Interim Advice Note No. 048/14

Design Criteria for Drainage Structures
Revision No. 0

Summary

This Interim Advice Note (IAN) provides information and guidance on the design criteria for drainage structures. These design criteria may be superseded in part by subsequently issued amendments to the Qatar Construction Specifications (QCS) or other IANs issued by Ashghal.

This IAN takes immediate effect. If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager on a scheme specific basis.

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Circulation:	**Ashghal Departments, Contractors, Supervision Consultants, Design Consultants.**
Application:	This Interim Advice Note (IAN) applies with immediate effect from the date of approval

0	August 2023	Issued for All Relevant Infrastructure Projects	Firas Alkadour / Christina Anagnostaki	Theodoros Tzaveas	Abdelaziz Salaheldein Omar	Abdulla Ahin A A Mohd
Rev	**Date**	**Reason For Issue**	**Authors**	**Checker**	**Reviewer**	**Approver**

Contents

1 Foreword

1.1 Interim Advice Notes (IAN) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case-by-case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay) departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Designs Department, Infrastructure Affairs.

Signed on behalf of Designs Department:

Abdulla Ahin A A Mohd

Designs Department Manager

Designs Department
Public Works Authority

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2 Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
Organisation:		Email:	
Position:		Address:	

Please email the completed form to:

Abdulla Ahin AA Mohd

Designs Department Manager
Designs Department
Public Works Authority

aahin@ashghal.gov.qa

We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3 Introduction

3.1 This Interim Advice Note (IAN), which takes immediate effect, provides requirements with regard to design criteria for drainage structures.

4 Withdrawn / Amended Standard

4.1 Not applicable.

5 Implementation

5.1 This IAN is to be used with immediate effect on projects as follows:

- All Ashghal projects in Design, Tender & Construction Stage

5.2 The only exceptions are:

- Projects where the construction of drainage structures has been substantially completed

5.3 If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager or the Engineer on a scheme specific basis.

6 Disclaimer

This Interim Advice Note and its recommendations or directions have been provided for application on Ashghal's infrastructure projects within Qatar only and they are not warranted as suitable for use on other roads, highways, or infrastructure with Qatar or elsewhere. Should any third party, consultant or contractor choose to adopt this Interim Advice Note for purposes other than Ashghal's infrastructure projects, they shall do so at their own risk.

Appendix A: Design Criteria for Drainage Structure

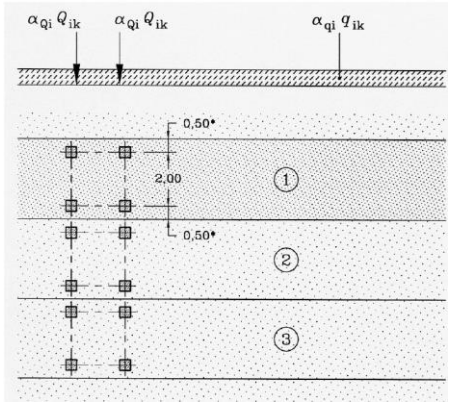
These Design Criteria may be superseded in part by subsequently issued Interim Advice Notes (IANs) or instructions by Ashghal. The designer shall review any such relevant documents issued after the date of these Design Criteria. If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager on a scheme specific basis.

