

# **CONCRETE BUNDS FOR OIL STORAGE TANKS**

# **CIRIA / ENVIRONMENT AGENCIES JOINT GUIDELINES**

*This document provides guidance for the construction of simple, reinforced concrete bunds for oil storage tanks up to 3.5 metres wide and 900mm high. It is based upon CIRIA Report 163 “Construction of bunds for oil storage tanks” and is jointly produced by the Environment Agency for England and Wales, the Scottish Environment Protection Agency and the Environment and Heritage Service for Northern Ireland, referred to as the agencies. Where circumstances dictate a larger or more complex construction reference should be made to the original report. A similar specification for reinforced masonry bunds is also available, free of charge, from the environment agencies. Contact details will be found at the end of this document.*

## *Notes:*

*To be read in conjunction with the enclosed construction drawings. The British Standards referred to in these guidelines are listed in Appendix 1.*

## **1. SITING AND SITE PREPARATION**

### **a. Site investigation**

Avoid sites with:-

- variations in substrata which may give rise to differential settlement
- unstable slopes that may cause slip or other movement
- geological faults, below ground voids or fissures
- deleterious matter present, which may have an adverse effect on construction materials
- a site history which may cause structural problems, e.g. previous mining, made-up ground, underground services, etc.
- low ground bearing pressure (the model designs are based on a permissible ground bearing pressure of not less than 200kN/m<sup>2</sup>).

Note: the siting of a bund is dictated by the location of the primary tank, which may in turn be dictated by the general layout of the facility of which it is part. It may not be possible, therefore, to avoid sites with the characteristics listed above, in which case suitable precautions must be taken. The model drawings assume that the proposed site does not have any of the undesirable features listed above. Where sites with any of the above undesirable features cannot be avoided, specialist advice should be sought.

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**

## b. Site preparation

- i. Remove all vegetation and organic top soil from the site to expose the subsoil. Suitable subsoils or substrata include:
  - firm or stiff clay
  - firm or stiff sandy clay
  - boulder clay
  - shale clay (non sulphurous)
  - compact sand or sandy gravel
  - chalk
  - rock.
- ii. Excavate and trim the surface of the excavations to the level surfaces necessary for the formation of wall foundations and the base slab.
- iii. Soft ground should be excavated and removed, and the formation levelled down to firm ground with a permissible ground bearing pressure of not less than 200kN/m<sup>2</sup>.
- iv. Compact the excavated surfaces using a vibrating roller or vibrating plate compactor.
- v. Protect the prepared formation from the elements prior to construction of base.

## 2. HARDCORE AND BLINDING CONCRETE

Note: Blinding concrete. The British Standard for water retaining structures, BS 8007, requires that at least 75mm of C20 blinding concrete be placed directly over the prepared formation. The structural concrete is then poured onto a polythene slip membrane placed on top of the blinding concrete.

In accordance with BS 8007, this specification requires ground level reinforced concrete slabs and wall foundations to be built on blinding concrete rather than hardcore. Blinding concrete is also required for making up discrepancies in level between the formation and the underside of the structure.

Hardcore should only be used for make up beneath the blinding concrete where the method of placing and compaction gives the hardcore sufficient strength to support the structure without any long-term adverse effect.

- a. Where hardcore is to be used for making up levels, it should conform with Granular Sub Base Type 2, Table 8/3 of the Department of Transport Specification. The following gradation should be used:

BS sieve size	Percentage by mass passing
75mm	100
37.5mm	85 - 100
10mm	45 - 100
5mm	25 - 85
600µm	8 - 45
75µm	0 - 10

If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)

Suitable materials include natural sands, gravels, crushed rock and concrete. The soluble sulphate content should be within the DoT specified limits.

- b. The hardcore should be placed in uniform horizontal layers not exceeding 150mm in depth. Each layer must be compacted prior to the placing of the next.
- c. The compaction method should be sufficient to achieve the required permissible bearing pressure of not less than 200kN/m<sup>2</sup>.
- d. Suitable compaction plant includes vibrating rollers having a mass per metre equivalent to 1,300kg with a total weight of 1,000kg, and vibrating plate compactors having an equivalent mass of 1,000kg.
- e. Granular fill in combination with geotextiles may be used to stabilise soft ground. Construction and design techniques are site-specific and expert advice should be obtained before using geotextiles.

