

EARTH RETAINING WALLS



TECHNICAL DESIGN GUIDE

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1. RETAINING WALL SELECTION PROCEDURE

a. Select the appropriate design table(s) depending on whether or not there are fences located above the retaining wall. Go to Section 3.1 or 4.1 of this document for retaining walls without fences above and Section 3.2 or 4.2 for retaining walls with fences above (up to a maximum of 1.8m high fence). It is noted that for retaining walls with fences above, refer to both Section 3.2.1 or 4.2.1 for general fence zones and Section 3.3.1 or 4.3.1 for the end zones of a fence (i.e. within 7.2 metres from the end of a fence).

b. Select the correct design table based on the backfill/subgrade material to be used for the retaining wall. 5 Different subgrade/backfill materials have been catered for, namely:

- Gravel;
- Medium Dense Sand (Medium grained);
- Medium Dense Silty Sand/Fine Sand/ Shales;
- Stiff Clay; or
- Soft Clay

Note: We recommend for walls greater than 2m height, geotechnical advice be sought to verify the nature of the subgrade/backfill materials to be adopted for the design.

c. The subgrade is the material into which the post is to be embedded and the backfill is the material which is placed and compacted behind the retaining wall.

d. Determine the actual height of the wall based on on-site measurements/survey.

e. Determine the maximum post spacing for the wall height by referring to the relevant table(s) from Step a). Choose the post spacing for which the maximum wall height is greater than the actual wall height determined in Step c).

f. Determine the minimum post embedment depth based on the selected subgrade/backfill type, wall height, and post spacing.

Example:

Step 1. An earth retaining wall with a 1,800mm high fence: Go to Section 3.2.1 for the general fence zones (away from the end of the fence).

Step 2. Select the correct backfill/subgrade material: Gravel

Step 3. Actual wall height: 1,100mm

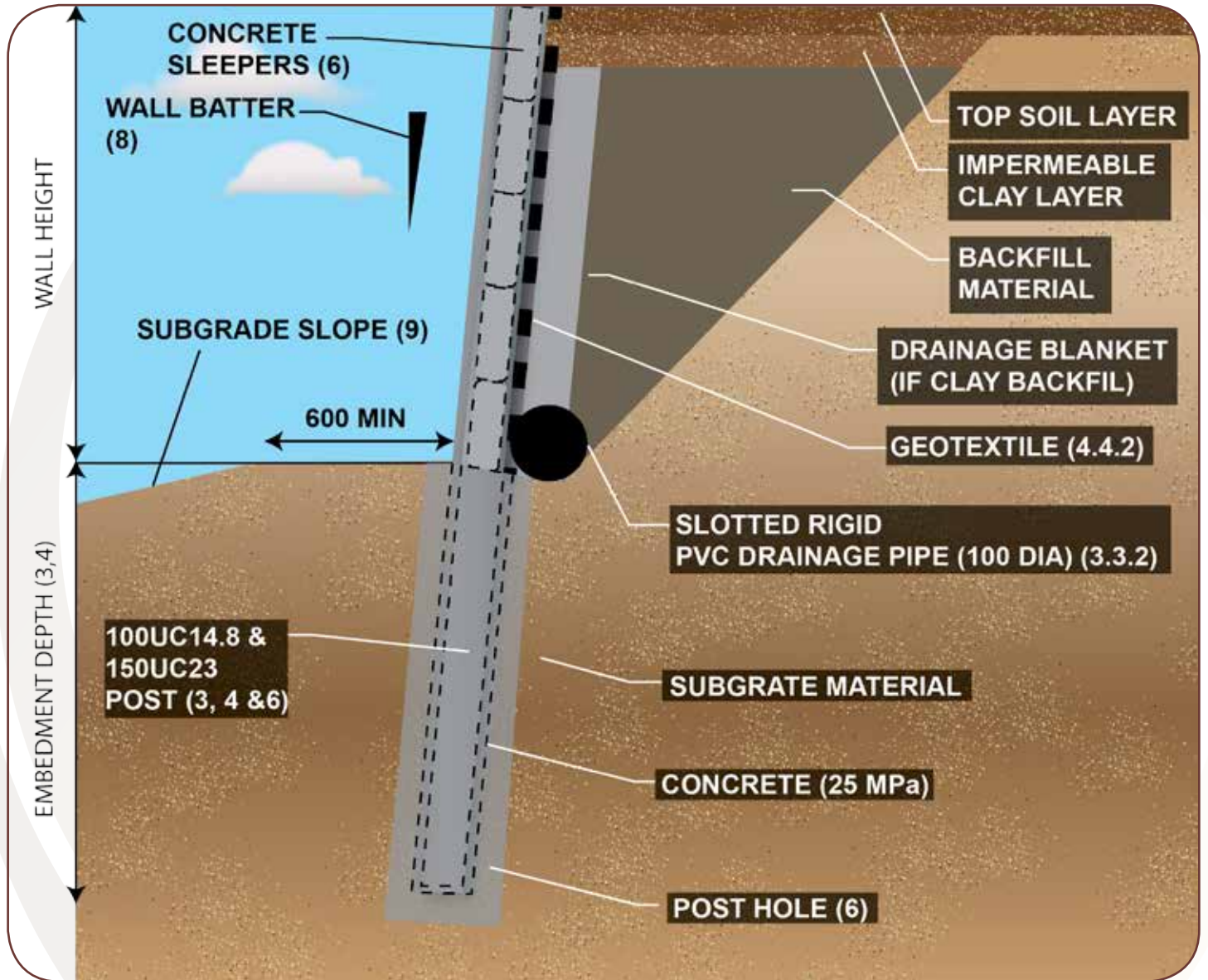
Step 4. Select the post spacing: 2,000mm (the maximum wall height for that spacing is 1,200mm which is greater than the required wall height).

