CONCRETE RETAINING BLOCK WALLS

Installation Manual

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Quality cast in concrete

CONCRETE RETAINING BLOCK WALLS INSTALLATION MANUAL

5th Edition 2009

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INTRODUCTION

Concrete retaining block (CRB) walls are becoming more and more popular throughout the world because of the relatively low cost, the ease and speed of construction, the ability to conform to any contour and the suitability of the wall to greening and vegetation. However, the success of all projects depends on the appropriate planning and scheduling and the correct installation procedure. This manual gives a guideline to the correct installation of CRB walls. Those sections in italics and with a light brown tint background should be considered prescriptive. Those sections in normal print and with a white background are for information only.

EARTHWORKS

Retaining walls are used in both cut and fill situations. In cut situations the properties of the backfill materials are fixed, i.e. given. In the cut situations, the earth will necessarily be cut back to allow for the construction of the wall and the installation of drainage behind the wall if necessary. In the fill situation, the backfill is imported and the properties will be as selected by the engineer. The backfill soil, the drainage of the blocks will be built up simultaneously. The following sections make the assumption that the earthworks are at a stage where construction of the wall can proceed and installation is commencing.

SITE HANDOVER

When the contractor takes control of the site, he shall ascertain the following:

a) Establish responsible person e.g. client/engineer/contractor, plus site communication/management/liaison.

b) Check access and suitable storage and stacking areas — secured for tools, cement and light machines and unsecured for blocks, sand, stone, etc.

c) Discuss sources of power and water and arrange availability and liability with regards to payment for usage.

d) Identify beacons, boundaries, benchmarks and survey points, and request responsible person (client/engineer/contractor) to point all the relevant pegs and markings, to establish finished ground levels, top of foundations, front of walls and extent, lengths and finished heights of walling to be constructed.

e) Request whereabouts of all buried services pertinent to the area in which work will be carried out.

SETTING OUT

The contractor shall:

a) Determine type of foundation and excavation details e.g. stepped, curved, depth below natural ground level (N.G.L.), base dimensions.

b) Angle of wall batter required e.g. 90º, 70º, 50º.

c) Confirm block rotation in relation to base (where applicable).

d) *Block spacing — confirm where blocks are to be laid in open face or closed face (where applicable). Some systems require faces closer for inside radius versus maximum width spacing for outside radius and regular recommended spaces for straight sections.*

e) *Determine start and finish of walls and, where necessary, how to tie in to existing structures.*

The setting out of the wall foundations is critical as often both the base and the top of the wall are constrained by boundaries. The fact that the base is often stepped and curved and that the angle of the batter may vary, makes the setting out even more critical. The layout of curves and corners for CRB walls requires planning by both the design engineer and contractor.

CONSTRUCTION PROCEDURE

a) *Obtain approval of items below from responsible person: client/engineer/contractor*

1. *Foundation excavation.*
2. *Concrete strength, method of placing, vibration, mesh reinforcement.*
3. *Block quality e.g. grey/colour/exposed aggregate and appearance.*
4. *Placing of first blocks - horizontal or rotated (where applicable) and set in wet concrete foundation (where required).*
5. *Backfill: - suitability to reach required compaction*
   - stabilised, properly mixed, placed and compacted
   - drainage medium, coarse clean sand, geotextile, core pipe slotted or perforated, correct diameter.

b) *Installer must be aware of the following:*

1. *Correct block spacing and interlock.*
2. *Seating of blocks and interface appearance (row upon row).*
3. *Line and level checks to void humping.*
4. *Profile of batter to maintain consistent degree.*
5. *Positioning of geofabric tie-backs (where required) and correct installation.*
6. *Correct compaction methods to maintain backfill density required.*
7. *Testing of compaction achieved and recording results.*
8. *Maintaining good housekeeping and discipline during construction period.*

Note: *As there are various systems on the market, the installer is advised to also refer to the manufacturer's installation manual.*

CONSTRUCTION SEQUENCE: STEP 1

EXCAVATION AND FOUNDATION

a. Wall layout and general excavation:

1. Survey and stake CRB location and general excavation limits for wall construction.
2. Ensure CRB is along proper alignment, and within appropriate property boundaries and construction easements.
3. Carry out general excavation for wall.