### 3. FORMWORK

- a. Formwork should be properly designed and accurately constructed to produce a finished concrete to the lines, levels and dimensions indicated on the drawings and to acceptable tolerances (vertical and horizontal tolerances bund walls and floor plus or minus 3mm).
- b. The formwork should be of an appropriate type to provide the required surface appearance. External surfaces should normally be smooth unless an alternative finish is specified for aesthetic reasons. Internal surfaces should be smooth except where required to be roughened to receive surface rendering, or at temporary construction joints where bonding between adjacent pours of concrete is required.
- c. A suitable mould oil should be applied to the surface prior to casting to prevent damage during stripping.
- d. Temporary shutter ties should be of an approved type, preferably of a type which do not leave holes through walls or other parts of the structure which, if improperly filled, could cause the finished structure to leak.
- e. The formwork should be designed for ease of stripping, i.e. without re-entrant angles which might cause damage to the cast concrete during removal.
- f. The formation of *in situ* kickers between 50mm and 150mm high is recommended at the junction between wall and slab. These provide an upstand at the base of the wall against which the formwork of the wall may be clamped, so minimising leakage of concrete fines at base level during the casting of the remaining wall sections.
- g. The formwork must be designed so that proper compaction of the concrete can be achieved and so that the reinforcement is not displaced during concrete pouring or compaction.

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**

#### 4. REINFORCEMENT

- a. Reinforcement sizes, lengths and shapes must comply with the bar bending schedules.
- b. Hot rolled bars to conform to BS 4449  
Cold worked bars to conform to BS 4449  
Steel fabric reinforcement to conform to BS 4483
- c. High tensile deformed bars to be grade 460  
Mild steel plain bars to be grade 250
- d. Cutting and bending to comply with BS 4466 and BS 8110
- e. Prior to use, reinforcement should be brushed to remove loose deposits of rust, mill scale, grease and other deleterious matter. Surface rust is acceptable provided that the reinforcement is not deeply pitted or the section reduced in size.
- f. The reinforcement should be properly fixed at the positions and centres indicated on the drawings in such a way that it will not be displaced from the indicated position during or after concrete casting.
- g. The nominal cover of concrete for all steel reinforcement, including links, stirrups, fabric and spacers, should be not less than 40mm (in compliance with BS 8110 Part 1 Section 3.3.4 - 'severe' exposure category).
- h. Laps in fabric reinforcement should be not less than one mesh. Bar laps should be not less than 42 times the bar diameter unless otherwise indicated on the drawings.

#### 5. CONCRETE MIXES

- a. Concrete mixes should conform to BS 5328, BS 8110 and BS 8007. Ready mixed concrete should be obtained from a supplier currently registered with an approved quality assurance scheme, e.g. QSRMC (Quality Scheme for Ready Mixed Concrete).
- b. Site mixing is not recommended unless a weight batching cement mixer conforming to the appropriate British Standards is used and aggregates, cements and mix designs can be demonstrated to conform to BS 5328 for a mix equivalent to those specified below.
- c. Recommended Concrete mixes :

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Reinforced concrete to ground slabs

To conform with BS 8007 specification:  
C35A mix designation  
Minimum cement content  
325kg/m<sup>3</sup>  
Water cement ratio not to exceed 0.55 for OPC mixes and 0.50 for blended cement mixes.

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Reinforced concrete to walls and foundations

To conform with either:  
C40 mix to BS 8110  
Minimum cement content  
325kg/m<sup>3</sup>  
Water cement ratio should not exceed 0.55  
or  
RC 40 mix to BS 5328 1991  
or  
C35A to BS 8007

Blinding concrete under slabs and foundations

GEN 2 to BS 5328 1991 or  
C20 to BS 8007

Concrete fill to reinforced blockwork

GEN 2 to BS 5328 1991 or as otherwise specified. Maximum size coarse aggregate 10mm