DESIGN CRITERIA FOR DRAINAGE STRUCTURES		
No.	**Subject**	**Requirement**
1.	Design Standard	1. Design Standard Drainage Structures shall comply with the technical requirements of Eurocodes (BS EN), Qatar Construction Specifications (QCS 2014) and Qatar Sewerage & Drainage Design Manual. 2. Design 2.1. Design of drainage structures shall be carried out following latest Eurocodes (BS EN 1990, 1991, 1992, 1993, 1994, 1997 & 1998) and UK National Annexes. 2.2. For circular manholes of uniform diameter up to 6m depth and not subject to thrust force, walls and base slabs shall be designed as plain concrete members. Design of plain concrete members shall be carried out following Section 12 of BS EN 1992-1-1:2004+A1:2014. Cover slabs shall be designed as reinforced concrete members. 3 Checking Independent design checks shall be carried out and documented (including calculations) in accordance with Design Manual for Roads and Bridges (DMRB) CG 300 and shall be certified accordingly. 3.1 Drainage structures are classified in the following categories: i. Category 3: Water / Storage / Attenuation Tanks with at least one side in plan ≥ 20.0 m. ii. Category 3: Drainage Tunnels/Microtunnels and/or Access Shafts (all diameters and depths) to be implemented in existing/new networks. iii. Category 3: Manholes with both diameter ≥ 5.0 m and depth ≥ 15.0 m. iv. Category 2: Pumping Stations. PWA may decide a higher Category if deemed appropriate in regard to the complexity of proposed configurations. The independent checker shall carry out a comprehensive examination of all aspects of the design (or assessment if the case might be) for Category 2/3 checks. The Category boundaries are not rigid and the category of each Proposal will be decided on its merits, having regard to potential consequences of failure, design complexity and whole life costs. Category 3 Checks shall also include geotechnical design, soil-structure interaction impact assessment works and earthworks design including the check of the interpretative report. 3.2 Authority's Approval for Consultants for the proposed Category 3 checks before engaging for the works shall be required. The Consultant/Contractor shall be responsible for proposing to the Engineer, three suitably qualified consultants to carry out the Category 3 independent checking. The Engineer reserves the right to select one of the proposed checking consultants. The Engineer may reject any or all of the proposed checking consultants as not suitably qualified. 3.3 A Design Criteria Report (DCR) shall be required for approval, for Category 2/3 Drainage Structures, before commencing the Detailed Design. Check Certificates (CG300-Appendix I) shall refer to the agreed DCR and any addenda and Departures agreed with PWA. Construction of the structure shall not proceed until the check certificates (Cat 2/3) have been formally accepted by PWA.

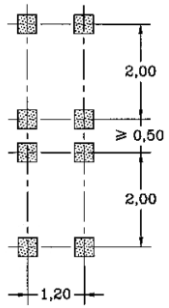
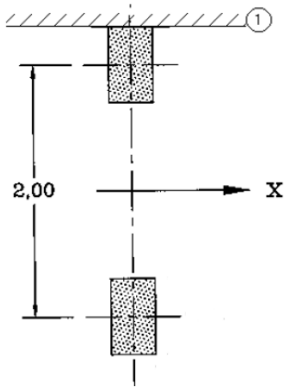
	Design Standard (continued)	3.4 For Category 2 structures, the Consultant/Contractor shall submit the comments log documenting all comments made by the Checking Consultant. 3.5 For Category 3 structures, the following shall be provided by the Checking Consultant: a. Confirmation that the principles in the DCR are valid and that they have been translated into appropriate levels of design and specification. Confirmation that sufficient information has been provided to enable the detailed design to be developed and completed in accordance with PWA requirements. b. Comments Log documenting all comments made by the Checking Engineer together with the Consultants responses. c. A complete set of independent checking calculations and check certificate. d. During the course of the design checking process, matters related to over-capacity of sections and elements shall be brought to the attention of PWA. e. Geotechnical Design (either Geotechnical Design Report or Geotechnical Interpretative Report with Geotechnical Design details) shall include Check Report (in a form of parallel calculations), Comments Log and Check Certificate. 3.6 Certificates shall be signed by the Designer and the Checker in Consultancy Contracts and accordingly by the Contractor and the Checker in D&B Contracts. All signatories to certificates shall: a. be authorised to sign on behalf of their organisation; b. be competent in the field of work undertaken; and, c. have relevant experience and appropriate engineering qualifications.		
2.	Design Life	The design life shall be the assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary. The Design Life of Drainage Structures shall be 60 years, and the Design Life for Drainage Tunnels/Microtunnels design elements shall be 100 years, unless otherwise noted.		
3.	Design Loads	3.1 General Actions – Unit Weights	Reinforced Concrete	25 kN/m^3
			Mass (Unreinforced) Concrete	24 kN/m^3
			Structural Steel	78.5 kN/m^3
			Pavement Materials	23 kN/m^3
			Soil Backfills	20 kN/m^3
			Flowable Fill	16-20 kN/m^3 (Specific value shall be specified in Design Drawings)
			Utilities (where no specific requirements given)	1.0 kN/m^2
			Water / Groundwater	10 kN/m^3
		3.2 Thermal Actions	Coefficient of thermal expansion (concrete & steel)	12 x 10^{-6} / ^{o}C
			Relative humidity	70 %
		General Thermal effects shall be taken into account when checking the serviceability limit states (SLS). Maximum element temperature = 50 ^{o}C Minimum element temperature = 5 ^{o}C Initial Temperature (T_o) = 20 ^{o}C Uniform Temperature - Expansion ($\Delta T_{U,exp}$) = 30 ^{o}C Uniform Temperature - Contraction ($\Delta T_{U,con}$) = -15 ^{o}C		