Step 5. Select the minimum post embedment depth: 1,000mm.

Step 6. Repeat Steps 1 to 5 for the end zones of a fence by referring to Section 3.3.1.



Typical wall configuration
(Figure 1)



The general configuration of the wall with drainage installed behind the wall should generally conform to the diagram above.

2. HARD SOUND IGNEOUS ROCK

Embedment of retaining wall posts within rock are not permitted.

3 POST SPACING AND EMBEDMENT DEPTH DESIGN TABLES

3.1 EARTH RETAINING WALL WITHOUT FENCES ABOVE 100UC14.8 POSTS IN 400MM Ø POST HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	2450	1050
	1200	2300	1050
	1600	2050	1050
	2000	1850	1050
	2400	1100	750
Medium Dense Sand (Medium Grained)	1000	2250	1150
	1200	2100	1150
	1600	1850	1150
	2000	1700	1200
	2400	1400	1100
Silty Sand Fine Sand Shales	1000	2200	1300
	1200	2050	1300
	1600	1800	1300
	2000	1650	1350
	2400	1436	1250
Stiff Clay	1000	2100	1250
	1200	1950	1050
	1600	1700	1050
	2000	1550	1050
	2400	1067	750
Soft Clay	1000	1850	2050
	1200	1700	2050
	1600	1500	2050
	2000	1350	2100
	2400	972	1550

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	3%	1%
20%	18%	6%	2%
30%	27%	9%	2%
40%	36%	12%	3%
50%	45%	15%	4%

3.2 EARTH RETAINING WALLS WITH FENCES ABOVE (MAX 1800MM HEIGHT)

3.2.1 GENERAL ZONES (AWAY FROM THE END OF A FENCE)

100UC14.8 POSTS IN 400MM Ø POSTS HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	1950	1000
	1200	1750	1000
	1600	1450	1000
	2000	1200	1000
	2400	1000	1000
Medium Dense Sand (Medium Grained)	1000	1850	1150
	1200	1650	1150
	1600	1350	1150
	2000	1100	1150
	2400	950	1150
Silty Sand Fine Sand Shales	1000	1800	1300
	1200	1600	1300
	1600	1300	1300
	2000	1100	1300
	2400	900	1300
Stiff Clay	1000	1700	1000
	1200	1550	1000
	1600	1250	1000
	2000	1050	1000
	2400	900	1050
Soft Clay	1000	1550	2000
	1200	1350	2000
	1600	1100	1950
	2000	900	1950
	2400	750	1950

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	3%	1%
20%	18%	6%	2%
30%	27%	9%	2%
40%	36%	12%	3%
50%	45%	15%	4%

3.3 EARTH RETAINING WALLS END ZONES (WITHIN 7.2M FROM THE END OF THE FENCE)

3.3.1 EARTH RETAINING WALL 100UC14.8 POSTS IN 400MM Ø POST HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	1450	1000
	1200	1250	1000
	1600	800	1000
	2000	550	1000
	2400	300	1000
Medium Dense Sand (Medium Grained)	1000	1400	1150
	1200	1150	1150
	1600	750	1150
	2000	500	1150
	2400	250	1150
Silty Sand Fine Sand Shales	1000	1350	1300
	1200	1100	1300
	1600	750	1300
	2000	450	1300
	2400	200	1300
Stiff Clay	1000	1350	1050
	1200	1100	1000
	1600	800	1000
	2000	500	1000
	2400	300	1000
Soft Clay	1000	1200	2050
	1200	950	1900
	1600	650	1900
	2000	400	1950
	2400	200	1950