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- d. For blended cements - *OPC/GGBS (Ground Granulated Blast Furnace Slag) or OPC/PFA (Pulverised Fuel Ash)* - the mean proportion should not exceed 50% for GGBS and 35% for PFA as stated in BS 8110 Part 1, 6.1.2. The water cement ratio for BS 8007 C35A mixes should not exceed 0.50 when blended cements are used. Sulphate resisting cement to be used in ground slabs where sulphates are present in the ground.
- e. Aggregates should conform to BS 882 or BS 1047 and have an absorption of not greater than 3% when tested in accordance with BS 812.
- f. The recommended sizes of coarse aggregate are as follows:
- |                                       |      |         |
|---------------------------------------|------|---------|
| Structural and blinding concrete      | 20mm | nominal |
| Concrete fill to reinforced blockwork | 10mm | nominal |
- g. Concrete workability should be specified so that the concrete can be placed without the risk of segregation, and so that it can be properly compacted around all reinforcement without leaving voids.
- h. A water cement ratio of less than 0.5 will produce an impermeable concrete but the workability will be low. Increasing the water cement ratio from 0.5 to 0.6 will result in a threefold increase in permeability making the concrete unsuitable for bund construction. The optimum water cement ratio for producing impermeable concrete is 0.35, but a plasticiser will have to be incorporated to give the mix sufficient workability. The approved supplier should be consulted on workability requirements. GGBFS and PFA may be used as replacements for plasticisers to increase workability.

## 6. CONCRETE PLACING AND WORKMANSHIP

- a. A polythene membrane (1,000g/m<sup>2</sup> gauge) should be placed on top of the blinding concrete to prevent leaching of water and fines out of the concrete mix

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**

during placing. Membrane joints should be sealed or lapped for added protection against leakage.

- b. Concrete must not be placed during adverse weather conditions, during freezing conditions or against frozen or frost covered surfaces.
- c. The concrete must be transported by appropriate means and placed in its final position in such a way that no segregation occurs.
- d. Concrete should be placed in one continuous operation up to construction joints and formwork surfaces. The concrete should be placed in layers no thicker than can be compacted effectively with the equipment available.
- e. The placed concrete should be properly compacted using mechanical vibrators such that no segregation, voids, or other defects that might affect the final condition of the cast concrete can occur.
- f. After casting and formwork removal, the exposed surfaces of the cast concrete should be cured in accordance with the requirements of BS 8110. Proper curing is essential to help prevent loss of moisture during hydration of the cement and to minimise cracking. It also helps the concrete reach its design strength more rapidly.
- g. Curing may be achieved by covering the work and wetting the surface of the concrete from time to time as necessary. Alternatively, a proprietary curing agent may be sprayed on to the surface of the concrete in accordance with the manufacturers instructions.
- h. Other precautions should be taken as necessary to protect the finished concrete against damage or adverse weather during curing.
- i. Concrete cube test results or test certificates should be provided by the contractor or concrete supplier to demonstrate compliance of the concrete mix with BS 8110 or BS 8007 as appropriate.

## 7. JOINTS

- a. The model drawings assume continuous construction of the base slab with no requirement for expansion, contraction or construction joints. Where vertical construction joints are required in walls, 'water stops' should be provided. Water stops should be provided at the junction between the walls and base slab.
- b. Contractors who are sufficiently experienced in constructing water-tight reinforced concrete structures may be able to dispense with the water stop at the junction of the wall and base slab. The technique requires the top surface of the kicker to be prepared by washing away the cement and fine sand before the concrete hardens completely. The clean aggregate which is exposed forms a surface to which the next layer of poured concrete in the walls can bond. To be successful, this method requires a skilled contractor and careful attention to detail.

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**

- c. Water stops should conform to BS 6213. The types that are likely to be used in bund construction are as follows:
  - i. centre bulb type (flexible polymer) - for expansion, contraction and partial contraction joints, set centrally in walls. The distance of the waterstop from the nearest exposed concrete face should be not less than half the waterstop width
  - ii. dumbbell type (flexible polymer) - similar to above but without centre bulb. Used only for contraction, partial contraction or construction joints
  - iii. surface types (flexible polymer) - used on the underside of concrete slabs and occasionally on the outer face of below ground walls
  - iv. rigid type (metal, e.g. copper or steel strip) - used for construction joints where no movement is anticipated.
- d. Water stops should be joined using proprietary joining pieces and heat welded, vulcanised or bonded together in accordance with the manufacturers' instructions.
- e. Joint sealing compounds should be resistant to the contained liquid, in this case oil, and the work detailed and constructed to the manufacturer's recommendations. BS 6213 specifies the various sealants and their application.

