

Air content at the point of delivery shall be in accordance with the relevant Concrete Mix Specification (7.1).

Weight of pozzolan materials shall not exceed 25% of the cement weight.

Table 3 Water Cement Ratio

	WCR maximum
Typical Structures (except as noted below)	0.45
Seal Slab or Blinding concrete and miscellaneous non-structural concrete fill.	0.55
liquid-retaining (hydraulic) structures	0.4
Concrete deposited by tremie under water or for Pre-stressed concrete structures and reinforced concrete of marine structures	0.44

Note: Water-cement ratio for mixtures containing pozzolan shall be the water to "cement plus pozzolan" ratio.

5.7.6 Trial mixes and trial pours

Trial mixes and trial pours shall be conducted before the permanent placing of concrete is started, to prove the workability of the design mix concrete and that the specified concrete grade can be obtained.

An analysis should be performed to determine whether trial mixes, or trial pours are required and a report shall be submitted to the Principal for review and comment.

For each trial mix inspection and testing shall be performed in accordance with the ITP developed for the project.

The time required for any trial mixes and pours with associated testing shall be included as a part of the constructions schedule, being completed one month prior to commencement of concreting works.

Method Statements shall be developed and submitted to the Principal for review and comment.

5.7.6.1 Trial mixes

Trial mixes shall be performed as follows:

- Laboratory Trial Mixes;

Laboratory tests shall be carried out to demonstrate the design mixes satisfy all the requirements of the specification with the available proven materials.

The trial mixes shall be tested in fresh and hardened form to determine the properties of mixes proposed.

- Full Scale Trial Mixes;

On satisfactory completion of laboratory trial mix tests, full scale trial mix tests shall be undertaken to demonstrate the adequacy of the selected batching plant and to confirm the fresh and hardened concrete properties as tested in the laboratory.

5.7.6.2 Trial pours

Trial pours including curing activities shall be performed under the same conditions as expected in the field (i.e. with the same formwork, equipment, personnel etc.) for the selected concrete mixes.

Special attention shall be paid to possible bleeding, or segregation, after placement. Trial tests, including a bleeding test in accordance with specified project test methods shall be performed especially for large or thick concrete elements (e.g. horizontal slabs, columns).

Non-Destructive, Destructive testing, or testing of cores, shall be performed as specified by the project to demonstrate the integrity and homogeneity of the test piece.

5.7.7 Heat of hydration

Mass Concrete should be poured in accordance with ACI 207.1R.

If the temperature gradient is more than 20°C between the inside and outside faces of the concrete, adequate measures shall be developed and proposed to reduce the thermal gradient. The proposal shall be submitted to Contractor for approval and proven through site trials.

Where Mass Concrete is specified, the heat of hydration shall be monitored in trials to demonstrate excessive thermal gradients shall not be present during the works. A formal method statement shall be developed and submitted when heat of hydration issues exist.

For each mix design for slabs and walls over 600 mm (24 inches) thick and sections which are required to be liquid retaining or liquid tight, the following shall be performed and a method statement developed accordingly:

- Computer model simulations shall be performed to confirm that the heat of hydration will not cause a temperature differential between the interior of the concrete and any outside face greater than 20 °C.
- The performance of trial mixes / trial pour with special attention to the heat of hydration and workability:
 - o Full size (scale 1:1) test pieces shall be cast and tested representing the actual pouring conditions;
 - o Temperature monitoring using thermocouples;
 - o Strength development versus time;
 - o Observation of bleeding and general condition of the concrete during the pour;
 - o Guidance and supervision by authorized personnel;
 - o Protective measurements and curing to avoid crack formation;
 - o The size and sequence of pours, concrete temperature-monitoring system of pours, formwork type and removal time, and calculations for temperature and strain development at internal and surface locations, taking into account heat of hydration, ambient radiation and temperature, and physical restraints;
 - o After removal of formwork a check on crack formation, supported by taking cores.