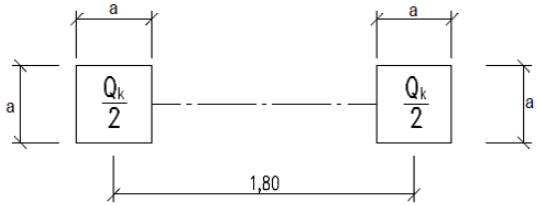
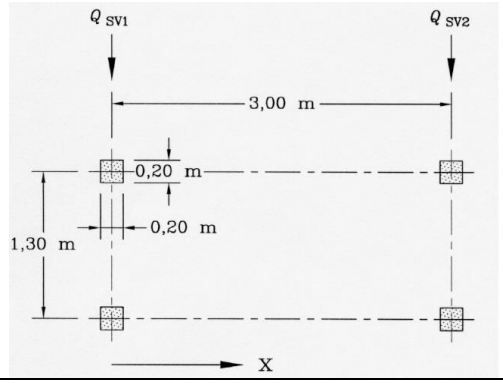
	Design Loads (continued)	*3.2 Thermal Actions (continued)*	Buried Structures 1. Temperature loads for manholes & chambers may be ignored. 2. Changes in uniform temperature may be ignored when the total depth from the top of the surfacing/fill to the roof/top slab is 1.5 m or greater. 3. For every additional 100 mm of total cover depth in excess of 200 mm: a) Uniform Temperature - Expansion ($\Delta T_{U,exp}$) may be reduced by 2 ^{o}C. b) Uniform Temperature - Contraction ($\Delta T_{U,con}$) may be increased by 1 ^{o}C.
		3.3 Earth and Water Pressure Loads	1. The structural design of drainage structures shall be carried out based on level and ground condition specific to each location, with groundwater level assumed to be at finished ground level, unless design groundwater level has been reliably established (i.e. supported by an approved geotechnical interpretative report). 2. At-rest earth pressures shall be considered for the design of structural members. 3. The value of at-rest coefficient (ko) shall not be less than 0.5 and shall be estimated according to the site conditions. 4. Where the structural arrangement calls for internal walls, these walls shall be checked for a full hydrostatic pressure applied at one side only (representing full chamber on one side, and empty chamber on the other side).
		3.4 Wind Actions	1. Wind load shall be calculated in accordance with BS EN 1991-1-4:2005+A1:2010. 2. 50-year return period Wind Speed: Mean 10 minutes wind speed = 27 m/s