## **8. COATINGS AND SURFACE TREATMENTS**

### **a. In situ reinforced concrete work.**

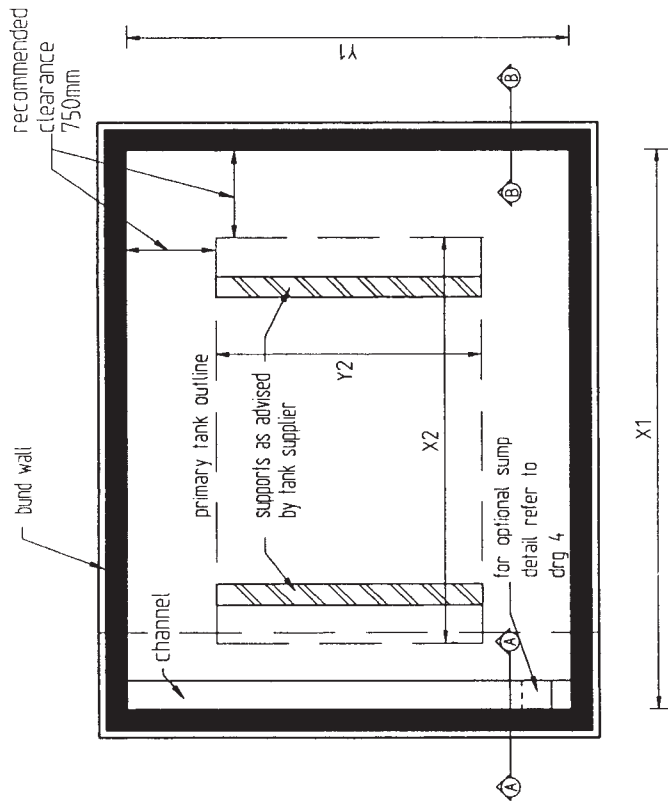
Providing that the concrete is in compliance with the specified mixes and the method of placing, compaction and all other workmanship conforms to BS 8110 or 8007 as appropriate, surface coatings should not be necessary. Any minor defects in the finished surfaces should be treated, if possible, while the concrete is still green. Pin holes and small cracks may be filled by bag rubbing the surface with a grout mix comprising 1 part OPC, and 1 part of the fine sand aggregate as used in the concrete mix. The floor slab should be trowelled or finished to a smooth finish and to the required falls leading to the sump.

Where other finishes are required for aesthetic reasons, they should be applied in accordance with the manufacturers specification. Care must be taken to ensure that any paints or other coatings that are specified are not be affected by oil.

### **b. Sump**

The sump has to withstand significantly more abrasion than other parts of the bund. It is therefore recommended that the surface of the sump is coated with an epoxy mortar render. The concrete surface should be properly prepared ready to receive the coating and the mortar applied strictly in accordance with the manufacturer's instructions.

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**



R.C. bund up to 3.5m wide where ground not susceptible to frost heave

Calculation of length / width of bund

X1 (internal length of bund) = X2 (length or diam. of primary tank) + 15 m

Y1 (internal length of bund) = Y2 (width or diam. of primary tank) + 15 m

Calculation of height of bund wall

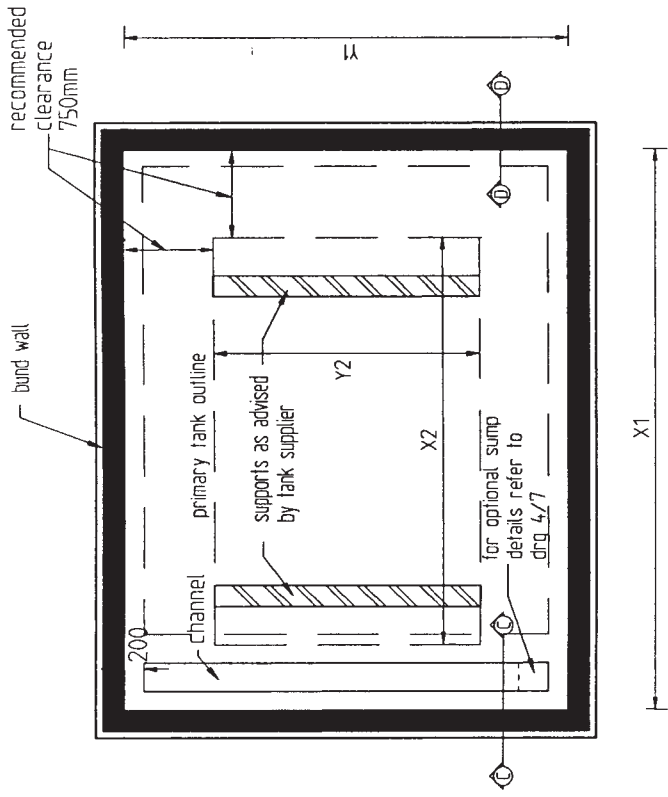
(a) Method 1 - 110% rule (see Section 32 of report)

height of bund wall =  $[1.1 \times \text{primary tank volume} / (X1 \times Y1)] + (\text{volume of tank supports} / (X1 \times Y1))$

(b) Method 2 - alternative method (see Section 33 of report)

height of bund wall =  $[\text{primary tank volume} / (X1 \times Y1)] + (\text{volume of tank supports} / (X1 \times Y1)) + \text{freeboard}$

Freeboard to be allowed for rainwater, fire fighting agents and dynamic effects as appropriate and as defined in Section 33 of report.