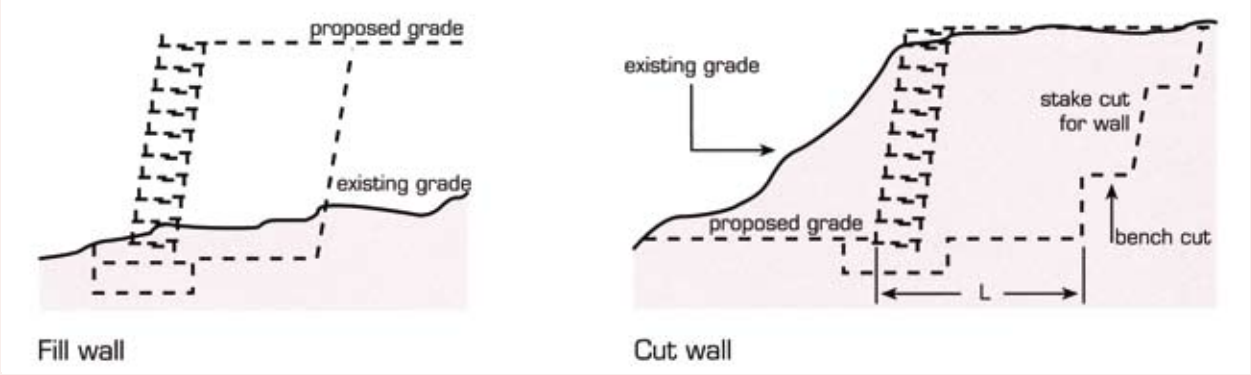

Figure 1: Section through wall.

b. Foundation construction:

1. Stake wall for foundation excavation.
2. Excavate trench to create a minimum foundation thickness (H) of 150mm (or as specified by the engineer) and to the minimum width shown. Place, level and compact concrete foundation material for CRB units.
3. For walls less tan 1,2m a foundation of stone/sand aggregate may be acceptable.
4. Install drain pipe with positive flow to outlet.
5. If specified, place and compact aggregate blanket drain. Install geotextile around blanket drain if required.

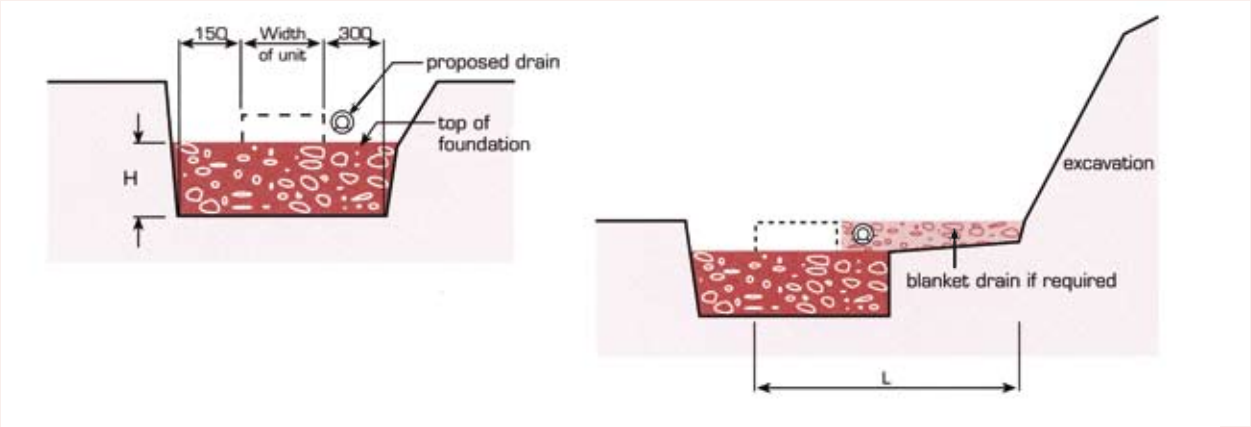

Figure 2: Section through foundation construction.