	Design Loads (continued)	3.5 Imposed Loads / Traffic Loads	3.5.1 Drainage structures subject to highway loading	Roof slabs subject to highway loading shall be designed for load models 1 and 2 (not simultaneously), unless otherwise specified. 1. Load Model 1 (LM1): a. LM1 shall be in accordance with BS EN 1991-2:2003, Clause 4.3.2 and NA+A1:2020 to BS EN 1991-2:2003, Clause NA.2.12. b. LM1 consists of two partial systems as illustrated below. • Double-axle concentrated loads (Tandem System: TS), each axle having weight of $\alpha_Q Q_k$ with two identical wheels, the load per wheel being therefore equal to 0.5 $\alpha_Q Q_k$. The contact surface of each wheel shall be taken as square of sides 0.40 m. Only complete tandem systems should be taken into account. • Uniformly distributed loads (UDL system), having weight per square metre of national lane of $\alpha_q q_k$. UDL should be applied only in the unfavourable parts.



Location	Tandem System TS			UDL System		
	Axle Load Q_{ik} (kN)	Adjustment Factor - α_{Qi}	$\alpha_{Qi}\, Q_{ik}$ (kN)	UDL q_{ik} (kN/m^2)	Adjustment Factor - α_{qi}	$\alpha_{qi}\, q_{ik}$ (kN/m^2)
Lane Number 1	300	1.0	**300**	9.0	0.61	**5.5**
Lane Number 2	200	1.0	**200**	2.5	2.2	**5.5**
Lane Number 3	100	1.0	**100**	2.5	2.2	**5.5**
Other Lanes	-	-	-	2.5	2.2	**5.5**
Remaining Area	-	-	-	2.5	2.2	**5.5**

	Design Loads (continued)	*3.5 Imposed Loads / Traffic Loads (continued)*	*3.5.1 Drainage structures subject to highway loading (continued)*	c. A tandem system should be applied at the most unfavourable location. Where two tandem systems on adjacent notional lanes are taken into account, they may be brought closer, with a distance between wheel axles not below 0.50 m as illustrated below. 
				2. Load Model 2 (LM2): a. LM2 shall be in accordance with BS EN 1991-2:2003 Clause 4.3.3 and NA+A1:2020 to BS EN 1991-2:2003, Clauses NA.2.14 & NA.2.15. b. LM2 consists of a single axle load $\beta_Q Q_{ak}$ equivalent to 400 kN with two identical wheels spaced at 2.00 m. c. Only one wheel of 200 kN may be taken into account. d. The contact surface of each wheel should be taken as square of sides 0.40 m.  **Key** X Bridge longitudinal axis direction 1 Kerb

	Design Loads (continued)	*3.5 Imposed Loads / Traffic Loads (continued)*	3.5.2 Drainage structures not in highway but subject to occasional traffic/ vehicle loading	1. Roof slabs not in highway but subject to occasional traffic loads shall be designed for uniformly distributed load of 20 kN/m^2. 2. Drainage structures in parking areas for vehicles ≤ 160 kN gross vehicle weight, on 2 axles, shall be designed for an additional load case in accordance with BS EN 1991-1-1:2002, Clause 6.3.3 and NA to BS EN 1991-1-1:2002, Clause NA.2.9 as illustrated below.  **Note:** a = 200mm and Q_k = 90 kN This shall not be considered simultaneously with UDL of 20 kN/m^2. 3. For accidental presence of a vehicle, see Design Criteria sub-section 3.5.4.
			3.5.3 Drainage structures not subject to traffic/ vehicle loading	1. Roof slabs not subject to traffic/vehicle loading shall be designed for uniformly distributed load of 10 kN/m^2. 2. For accidental presence of a vehicle, see Design Criteria sub-section 3.5.4.
			3.5.4 Drainage structures subject to Accidental Actions (Wheel Load)	If no permanent obstacle prevents a vehicle being driven onto roof slabs of buried drainage structures, the accidental presence of a vehicle shall be taken into account. The vehicle model given in Figure 5.2 of BS EN 1991-2:2003 with characteristic axle loads, Q_{sv1} = 115 kN and Q_{sv2} = 65 kN should be used in accordance with NA+A1:2020 to BS EN 1991-2:2003, Clause NA.2.43. 