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	3%	1%
20%	18%	6%	2%
30%	27%	9%	2%
40%	36%	12%	3%
50%	45%	15%	4%

4 POST SPACING AND EMBEDMENT DEPTH DESIGN TABLES

4.1 EARTH RETAINING WALL WITHOUT FENCES ABOVE 150UC23 POSTS IN 450MM Ø POST HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	3350	1300
	1200	3100	1300
	1600	2800	1350
	2000	2550	1350
	2400	1700	1000
Medium Dense Sand (Medium Grained)	1000	3100	1500
	1200	2850	1500
	1600	2550	1500
	2000	2350	1500
Silty Sand Fine Sand Shales	1000	3050	1700
	1200	2850	1700
	1600	2500	1700
	2000	2300	1700
	2400	1450	1250
Stiff Clay	1000	2800	1500
	1200	2600	1500
	1600	2350	1550
	2000	1800	1250
	2400	1050	800
Soft Clay	1000	2500	2900
	1200	2300	2900
	1600	2000	2900
	2000	1650	2550
	2400	950	1500

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	6%	3%
20%	18%	12%	7%
30%	25%	16%	10%
40%	33%	21%	14%
50%	41%	25%	17%

4.2 EARTH RETAINING WALLS WITH FENCES ABOVE (MAX 1800MM HEIGHT)

4.2.1 GENERAL ZONES (AWAY FROM THE END OF A FENCE) 150UC23 POSTS IN 450MM Ø POST HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	3000	1300
	1200	2750	1300
	1600	2350	1300
	2000	2100	1300
	2400	1700	1250
Medium Dense Sand (Medium Grained)	1000	2800	1500
	1200	2550	1500
	1600	2200	1500
	2000	1950	1500
	2400	1400	1300
Silty Sand Fine Sand Shales	1000	2750	1650
	1200	2500	1650
	1600	2150	1650
	2000	1850	1650
	2400	1450	1550
Stiff Clay	1000	2550	1500
	1200	2350	1500
	1600	2000	1500
	2000	1800	1500
	2400	1050	1100
Soft Clay	1000	2300	2900
	1200	2050	2900
	1600	1750	2900
	2000	1550	2900
	2400	1000	2250

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	6%	3%
20%	18%	12%	7%
30%	25%	16%	10%
40%	33%	21%	14%
50%	41%	25%	17%

4.3 EARTH RETAINING WALLS END ZONES (WITHIN 7.2M FROM THE END OF THE FENCE)

4.3.1 150UC23 POSTS IN 450MM Ø POST HOLES

Backfill Material/ Subgrade Material	Post Spacing (mm)	Maximum Wall Height (mm)	Minimum Post Embedment Depth (mm)
Gravel	1000	2650	1300
	1200	2400	1300
	1600	1950	1300
	2000	1650	1300
	2400	1400	1300
Medium Dense Sand (Medium Grained)	1000	2500	1450
	1200	2250	1450
	1600	1850	1450
	2000	1500	1450
	2400	1300	1450
Silty Sand Fine Sand Shales	1000	2450	1650
	1200	2200	1650
	1600	1800	1650
	2000	1500	1650
	2400	1250	1650
Stiff Clay	1000	2300	1500
	1200	2050	1500
	1600	1700	1500
	2000	1450	1500
	2400	1100	1500
Soft Clay	1000	2000	2700
	1200	1750	2700
	1600	1400	2700
	2000	1150	2700
	2400	1000	2700

EMBEDMENT DEPTH VARIATION TABLE

% Reduction in Wall Height	% Reduction in Embedment Depth		
	No Fence	With Fence - General Zones	With Fence - End Zones
10%	9%	6%	3%
20%	18%	12%	7%
30%	25%	16%	10%
40%	33%	21%	14%
50%	41%	25%	17%

4.4 NOTES ON TABLES

4.4.1 EMBEDMENT DEPTHS

Embedment depths for cantilever retaining walls is critical. A small reduction in embedment depth results in a significant increase in stress within the foundation material and increases the likelihood of a foundation failure. Accordingly embedment depths noted within this document are considered minimum values.