The following shall be taken into consideration for cold climates:

- The precautions to be considered for reducing the heat of hydration shall include the use of heating measures, plywood formwork, the insulation of surfaces, protection of newly cast surfaces from solar radiation and the avoidance of cold water curing leading to thermal shock and/or by applying low-heat cement, retarder, pozzolanic material.

The following shall be taken into consideration for hot climates:

- The precautions to be considered for reducing the heat of hydration shall include the use of cooling measures, plywood formwork, the insulation of surfaces, protection of newly cast surfaces from solar radiation and the avoidance of evaporation leading to thermal shock and/or by applying low-heat cement, retarder, pozzolanic material.

5.8 EXTREME WEATHER PROVISIONS

Provisions for pouring concrete in extreme weather conditions shall be made with reference to the relevant Extreme Weather Specifications (7.1).

5.8.1 Hot weather concreting

A method statement shall be developed and submitted to the Principal for review and comment if it is likely the combination of temperature, humidity, and wind velocity is expected to cause a rate of evaporation equal to or greater than 9.6 Newtons per square meter per hour (0.2 pounds per square foot per hour).

The temperature of the concrete shall not be higher than 32.2°C (90°F) and shall not be so high as to cause loss of slump, flash test, or cold joints.

5.8.2 Cold weather concreting

A method statement shall be developed and submitted to the Principal for review and comment if it is likely that the ambient temperature is expected to be below 4.4°C (40°F) during placement of concrete, or within 24 hours thereafter, the temperature of the concrete as placed shall not be lower than the values listed in Table 4.

Table 4 Cold Weather Concreting

Air Temperature °C (°F)	Thin Sections Less Than 760 mm (30 in) in Least Dimension °C (°F)	Mass Concrete 760 mm (30 in) or greater °C (°F)
-1 - 7 (33.8 – 44.6)	16 (60.8)	10 (50)
-18 - -1 (-0.4 – 30.2)	18 (64.4)	13 (55.4)
Below -18 (Below 30.2)	21 (69.8)	16 (60.8)

Formwork temperature shall be raised to above 5°C (41°F) at the time of concrete placement. Concrete shall not be placed on frozen sub-grade or on sub-grade that contains frozen materials.

Concrete shall remain protected from freezing for seven days. When forms are removed the ambient air temperature inside the protection shall be not more than 5°C (41°F) above the placing temperature. No curing water is required if adequate steam is used.

Ground, rock, formwork or structural parts in contact with the section to be cast shall have a temperature which does not result in freezing of the concrete before it has sufficient strength to resist the effects of freezing (in general > 5 N/mm² (725 psi)).

5.9 CONCRETE PLACING**5.9.1 General**

The placing of concrete shall be in accordance with the appropriate clauses of the relevant General Concrete Specification (7.1) with the following clarifications:

- Mixing in concrete trucks is not permitted.
- Concrete shall not be hand-mixed or re-tempered, nor shall anything be added to the concrete after batching.
- The amount of water shall be in compliance with the approved mix design. No additional water or ice shall be added to the mix at any time. Addition of ice or water at site is not permitted
- All admixtures shall be added at the batch plant.
- The dosage and method of application of admixtures shall conform to the Admixture Manufacturer's recommendations.
- An auditable record system shall be in place to record delivery of ready mixed concrete.

- Concrete that has achieved initial set or has been contaminated by foreign matter shall not be deposited in the structure or foundation.
- Slabs shall be carefully screeded to ensure proper drainage slopes and placed in alternating strips.
- Curing and protection of placed concrete shall begin immediately after compaction of the concrete.
- Formwork shall be inspected during placement. If shores, braces, or inserts move, placement shall be stopped until corrective work is completed.
- Concrete shall not be placed during rain, sleet, or snow unless adequate protection is provided. Protective measures shall be provided to the Principal for review and comment.
- Rainwater shall not be allowed to increase the mixing water nor damage the concrete surface.
- Placing (pouring) vertical and horizontal elements of the same structure shall not be done at the same time.

5.9.2 Placing by a pumping method

For placing by pumping, the concrete mix shall be in accordance with the relevant Pumping Specification (7.1). The contingency plan (including facilities) shall be submitted to ensure the continuity of concrete placing in case the pump should fail.