	Design Loads (continued)	*3.5 Imposed Loads / Traffic Loads (continued)*	3.5.5 Other imposed loads	1. Floors in enclosed structures shall be designed to carry out a uniformly distributed live load of 7.5 kN/m^2. 2. Roof slabs in buildings not accessible except for normal maintenance and repair shall be designed for minimum uniformly distributed live load of 1.0 kN/m^2. 3. Roof slabs in buildings with provision of access shall be designed for minimum uniformly distributed live load of 2.0 kN/m^2.
			3.5.6 Live load surcharge for Lateral Earth Pressure	1. Underground drainage structures subject to highways loading shall be designed for 20 kN/m^2 surcharge. 2. Underground drainage structures not subject to highways loading shall be designed for 10 kN/m^2 surcharge.
		3.6 Pipe Thrust Force	For pressurized network structures, thrust force considered in structural design shall be calculated based on Maximum Design Pressure (MDP) and System Test Pressure (STP) as defined in Qatar Sewerage and Drainage Design Manual, Volume 4: TSE System Design (June 2005), Clause 2.7.3. Approval for the pressure values from PWA-DD Drainage team shall be obtained prior to the initiation of the structural design. • For Service Limit State (SLS), MDP shall be considered. • For Ultimate Limit State (ULS), the greater of $\gamma_{Q,MDP}$ x MDP or $\gamma_{Q,STP}$ x STP shall be considered (values for $\gamma_{Q,MDP}$ and $\gamma_{Q,STP}$ shall be as defined in Design Criteria # 4).	
4.	Combination of Actions	1. Combination of actions applied in the design of drainage structures are those specified in BS EN 1990:2002+A1:2005 and NA to BS EN 1990:2002+A1:2005 for Ultimate Limit States (ULS) & Serviceability Limit States (SLS). For liquid retaining structures, reference shall also be made to BS EN 1991-4:2006 and NA to BS EN 1991-4:2006. 2. Combination of actions for ULS: a. Persistent or transient design situations: The actions shall be combined in accordance with NA to BS EN 1990:2002+A1:2005, Table NA.A1.2 (B). b. Accidental or Seismic design situations: The actions shall be combined in accordance with NA to BS EN 1990:2002+A1:2005, Table NA.A1.3. 3. Combination of action for SLS: a. The actions shall be combined in accordance with BS EN 1990:2002+A1:2005, Clause A1.4. b. Stress limitation shall be checked under characteristic combination. c. Crack width (w_{max}) for reinforced concrete members shall be checked under Quasi-permanent combination. 4. Thermal actions and wind actions shall not be considered simultaneously. 5. Where thermal effects are taken into account they should be considered as variable actions and applied with a partial factor and ψ factor.		

Combination of Actions (continued)

6. Partial factors for actions and combinations of actions shall be in accordance with BS EN standards and as follows.

Partial factors for Ultimate Limit States (ULS) on actions (Persistent and transient) design situations

Action					Partial Factors (γ_F)
Type	**Group**		**Symbol**	**Resulting Effect**	
Permanent Action (G_k)	All[1]		$\gamma_{G,sup}$[2]	Unfavourable	1.35
			$\gamma_{G,inf}$[2]	Favourable	1.0
Variable action (Q_k)	All except for Liquid Loads & Pipe Thrust Loads		$\gamma_{Q,All}$	Unfavourable	1.5
	Liquid Loads	Operation	$\gamma_{Q,LO}$		1.2
		Test	$\gamma_{Q,LT}$		1.0
	Pipe Thrust Loads	Maximum Design Pressure (MDP)	$\gamma_{Q,MDP}$		1.5
		System Test Pressure (STP)	$\gamma_{Q,STP}$		1.0
	All		$\gamma_{Q,inf}$	Favourable	0

Note 1: Applied to all permanent action including self-weight of structural and non structural elements, soil, ground water, etc.