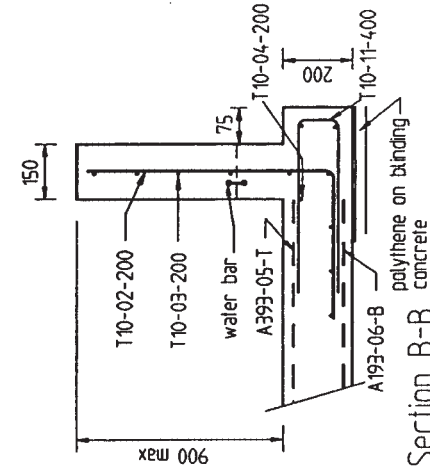
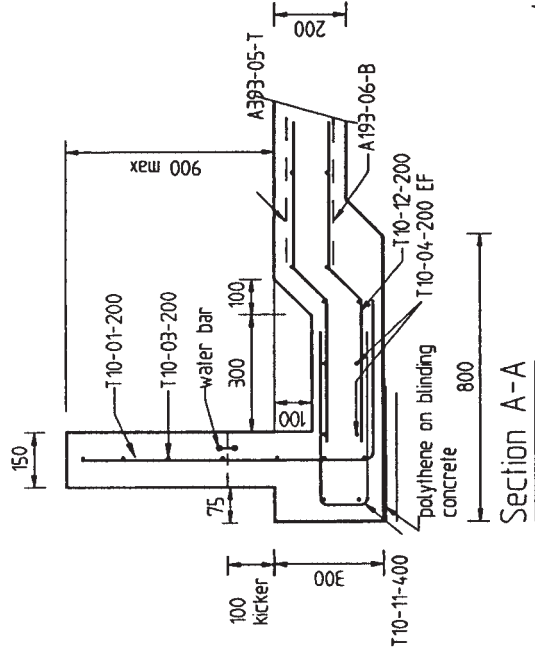
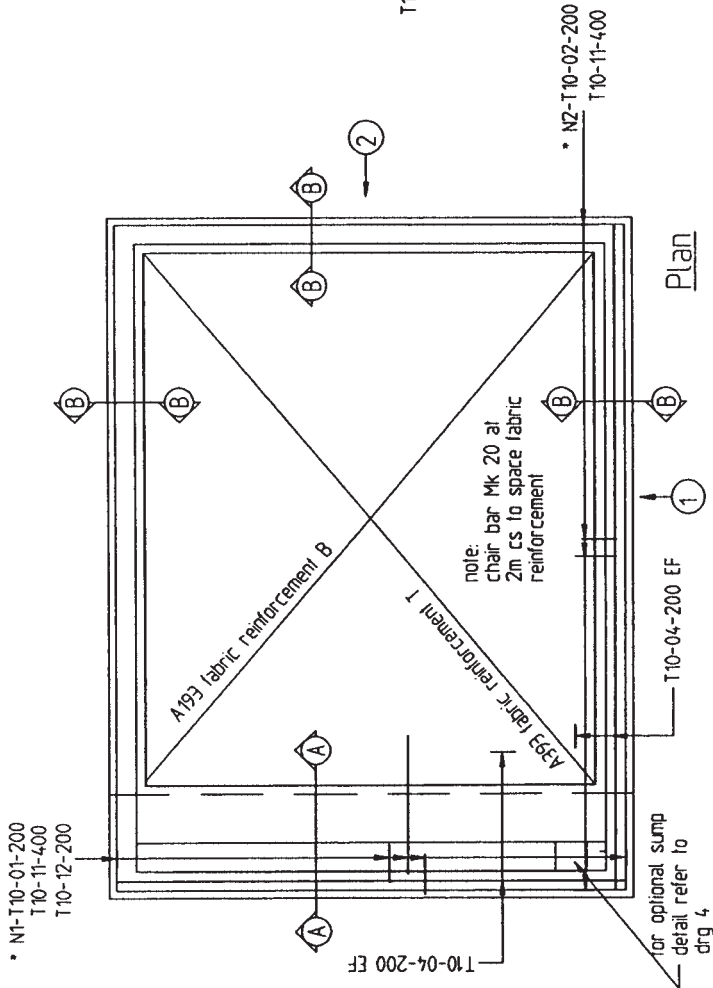