5.9.3 Mixing time

A mixing, transportation and pouring schedule shall be produced to address transportation, mixing, and delivery period to prevent the segregation of aggregates and any workability issues that could result.

5.9.4 Concrete placed in underwater structures

Prior to the pour a concrete placing plan for underwater structures shall be submitted.

Concrete trials, which demonstrate the required quality and consistency of the concrete mix, are required for underwater concrete pours.

5.10 FINISHING

Concrete surfaces of concrete walls, beams, buttresses and floors shall be to the proper slopes and level within tolerance. The finish shall be without objectionable surface fins, holes or rough patches and as follows:

- Surfaces requiring subsequent plastering or tiling shall be rough-finished to provide a proper key for the finishing layer.
- For surfaces that will receive forklift traffic or other movable equipment a hardener and/or densifier may be applied per the Manufacturer's recommendations. These materials shall be submitted for approval by the Principal. Air entrained concrete shall not be used when concrete hardeners and densifiers are specified.
- Equipment bases shall be finished with a floated finish. Stairs, steps, ramps, and walks shall be finished with a broom finish.
- Interior floor slabs shall be finished with a trowel finish in accordance with the conventional flat tolerance requirements of the relevant Concrete Finishing Specification (7.1).
- Roads, area paving, and exterior slabs shall be finished with a broom or belt finish in accordance with the conventional straight-edged tolerance requirements of the relevant Concrete Finishing Specification (7.1).
- Roads and area paving shall be finished with a broom or belt finish as specified in the relevant Design of Concrete Structure Specification (7.1).

- Floor slabs shall be finished to a trowel finish as defined in the relevant Design of Concrete Structure Specification (7.1).
- Formed surfaces shall have an as-cast finish.
- For machinery foundations the following finish shall be provided.
 - i. A minimum of 12 mm (0.5 inch) of concrete shall be removed in the area where the machinery base-plate/soleplate is to be installed. Top surface shall be chipped to exposed and fractured aggregate.
 - ii. If chock blocks or fixators are to be used, additional concrete shall be removed in these specific areas as required to avoid excessive grout between soleplate and concrete.

5.11 CURING AND REPAIR OF CONCRETE

5.11.1 Curing

Concrete not in contact with formwork shall utilize any of the methods indicated in the relevant Concrete Curing Specification (7.1) for the preservation of moisture.

For interior concrete slabs, ponding, sprayed water, or wet sand shall not be permitted without specific approval by the Principal.

Liquid membrane curing compounds shall not be used on surfaces that receive bonded treatments, tiles, paint or other adhered finishes, epoxy toppings, or additional concrete.

After initial setting of the concrete, any disturbance thereon (e.g. from walking, wheeling-over or vibration of the formwork) shall be prevented until the concrete has sufficiently hardened.

Reinforcement, anchor bolts etc. projecting from the concrete shall not be disturbed during hardening of the concrete.

Unless otherwise specified, curing shall continue for a minimum number of cumulative days, or fractions thereof, as follows:

(a) Concrete with Type II cement	14
(b) Concrete with Type III cement	3
(c) Concrete for machinery foundations	28
(d) All other concrete	7

Curing shall begin immediately after concrete has hardened sufficiently to prevent damage to the surface. During the curing period, the concrete shall be protected from load stresses, heavy shock, and excessive vibration.

Finished concrete surfaces shall be protected from damage by curing methods or materials.

Water curing shall be provided when the combined concrete temperature and relative humidity exceed that listed in Table 5.

Table 5 Water Curing

Concrete Temp, °C	Concrete Temp., °F	Relative Humidity, %
40.6	105	90
37.8	100	80
35	95	70
32.2	90	60
29.4	85	50
26.7	80	40
23.9	75	30

Area warming and humidification control of the curing of concrete that will be exposed to severe freezing and thawing shall continue until it develops more than 85% of the compressive strength.