Note 2: The characteristic values of all permanent actions from one source are multiplied by $\gamma_{G,sup}$ if the total resulting action effect is unfavourable and $\gamma_{G,inf}$ if the total resulting action effect is favourable. For example, all actions originating from the self weight of the structure may be considered as coming from one source; this also applies if different materials are involved.

Recommended value of ψ factors for drainage structures

Action			Values of ψ factors		
			ψ0	**ψ1**	**ψ2**
Liquid Loads / Pipe Thrust Loads			1.0	0.9	0.3
Wind Loads			0.6	0.2	0
Temperature			0.6	0.5	0
Traffic Loads	LM1	TS	0.75	0.75	0
		UDL			
	LM2 (Single Axle)		0	0.75	0
	UDL (20 kN/m^2 / 10 kN/m^2)		0.7	0.5	0.3
	Parking (Category G)		0.7	0.5	0.3
Imposed Loads in buildings	Roofs not accessible except for normal maintenance and repair (Category H)		0.7	0	0
	Roofs accessible with occupancy (Category E11)		1.0	0.9	0.8
	Floor imposed load in enclosed structures (Category E)		1.0	0.9	0.8

<table>
<tr><td rowspan="6">5.</td><td rowspan="6">Design Crack Widths for Reinforced Elements</td><td>Environment</td><td>Design Crack Width</td><td colspan="2">C_{nom} Nominal Cover (see Note 2)
Concrete Grade (Cylinder / Cube) N/mm^2</td></tr>
<tr><td></td><td></td><td>32/40</td><td>40/50</td></tr>
<tr><td>Elements below ground</td><td>0.20 mm</td><td>40 mm</td><td>35 mm</td></tr>
<tr><td>Piles</td><td>0.15 mm</td><td>45 mm</td><td>40 mm</td></tr>
<tr><td>Elements above ground</td><td>0.30 mm</td><td>40 mm</td><td>35 mm</td></tr>
<tr><td colspan="2">For liquid retaining structures (reinforced concrete structures for the containment of liquids, i.e. tanks and reservoirs), the following shall be adopted for elements of structure which directly support the stored liquids:
• For $h_D/h \leq 5$, Design Crack Width = 0.20 mm,
• For $h_D/h \geq 35$, Design Crack Width = 0.05 mm,
• For intermediate values of h_D/h, linear interpolation between 0.2 and 0.05 may be used.
h_D is the hydrostatic pressure inside the tank and h is the structural element thickness. For the purposes of Table 7.105 in BS EN 1992-3:2006, Tightness Class 3 applies, unless an approval from DD-Drainage and DNOM is presented for a tightness class 0 to 2.</td><td>40 mm</td><td>35 mm</td></tr>
<tr><td colspan="4">Notes:
1. Calculated crack widths shall not exceed the Design Crack Width for early thermal effects or at serviceability limit state.
2. The Nominal Cover shown shall only be used in calculating crack widths to Section 4 of BS EN 1992-1-1:2004+A1:2014. Note that this is not the actual cover provided.</td></tr>
<tr><td>6.</td><td>Deflection Control</td><td colspan="4">Deflection control shall be checked in accordance with BS EN 1992-1-1:2004+A1:2014, Clause 7.4 where deemed required.</td></tr>
<tr><td>7.</td><td>Concrete Grade</td><td colspan="4">The classes of concrete are based on the characteristic cylinder strength (f_{ck}) determined at 28-days. The grade of concrete is denoted as cylinder strength / cube strength (MPa) and shall not be less than the following unless agreed otherwise with Ashghal. Environmental exposure conditions shall be considered. For mechanical characteristics necessary for design, reference shall be made to BS EN 1992-1-1:2004+A1:2014, Table 3.1.
1. Cast-in-place reinforced elements — Grade C32/40
2. Cast-in-place unreinforced elements — Grade C32/40
3. Pre-cast reinforced elements — Grade C40/50
4. Mass concrete (benching) — Grade C32/40
5. Blinding concrete — Grade C20/25
6. Membrane protection — Grade C20/25
7. Protection to pipelines (non structural concrete) — Grade C16/20
8. General fill below structures — Grade C16/20</td></tr>
</table>