R.C. bund from 3.5m to 7m wide or where ground susceptible to frost heave - includes perimeter ground beam

This drawing to be read in conjunction with drawing No's 2, 4 and specification

Drawing Title  
Reinforced concrete bund:  
general arrangement

drg No 1



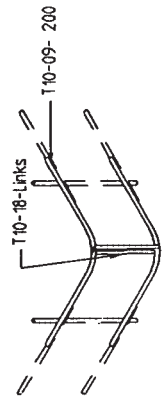
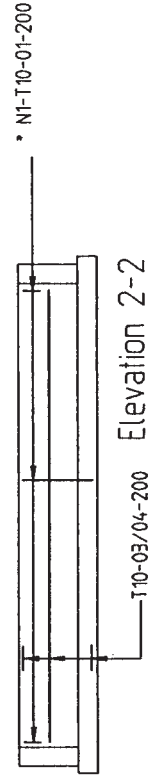
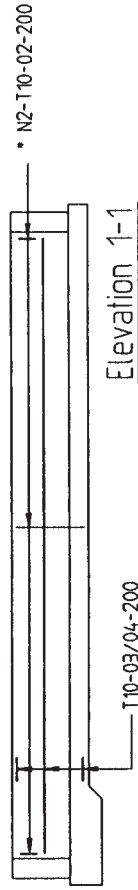
member	bar Mk	type/size/cs	shape code	length	A	B	C	D
wall/founds	01	T10-200	37	H+775	H+200	600		
wall/founds	02	T10-200	37	H+675	H+100	600		
wall	03	T10-200	20	distribution to suit	W	or		
wall corner	09	T10-200	37	1175	600	600		
wall corner	18	T10	81	1820	210	60		
foundations	04	T10-200	20	distribution to suit	W+L	or	L+1	
foundations	05	A393 fabric	-					
foundations	06	A193 fabric	-					
foundations	11	T10-400	38	1330	650	80	650	
foundations	12	T10-200	41	1090	450	140	500	100
foundations	20	R10-2000	83	1630	250	80	150	150

\* number of bars (N1,N2) = (wall length / 200) + 1

H = height of bund wall l = thickness of bund wall.

W = Y1 + thickness of bund wall + 50mm Y1 = internal width of bund

L = X1 + thickness of bund wall + 50mm X1 = internal length of bund



This drawing to be read in conjunction with drawing 1, 4 and specification

Drawing Title

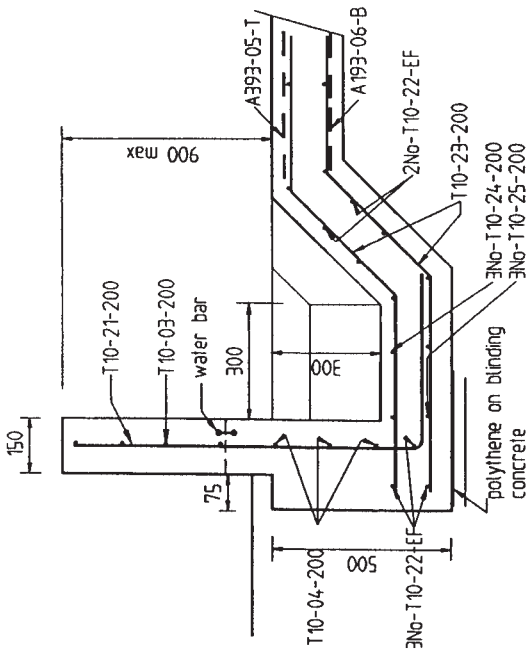
Reinforced concrete bund:

up to 3.5m wide and

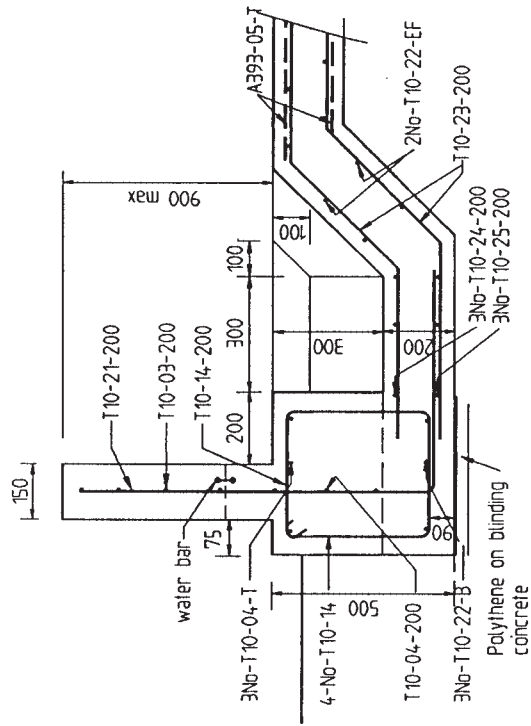
900mm high

drg No

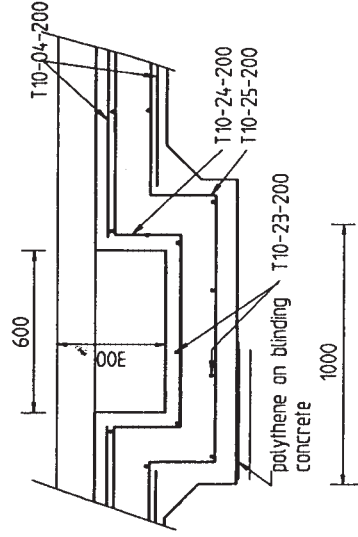
2



Section A-A sump detail for bund construction to drg 2



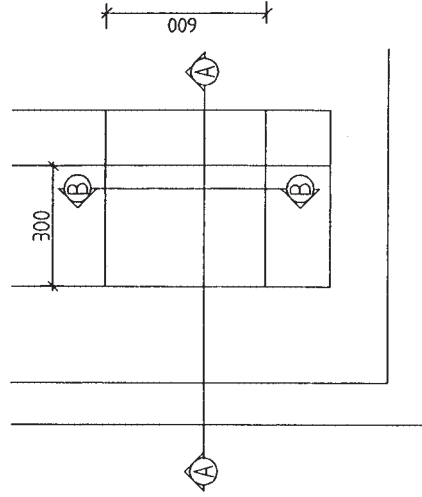
Section A-A sump detail for bund construction to drg 3



Typical Section B-B

member	bar	Mk	type/size/cs	shape	length	A	B	C	D
Section A-A sump detail for bund construction to drg 3									
wall/founds	21		T10-200	37	H+975	H+400	600		
wall	03		T10-200	20	distribution to suit	W			
foundations	04		T10-200	20	distribution to suit	W+1			
foundations	14		T10-200	60	1650	350	375		
foundations	22		T10-200	20	distribution to suit	Y5-80mm			
foundations	23		T10-200	41	1375	450	425	500	
foundations	24		T10-200	53	Y5+1320	450	200	Y5+120	200
foundations	25		T10-200	53	Y5+1520	450	200	Y5+320	200
foundations	05		A393 fabric	T+B					
Section A-A sump detail for bund construction to drg 2									
wall/founds	21		T10-200	37	H+975	H+400	600		
wall	03		T10-200	20	distribution to suit	W			
foundations	04		T10-200	20	distribution to suit	W+1			
foundations	22		T10-200	20	distribution to suit	Y5-80mm			
foundations	23		T10-200	41	1375	450	425	500	
foundations	24		T10-200	53	Y5+1320	450	200	Y5+120	200
foundations	25		T10-200	53	Y5+1520	450	200	Y5+320	200
foundations	05		A393 fabric	T					
foundations	06		A193 fabric	B					

H = height of bund wall  
W = Y1 + thickness of bund wall + 50mm Y1 = internal width of bund  
L = X1 + thickness of bund wall + 50mm X1 = internal length of bund



Plan of sump

Drawing Title  
Reinforcement details for optional insitu concrete sump.  
drg No 4

## **APPENDIX 1 List of British Standards referred to in this specification**

- BS 8007:1987 *Design of concrete structures for retaining aqueous liquids*
- BS 4449:1988 *Specification for carbon steel bars for the reinforcement of concrete*
- BS 4483:1985 *Specification of steel fabric for the reinforcement of concrete*
- BS 4466:1989 *Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete*
- BS 8110:1985 *Structural use of concrete*
- BS 5328:Part 2: 1991 *Methods for specifying concrete mixes*
- BS 882: 1992 *Specification for aggregates from natural sources for concrete*
- BS 1047:1983 *Specification for air-cooled blastfurnace slag aggregate for use in construction*
- BS 812: (comprising 24 Parts) *Testing aggregates*
- BS 6213:1992 *Guide to selection of constructional sealants*