5.11.2 Hydraulic (Liquid-Tight) structures

Any structure designated as a hydraulic (liquid containing) structure in the drawings shall comply with the following:

1. Hydraulic structures shall be cured by a wet-cure procedure only (e.g., use of ponding, sprinkling, or a moisture-retaining fabric).
2. Moist wood forms in contact with concrete shall not be considered as curing for hydraulic structures.
3. Immediately after placement, concrete shall be protected from premature drying, excessive high or low temperatures, rain, flowing water or mechanical damage.
4. Curing shall occur for a minimum of 14 days. Wall forms shall then be loosened and water continually sprinkled between the wall and forms.

5.11.3 Repair

Before starting any concrete work, a repair method statement shall be developed and submitted to the Principal for review and comment. The method statement shall address the following criteria and include the repair materials based on cement types. The cured mortar colour shall be approximate to the cured mother material.

Tie holes, sand pockets, honeycombs, excessive fanning, and other concrete surface defects shall be repaired promptly after form removal at a time and in a manner that shall not delay, interfere with, or impair the proper curing of the fresh concrete.

Touching up of concrete surfaces after the removal of formwork is not permitted until they have been inspected and released in accordance with the quality procedures.

The repair method, including materials and the extent of the repair works to remedy the imperfections of the concrete, shall be specified and approved for each repair case and comply with the design requirements of the structure concerned.

If the defect is greater than either of the following sizes, an individual repair method statement shall be submitted to the Principal for review and comment:

(NOTE: For the US/CA, the Engineer of Record shall approve)

- a. Depth is 75 mm (3 inches) at the maximum point and surface area is greater than 100,000 square mm (150 square inches).
- b. Depth is greater than 1/4 the thickness of the member and greater than 150 mm (6 inches) in any other direction.

Critical slab areas, identified in the drawings and/or specifications shall be replaced if out-of-tolerance. A demolition and replacement plan for the slab areas shall be submitted to the Principal before proceeding.

Cracks in liquid retaining structures, structural cracks and other cracks that are judged by the Principal to be potentially deleterious to the integrity of the structure shall be repaired.

6. QUALITY PLANS

6.1 GENERAL

Written Quality Plans and procedures shall be submitted to the Principal for review and comment. These documents shall provide details of how compliance with the requirements of this DEP, drawings and specifications is to be achieved.

The quality system shall be based on ISO 9000 quality system requirements.

Quality plans shall address all aspects related to local conditions, such as climatic conditions, back up facilities, spare parts, transport possibilities, storage facilities, quarries, local Manufacturer/Suppliers, test facilities (field laboratory), etc.

6.2 INSPECTION, TESTING AND REPORTING

Inspection & Test Plans (ITPs) identifying the tests, frequencies, rejection criteria and responsibilities shall be prepared as part of the quality plan.

A reporting system of Quality Control Records (QCRs) shall be part of the quality plan. The reporting system shall record all results obtained during inspection, testing, transporting, production, supplying, placing/pouring, finishing, curing, striking, etc. Weather conditions shall also be recorded in the quality records. The proposed ITPs and QCRs shall be included in the Quality Plan and shall cover among other items:

- Setting out;
- Anchor bolts;
- Rebar and cover;
- Inserts and other embedments;
- Formwork (including loading capacity, if required);
- Concrete placing;
- Field concrete workability;
- Curing;
- Removal of formwork (take loading capacity into account);
- Joint preparations- Defects.

Standard Forms of Inspection and Test Plans shall be used as a basis for the development of the ITPs and QCRs supplemented by the requirements of the "Specifications" for the work to be executed.

After completion, rebound and/or ultrasonic measurements shall be taken to control and verify the concrete quality against the compliance tests and required concrete quality if there is any doubt about the above records. The results shall be recorded. Any deviation shall be reported, including the measurements to be taken.

The Principal shall be permitted to make inspections at any time at the source of supply of materials, at the place of preparation of materials, at the mixing plant if ready mixed concrete is used, and during execution of all concrete work.