<table>
<tr><td>8.</td><td>Reinforcement</td><td colspan="2">1. Reinforcement shall be type 2 deformed with a minimum yield strength of 500N/mm2, conforming to BS4449 and BS8666.
2. Anchorage and lap lengths shall be calculated in accordance with Section 8 of BS EN 1992-1-1:2004+A1:2014.</td></tr>
<tr><td rowspan="2">9.</td><td rowspan="2">Minimum Cover to Reinforcement.</td><td>Structural Element</td><td>Minimum Cover to Reinforcement</td></tr>
<tr><td colspan="2">1. Elements above ground
2. Foundations – all sides
3. Elements – soil face
4. Elements – liquid face
5. Elements – non soil/liquid face

Note: The actual cover provided to reinforcement shall not be less than the minimum values shown above.</td><td>50 mm
75 mm
75 mm
75 mm
50 mm</td></tr>
<tr><td>10.</td><td>Protective treatments</td><td colspan="2">Concrete surfaces shall be protected in accordance with QCS 2014. Specific requirements for different type of structures, reference shall be made to PWA SD 8-4-106.</td></tr>
<tr><td>11.</td><td>Stability checks</td><td>11.1 General</td><td>1. Stability of drainage structures shall be checked in accordance with BS EN 1997-1:2004+A1:2013.
2. Stability of thrust blocks shall be checked in accordance with CIRIA Report 128 considering the following:
a) Cohesion value shall be considered as zero.
b) The magnitude of the design force shall be based on the system test pressure as defined in Qatar Sewerage and Drainage Design Manual, Volume 4: TSE System Design (June 2005), Clause 2.7.3.</td></tr>
<tr><td></td><td></td><td>11.2 Uplift check</td><td>1. Uplift for all buried structures shall be checked in accordance with BS EN 1997-1:2004+A1:2013, Clause 2.4.7.4.
2. For the verification of the uplift limit state (UPL), the following partial factors shall be applied.
<table>
<tr><th>Action</th><th>symbol</th><th>Design GWL at FGL</th><th>Design GWL lower than FGL</th></tr>
<tr><td colspan="4">Permanent</td></tr>
<tr><td>Unfavourable (Destabilising)</td><td>$\gamma_{G;dst}$</td><td>1.0</td><td>1.1*</td></tr>
<tr><td>Favourable (Stabilising)</td><td>$\gamma_{G;stb}$</td><td>0.9</td><td>0.9</td></tr>
</table>
*$\gamma_{G;dst}$ of 1.1 account for uncertainty in the future level of ground water
3. The design groundwater level (GWL) shall be at finished ground level. For lagoons and tanks/reservoirs, the design GWL maybe assumed at a level reliably established and supported by an approved Geotechnical Interpretative Report (GIR).</td></tr>
</table>

	Stability Checks (continued)	11.3 Sliding check	1. Sliding for drainage structures be checked in accordance with BS EN 1997-1:2004+A1:2013, Clause 6.5.3. 2. Partial factors for structural (STR) and geotechnical (GEO) limit states verification shall be in accordance with NA+A2:2022 to BS EN 1997-1:2004+A1:2013, A.3. The following partial factors shall be applied for buried structures of pressurized network.

Partial Factors on actions (γ_F)					Partial Sliding Factor of Resistance ($\gamma_{R;h}$)
Sliding Actions - Unfavourable			Stabilizing Actions - Favourable		
Permanent	Variable		Effective Vertical Action [5] V'd, ($\gamma_{G,inf}$)	Passive Ep [6], ($\gamma_{G,inf}$)	
Active EP ($\gamma_{G,sup}$)	Thrust Force ($\gamma_{Q,1}$)	Active LL-Surcharge ($\gamma_{Q,2}$)			
1.35	1.5[a] or 1.0[b]	1.50	1.00	1.00	1

Note. (a) applies to maximum design pressure and (b) applies to system test pressure.
The greater value shall only be considered.