The foundation must follow the contours as required. The top of the foundation level should be level. If the natural ground level is sloping along the line of the foundation, the foundation should be stepped, taking due cognisance of the set back (see Figure 3). Where the level of the foundation is stepped, the next row of blocks will be stepped back by the amount of the specified setback (see Figure 4).

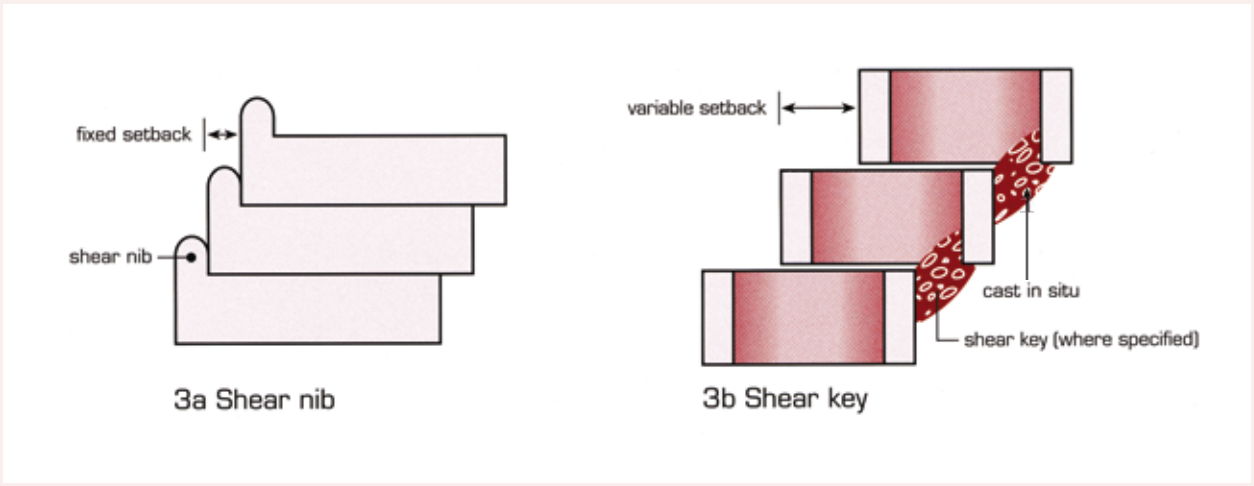

Figure 3: Section through blocks showing setback and shear keys/nibs.