**If a larger or more complex construction is required, please refer to CIRIA Report 163 (see back page for details)**



For 40 years CIRIA - the Construction Industry Research and Information Association - has managed collaborative research and produced information aimed at providing best practice solutions to industry problems. CIRIA stimulates the exchange of experience across the industry and its clients, and has an established reputation for practical, high quality information. Through networking and the dissemination of publications and newsletters, CIRIA seeks to improve the performance of all concerned with construction and the environment.

For further information please contact CIRIA by:

Post: 6, Storey's Gate, Westminster, London SW1P 3AU  
Tel: 020 7222 8891 (General Enquiries) 020 7799 3243 (Publications)  
Fax: 020 7222 1708  
e-mail: enquiries@ciria.org.uk

Further details are available on CIRIA's Web site: [www.ciria.org.uk](http://www.ciria.org.uk)

CIRIA Report 163 "Construction of bunds for oil storage tanks"  
ISBN 0 86017 468 9 Available from CIRIA, price £18

All the Agencies' pollution prevention guidance notes are available on the web sites listed below.

#### ENVIRONMENT AGENCY

##### HEAD OFFICE

Rio House, Waterside Drive, Aztec West  
Almondsbury, Bristol BS32 4UD.  
Tel: 01454 624 400 Fax: 01454 624 409  
World Wide Web: <http://www.environment-agency.gov.uk>

##### REGIONAL OFFICES

###### ANGLIAN

Kingfisher House  
Goldhay Way  
Orton Goldhay  
Peterborough PE2 5ZR  
Tel: 01733 371 811  
Fax: 01733 231 840

###### MIDLANDS

Sapphire East  
550 Streetsbrook Road  
Solihull B91 1QT  
Tel: 0121 711 2324  
Fax: 0121 711 5824

###### NORTH EAST

Rivers House  
21 Park Square South  
Leeds LS1 2QG  
Tel: 0113 244 0191  
Fax: 0113 246 1889

###### NORTH WEST

Richard Fairclough House  
Knutsford Road  
Warrington WA4 1HG  
Tel: 01925 653 999  
Fax: 01925 415 961

###### SOUTHERN

Guildbourne House  
Chatsworth Road  
Worthing  
West Sussex BN11 1LD  
Tel: 01903 832 000  
Fax: 01903 821 832

###### SOUTH WEST

Manley House  
Kestrel Way  
Exeter EX2 7LQ  
Tel: 01392 444 000  
Fax: 01392 444 238

###### THAMES

Kings Meadow House  
Kings Meadow Road  
Reading RG1 8DQ  
Tel: 0118 953 5000  
Fax: 0118 950 0388

###### WELSH

Rivers House  
St Mellons Business Park  
St Mellons  
Cardiff CF3 0EY  
Tel: 029 2077 0088  
Fax: 029 2079 8555

#### SCOTTISH ENVIRONMENT PROTECTION AGENCY

##### HEAD OFFICE

Erskine Court  
The Castle Business Park  
Stirling FK9 4TR  
Tel: 01786 457 700  
Fax: 01786 446 885  
World Wide Web: <http://www.sepa.org.uk>

##### REGIONAL OFFICES

###### NORTH REGION HQ

Graesser House  
Fodderty Way  
Dingwall Business Park  
Dingwall IV15 9XB  
Tel: 01349 862 021  
Fax: 01349 863 987

###### WEST REGION HQ

SEPA West  
5 Redwood Crescent  
Peel Park  
East Kilbride G74 5PP  
Tel: 01355 574 200  
Fax: 01355 574 688

###### EAST REGION HQ

Clearwater House  
Heriot-Watt Research Park  
Avenue North  
Riccarton  
Edinburgh EH14 4AP  
Tel: 0131 449 7296  
Fax: 0131 449 7277

#### ENVIRONMENT & HERITAGE SERVICE

Calvert House,  
23 Castle Place,  
Belfast  
BT1 1FY  
Tel: 028 9025 4868  
Fax: 028 9025 4777

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**ENVIRONMENT AGENCY**