3. The design GWL maybe assumed at a level reliably established and supported by an approved GIR, otherwise it shall be considered at FGL.
4. Lateral live load surcharge shall be applied only at active side.
5. Effective Vertical Action (V'd = N – U), where N is the normal component of the resulting force acting on the foundation and U is the uplift force.
6. Passive Earth Pressure shall be calculated considering lateral earth pressure coefficient not exceeding 0.5 x passive earth pressure coefficient (kp).
7. Friction Coefficient:
   The friction coefficient shall be limited to a maximum value of 0.4. In case of shear key, friction coefficient shall be determined based on the founding soil.

   The value of the soil structure interface coefficient of friction (tan δ) shall comply with Formula

   $$\tan\delta \leq k_{\tan\delta} \tan\varphi'$$

   where

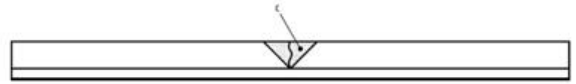
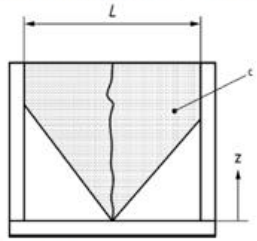
   $\tan\varphi'$ is the value of the soil coefficient of effective friction;

   $k_{\tan\delta}$ is a reduction factor depending on the foundation material and execution method.

   For spread foundations made of concrete cast directly against soil or fill, the value of $k_{\tan\delta}$ should be taken as 1.0 if the base is rough or ridged; or as 2/3 if the base is smooth.

   For spread foundations made of pre-cast concrete, the value of $k_{\tan\delta}$ should be taken as 2/3.

8. For testing or maintenance, the following must be noted in Design Drawings (unless specified otherwise):
   a. Maintenance operations requiring removal of surrounding ground, or any adjacent excavations required for utilities must be executed on fully restrained concrete structures.
   b. Testing of the pipe must be carried out after backfilling is completed to the proposed FGL. Otherwise, the structure shall be adequately braced such that stability of the structure is not compromised.

12.	Early Thermal Cracking of Concrete	12.1 General	1. Early thermal cracking shall be checked in accordance with CIRIA Report C766. 2. Early thermal cracking checks for manholes, chambers and other minor structures may be ignored. 3. Concrete mix details considered in design shall be noted in Design Drawings for contractor's consideration. Construction sequence and construction joints shall be clearly shown in Design Drawings.
		12.2 Temperature Input	1. Temperature drop, T_1 Placing Temperature = 32 °C Ambient Temperature - Minimum = 22 °C - Mean = 27 °C - Maximum = 32 °C Placing Time (24 hours clock) = 10 hours 2. Temperature drop, T_2 T_2 value of 20 °C shall be considered. If full movement joints are provided at no more than 15 m spacing, or restraint is being provided by a section subject to same climatic exposure, T_2 value of 0 °C may be considered.
		12.3 Coefficient for bond (k1)	1. For thickness > 300 mm & Cover ≤ 50 mm, k1 = 1.14 2. Others, k1 = 0.8
		12.4 External restraint of combined edge and end restraint	If an element is restrained both at the ends and at the edges, the criterion defined below may be applied.  a) Element restrained at an edge (e.g. jointless wall) — only first crack is represented  b) Element restrained at the ends (typical tie) — only first crack is represented  If $z > L/2$, apply formulation for end restraint If $z \leq L/2$, apply formulation for edge restraint c) Element restrained at edge and ends (e.g. wall grid) — only first crack is represented Key C area where forces are affected by crack development