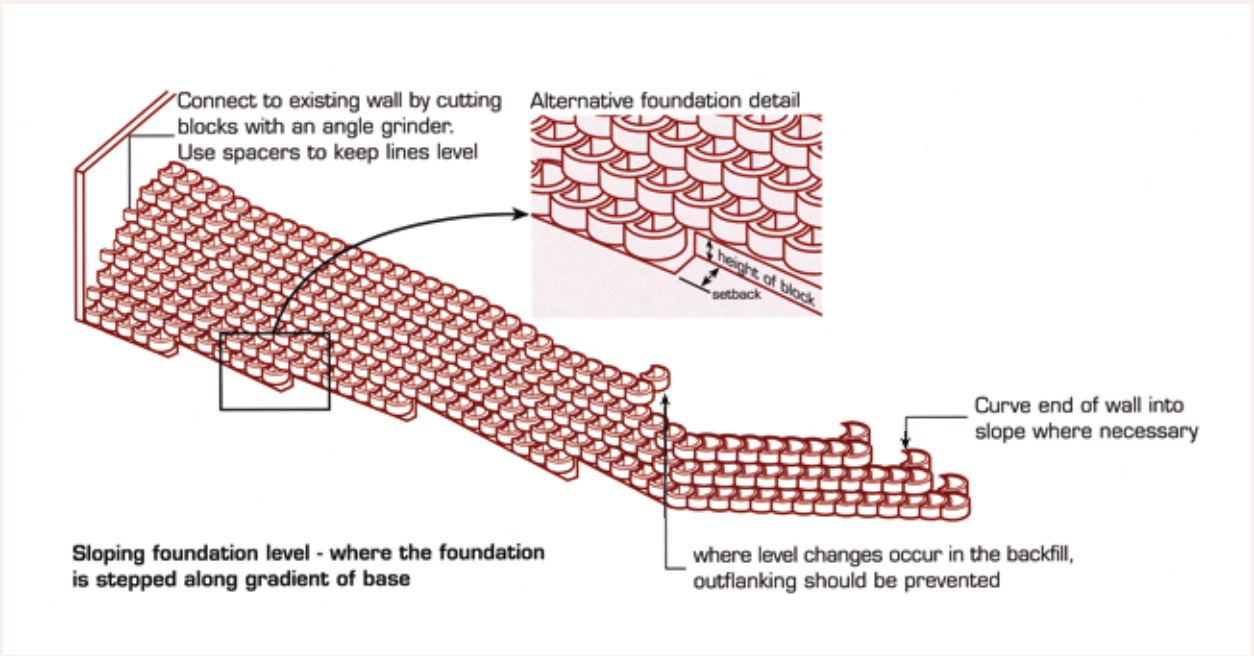

Figure 4: View of blocks showing step-backs.

CONSTRUCTION SEQUENCE: STEP 2

FIRST COURSE OF CRB UNITS

a. Setting first course of CRB units:

1. Check foundation surface is smooth and level (except where stepped).
2. Stake and string-line the wall location. Pay close attention to exact location of curves, corners, vertical and horizontal steps. String-line must be along a moulded face of the CRB unit, and not along a broken block- finished surface.
3. Install first course of CRB units. Checking level of blocks as placed.

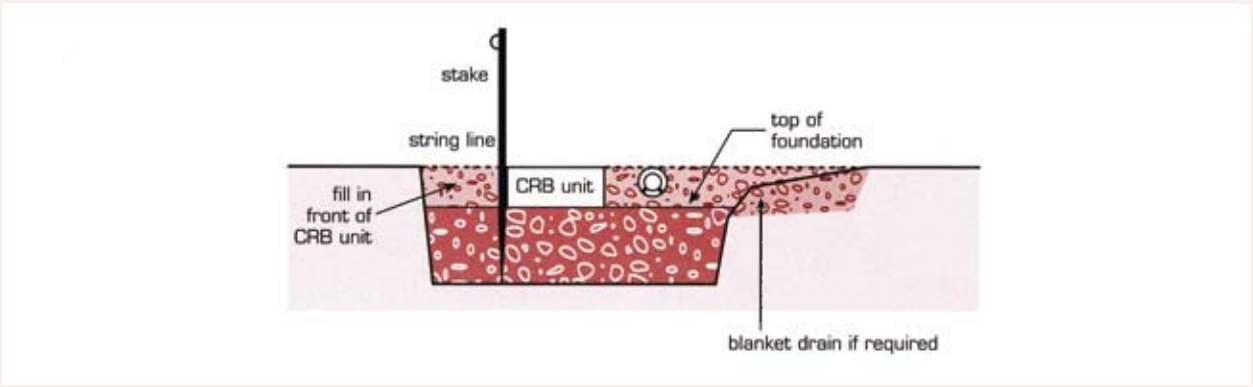

Figure 5: Section through first course of CRB units.

b. Backfilling first course of CRB units:

1. Recheck wall location.
2. Use topsoil or on-site soil (mixed with compost and lightly stamped) to fill any openings in and between CRB units, as required. Where specified, fill the blocks with concrete.
3. Where specified, carefully place drainage aggregate within geotextile around pipe, behind and up to the height of CRB unit to create wall face drain.
4. Place and compact fill soil behind wall.
5. Place fill soil in front of CRB unit.
6. Compact fill soil in front and back simultaneously.