The figures given in Tables 3.1, 3.2.1, 3.3.1, 4.1, 4.2.1 and 4.3.1 assume that the same soil type is used for both backfill and subgrade embedment.

4.4.2 INSTALLATION NOTES

- Allow minimum 48 hours for concrete to set in post holes prior to installing sleepers.
- Ensure horizontal alignment and correct height spacing prior to inserting sleepers into posts. Use packing under bottom row of sleepers if required.
- Place geotextile to rear face of sleepers to prevent drainage material from flowing through the small gaps between the sleepers. Lay slotted rigid PVC pipe behind the sleepers connected to stormwater as detailed in Typical Wall Configuration diagram (figure 1).



5. SOIL PARAMETERS

The formulation of the cantilever retaining walls within this document have been undertaken based on the following soil parameters:

Subgrade/ Backfill Type	Density (kN/m ³)	Angle of Internal Friction	Cohesion (kPa)
Gravel	19	35	-
Sand	20	32	-
Silty sand	18	30	-
Stiff clay	20	-	75
Soft clay	18	-	18

The sizes and dimensions shown for the tables in Section 3 and 4 of this document have been based on a Type 3 structure classification to AS4678-2002. This assumes that failure of this type of structure would only result in minimal damage and loss of access. For higher structure classifications, engineering advice should be obtained.

The tables shown in Section 3 and 4 of this document assumes that the backfill behind the retaining wall is placed in a manner which is consistent with Controlled Fill - Class 1 as per AS 4678-2002. The levels of compaction required to achieve this would be 98% of standard dry density in maximum 200mm compacted layers at optimum moisture content +/- 2%. For retaining walls where it is intended to place and compact the backfill consistent with a lower classification, engineering advice should be obtained.

6. POST AND SLEEPER SIZES

All steel posts shall be 100UC14.8 or 150UC23 Grade 300 unless noted otherwise (refer Table 3 and 4).

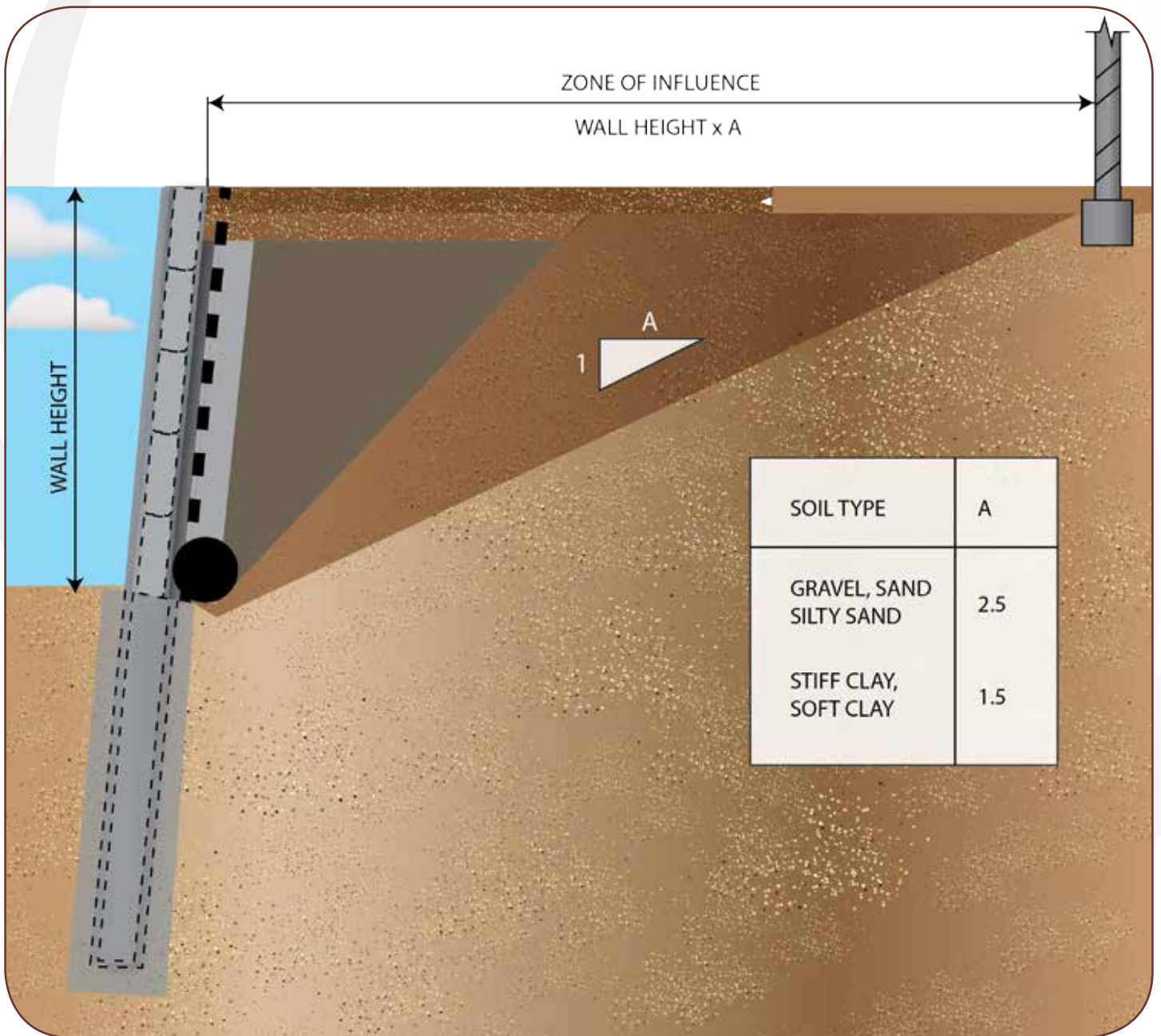
The post holes into which these members are placed shall be of a minimum diameter of 400mm or 450mm with minimum 100mm concrete cover at base of hole (refer Table 3 and 4). Minimum concrete grade in post hole to be 25MPa at 28 days.