7. REFERENCES

7.1 CONCRETE SPECIFICATION CODES AND STANDARDS

The Principal shall confirm which standards will be applicable to the project. This is especially true for project specific specifications that are outside the United States, Canada and Europe.

Table 6 Concrete Codes and Standards

	Specification	EU Standards	US Standards	CA Standards
a.	Design of Concrete Structure Specification	EN 1992	ACI 318	CSA A23.1 / A23.2
b.	Design of Liquid Retaining Structures	EN 1992-3	ACI 350R with testing using ACI 350.1R	ACI 350R with testing using ACI 350.1R
c.	General Concrete Specification	EN 206-1	ACI 301-05	CSA A23.1-09 / A23.2-09
d.	Portland Cement Specification	EN 197	Per ASTM C618 Type C or Type F* Typical concrete: ASTM C150/C150M Type I or II High Early Strength: ASTM C150/C150M Type III Shrinkage Compensating Cement: ASTM C845 Type K	Typical concrete: CSA A5 Type 10 High Early Strength: CSA A5 Type 30 Massive pours and Shrinkage Compensating: CSA A5 Type 40 Structures in contact with seawater: CSA A5
e.	Anchorage Design Criteria Specification	ETAG-001 through 006	ASCE Guidelines - Wind Loads and Anchor Bolt Design for Petrochemical Facilities	ASCE Guidelines - Wind Loads and Anchor Bolt Design for Petrochemical Facilities
f.	Mix Water Specification	EN 1008	ACI 318	CSA A23.1-09/A23.2-09
g.	Reinforcement Steel Specification	EN 10080, EN 1992	ASTM A615/ ASTM A615M and ASTM A996/A996M	CSA A23.1-09/A23.2-09 and CSA A23.3-04
h.	Formwork Specification	EN 13670	ACI 301-05 and ACI 304R	CSA A23.1/A23.2, S269.3 and CSA S269.3-M92-CAN/CSA
i.	Steel Reinforcement Specification	EN 1992-1-1, EN 13670, EN ISO 3766	ACI 301-05, ACI 318 and ACI 117	ACI 301-05, ACI 318 and ACI 117

	Specification	EU Standards	US Standards	CA Standards
j.	Concrete Mix Specification	EN 1992 and EN 206-1	ACI 301-05 and ASTM C94/C94M	ACI 301-05 and ASTM C94/C94M
k.	Concrete Finishing Specification	n/a	ACI 117	CSA A23.1
l.	Extreme Weather Specification	CEB-FIP Model Code:1990 Clause D.13 and 14	ACI 305.1R; ACI 306.1R	ACI 305R; ACI 306R
m.	Pumping Specification	CEB-FIP Model Code 1990, Appendix D.11.5	ACI 304.2R	ACI 304.2R
n.	Concrete Curing Specification	EN 13670	US – ACI 301-05, ACI 308R, ACI 308.1	CSA A23.1, ACI 308R, ACI 308.1

* If Class C fly ash is used in a moderately to extremely aggressive sulphate environment, the mix design shall be tested in accordance with ASTM C 1012 to verify sulphate resistance. The slag shall comply with ASTM C 989.

7.2 LIST OF APPLICABLE STANDARDS

In this DEP, reference is made to the following publications:

- NOTES:
1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.
 2. The DEPs and most referenced external standards are available to Shell staff on the SWW (Shell Wide Web) at <http://www.shell.com/standards/>.

SHELL STANDARDS

Structural design and engineering of onshore structures DEP 34.00.01.30-Gen.

Onshore Steel Structures DEP 34.28.00.31-Gen.