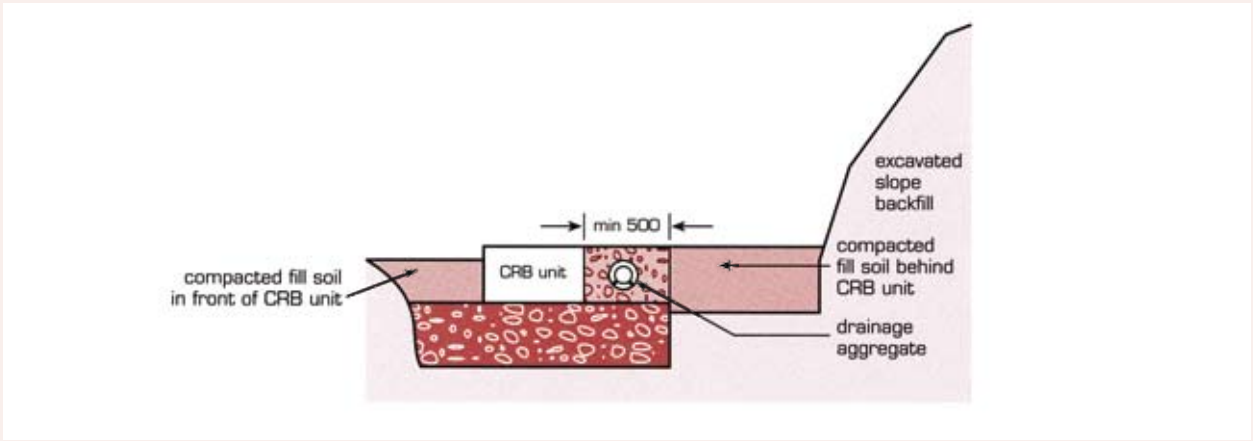

Figure 6: Back filling first course of CRB units.

CONSTRUCTION SEQUENCE: STEP 3

PLACEMENT AND BACKFILLING OF CRB UNITS

a. Installing successive courses of CRB units:

1. Ensure the drainage aggregate is level with or slightly below the top of CRB unit below.
2. Clean debris off top of unit.
3. Move CRB unit to engage shear connector and establish proper setback, consistent with manufacturer's and engineer's recommendations.

   Note: With certain systems, the shear keys (where specified) are cast in situ (see Figure 3b).

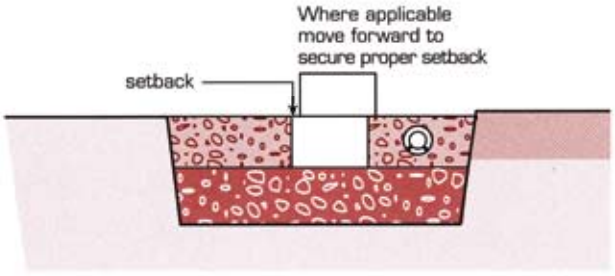

Figure 7: Installing successive courses of CRB units.

b. Fill placement and compaction:

1. Use topsoil or on-site soil (mixed with compost and lightly stamped) to fill openings in and between CRB units as required. Where specified, fill blocks with concrete.
2. Place and compact fill soil behind wall.
3. Where specified, place drainage aggregate wrapped in geotextile behind and up to height of CRB unit to continue wall face drain.
4. Compact fill soil behind CRB units or wall face drain.

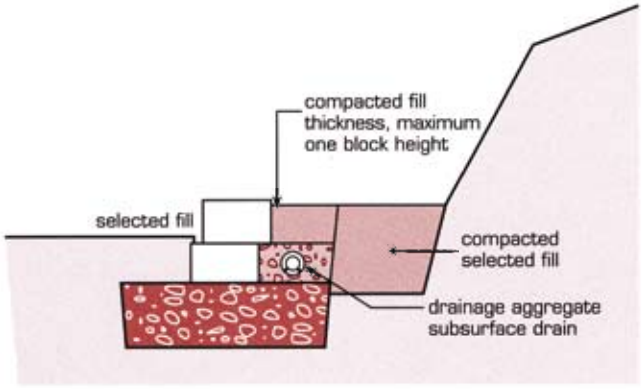

Figure 8: Fill placement and compaction.