The sleepers used within these retaining walls consist of precast concrete 75mm thick and 200mm high. Minimum concrete strengths shall be 40 MPa at 28 days. Each sleeper shall be reinforced with 2N12 reinforcing bars longitudinal, with minimum 30mm cover.

7. SURCHARGE LOADS

The retaining walls specified in this document have been designed based on a 2.5kPa surcharge load in accordance with AS4678-2002. For retaining walls where a higher surcharge loading is required or where the retaining wall is within the zone of influence of other structures (refer to Figure 2), engineering advice should be obtained.

Figure 2



8. RETAINING WALL POST BATTERING

Retaining walls of a height greater than 1,000mm, shall be battered back from vertical in the following amounts:

Backfill/Subgrade type	Batter (Vertical:Horizontal)
Gravel, sand, silty sand	20:1
Stiff clay, soft clay	15:1

9. SUBGRADE SLOPE

The information contained within Section 3 and 4 of this document has been based on a maximum subgrade slope from 600mm beyond the base of the wall, of 1 vertical to 6 horizontal away from the wall (Refer to Typical Wall Configuration Figure 1). If the subgrade slope is beyond this amount, engineering advice should be obtained.

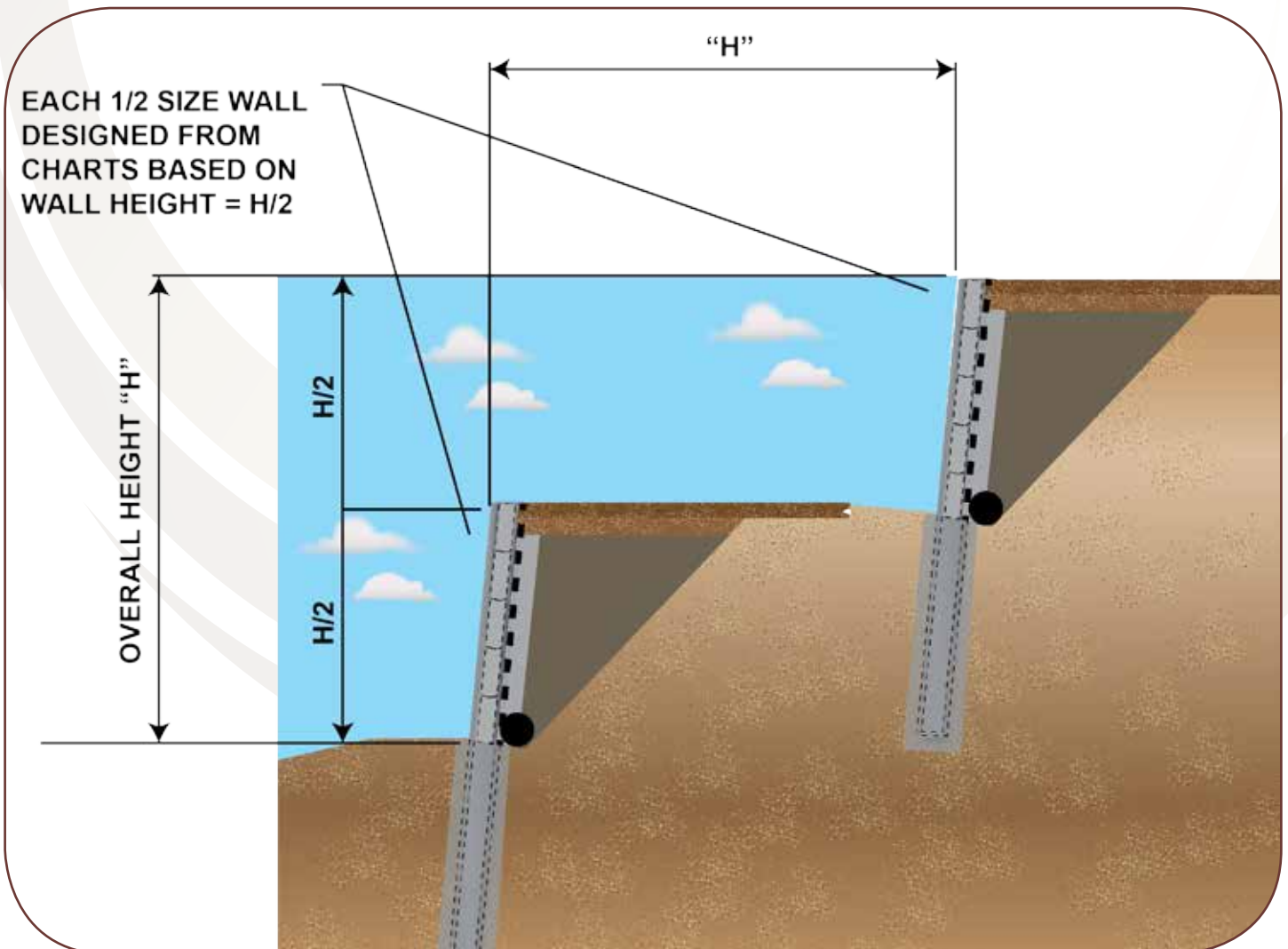
10. BACKFILL SLOPE

The information on the tables has been based on a horizontal backfill slope only. For backfill slopes beyond this amount, engineering advice should be obtained.

11. WALL TERRACING

Utilising two terraced cantilever walls of half height instead of a single wall of full height is permitted so long as the distance between the two terraced walls conforms to Figure 3.

Figure 3



12. ATTACHMENT OF PALING FENCES

Paling fences can be installed adjacent to the top of the retaining wall. The associated tables within Section 3 and 4 of this document have considered the following maximum wind loading on the associated paling fences:

- Maximum Fence Height: 1.8m