STANDARD DRAWINGS

Anchor bolts with sleeve for concrete foundations and structures S10.045

Standard detail for ties/ stirrups S19.012 [2 shts]

Octagon foundation drain details S19.014

Anchor bolts S28.020

AMERICAN STANDARDS

Specification for Tolerances for Concrete Construction and Materials (ACI 117-10) and Commentary	ACI 117
Guide to Mass Concrete	ACI 207.1R
Specifications for Structural Concrete	ACI 301-05
Guide for Concrete Floor and Slab Construction	ACI 302.1R
Guide for Measuring, Mixing, Transporting, and Placing Concrete	ACI 304R
Placing Concrete by Pumping Methods	ACI 304.2R
Hot Weather Concreting	ACI 305.1/R
Cold Weather Concreting	ACI 306.1/R
Guide to Curing Concrete	ACI 308.1/R
Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)	ACI 318
Code requirements for environmental engineering concrete structures and commentary	ACI 350R
Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures (ACI 350.1-10) and Commentary	ACI 350.1R
American Concrete Institute (ACI) Detailing Manual	ACI SP-66
ASCE Guidelines - Wind Loads and Anchor Bolt Design for Petrochemical Facilities	ASCE Guidelines - Wind Loads and Anchor Bolt Design for Petrochemical Facilities
Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement	ASTM A615/A615M
Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement	ASTM A996/A996M
Standard Specification for Ready-Mixed Concrete	ASTM C94/C94M
Standard Specification for Portland Cement	ASTM C150/C150M
Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	ASTM C618
Standard Specification for Expansive Hydraulic Cement	ASTM C845
Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete	ASTM C881/C881M
Standard Specification for Slag Cement for Use in Concrete and Mortars	ASTM C989
Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Types)	ASTM D994
Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)	ASTM D1751
Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements	ASTM D6690
Standard Test Methods for Water Vapor Transmission of Materials	ASTM E96/E96M

Concrete Reinforcing Steel Institute (CRSI) Reinforcement Manual

BRITISH STANDARDS

Design of joints and jointing in building construction – Guide BS 6093

Selection of construction sealants - Guide BS 6213

CANADIAN STANDARDS

Portland Cement CSA A5
Concrete Materials and Methods of Concrete Construction/
Test Methods and Standard Practices for Concrete CSA A23.1/ CSA A23.2
Concrete Formwork CSA S269.3-
M92-CAN/CSA

EUROPEAN STANDARDS

Comité Euro-International du Béton – CEB-FIP CEB-FIP Model Code:1990
Model Code for concrete structures, Bulletin
No. 213/214
Cement EN 197
Concrete – Part 1: Specification, performance, production and EN 206-1
conformity
Mixing water for concrete – Specification for sampling, testing EN 1008
and assessing the suitability of water, including water recovered
from processes in the concrete industry, as mixing water for
concrete
Eurocode 2: Design of concrete structures EN 1992
Part 1-1: General rules and rules for buildings EN 1992-1-1
Part 3: Liquid retaining and containment structures EN 1992-3
Steel for the reinforcement of concrete – Weldable reinforcing EN 10080
steel – General
Execution of concrete structures EN 13670
Construction drawings – Simplified representation of concrete EN ISO 3766
reinforcement
European Organisation for Technical Approvals ETAG – Metal ETAG-001 through 006
Anchors for use in Concrete

INTERNATIONAL STANDARDS

Quality management systems – Fundamentals and ISO 9000
vocabulary

APPENDIX A GENERAL NOTES FOR STRUCTURAL CONCRETE DRAWINGS

The Concrete General Notes should state the following:

1. The basis for grade elevation, with reference to the highest point of grade;
2. The dimensional units of measure;
3. Reinforcing bar diameters are expressed in millimetres (applicable number rebar e.g. #9 rebar in the US). Prestressing steel in diameters and total area of a bar, strand or cable;
4. The grade(s) of steel reinforcing bars and prestressing steel, indicating which grade for each part (including yield strength f_y , ultimate strength f_u , modulus of elasticity E_s , ductility class);
5. The strength or grade(s) of concrete, indicating which is applicable for each part or component;
6. The grade(s) of cement, indicating which grade for each part;
7. Concrete blinding/mud mat (location, quality and thickness);
8. Polyethylene sheeting, if applicable (location and quality);
9. Concrete cover (type of construction, location and thickness);
10. The convention for indication of reinforcement;
11. Inserts;
12. Construction and expansion joints;
13. The usage of prefab concrete and in situ concrete by means of shading;
14. List of reference drawings and related documents stating their titles and numbers.