

DEP SPECIFICATION

REINFORCED CONCRETE STRUCTURES

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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.