- Wind Region B to AS/NZS1170.2-2011
- Terrain Category 2
- N2 Wind Rating
- Structure Importance Level 1
- Design Life 50 years

It is noted that the fences are subjected to two different wind pressures. The wind pressures within a horizontal distance of 7.2 metres from the end of a fence are double that for general zones of the fence.

For areas where the wind loading is greater than that noted above, engineering advice should be obtained.

13. FURTHER ASSUMPTIONS

The formulation of this document has been undertaken on the following additional assumptions:

- The retaining wall is not subject to vibrations
- The water table is, in all cases, below the underside of the cantilever posts
- The subgrade into which the posts are to be placed is in a undisturbed natural state during the construction of the retaining wall.

14. EXPOSURE CONDITION

The 100UC14.8 and 150UC23 steel posts are protected from corrosion based on atmospheric category C in accordance with AS/NZS 2312:2002. The coating system used in this case consists of hot dipped galvanising designated as HDG600. Unless noted otherwise or where engineering advice has been sought, the retaining walls shown within this document are not permitted to be installed in the following locations:

- Within 1km of the coast;
- Within 1km of a large body of salt water.

15. RELEVANT STANDARDS FOR THIS TYPE OF WALL:

- AS4678-2002 Earth-retaining structures
- AS/NZS1170.0-2002 Structural design actions - Part 0: General principles
- AS/NZS1170.0-2011 Structural design actions - Part 2: Wind actions
- AS3600-2009 Concrete structures
- AS/NZS 2312: 2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

These tables were compiled by David Beneke Consulting. The information is provided for guidance purposes only in the design of retaining walls. If in doubt about the interpretation of the tables or the nature of the soil combinations at the site please seek expert advice.