SHEAR RESISTANCE BETWEEN BLOCKS

The different types of blocks employ various methods of shear resistance to prevent one block moving relative to the underlying block. Some blocks have nibs, others use shear keys. For small walls (less than 1,2m in height), the use of shear nibs/keys is not critical, for higher walls it is important (depending on the inclination). Check with manufacturer as to their requirements for shear.

The height of the wall is a function of the batter or slope of the wall. The less steep the slope is, the higher the wall can be constructed. The batter or slope of the wall is achieved by laying the blocks with a setback. Often the setback is determined by the nib or shear key employed to prevent shear. In these cases, the setback is fixed. Greater setbacks can be achieved by simply placing the blocks further back. However, this can only be done when the friction between the blocks is sufficient to resist the horizontal earth pressures. For high walls (>1.2m), it is recommended that the blocks are placed with the setback as determined by the shear nib or shear key, in order to ensure that shear resistance becomes fully effective. If a less steep slope is required, this can be achieved by rotating the base block on the foundation by a predetermined angle. Note, with certain systems, that the shear key is cast in situ. Hence, the size of the shear key, length of the setback and hence the batter can be adjusted without the need to rotate the base block.

ROTATION OF BASE BLOCK

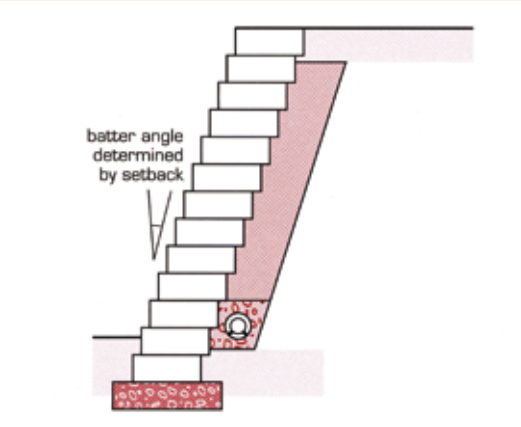

Figure 9a: Batter of wall determined by setback of block.

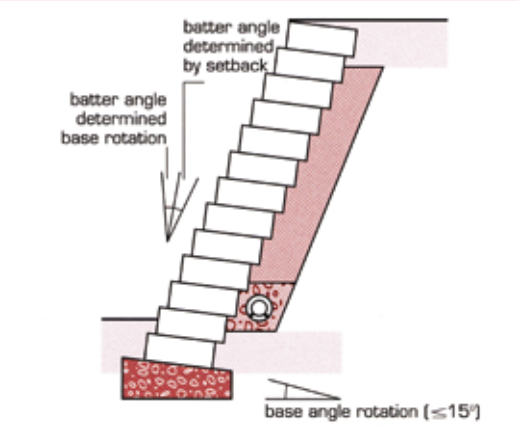

Figure 9b: Batter of wall increased by rotating base block.

GEOSYNTHETIC REINFORCEMENT

Depending on the design of the wall, the engineer may have specified the use of geosynthetic reinforcement. The purpose of geosynthetic material for reinforcement is to incorporate the backfill soil into the retaining wall, thus increasing the total mass of the wall and so increasing the stability of the wall. The contractor must ensure that the geosynthetic is in accordance with the specification, is stored in an acceptable manner and is not damaged before or during installation.

CONSTRUCTION PROCEDURE FOR GEOSYNTHETIC REINFORCEMENT

1. *The CRB blocks are positioned and levelled as before.*
2. *The soil is filled inside the block and behind the block and compacted, ensuring that the surface is level and free from sharp objects.*
3. *The geosynthetic is laid on the soil. Ensure that the geosynthetic is laid with the warp perpendicular to the wall. Ensure that the geosynthetic is properly tied into the CRB block in accordance with the manufacturer's instructions.Ensure that the geosynthetic is flat and without creases or folds. Ensure that the geosynthetic extends to the required length into the soil mass. Ensure that the geosynthetic remains taut during the backfill for the subsequent layers.*
4. *Proceed with the next layer in the same manner.*
5. *Where the geosynthetic is to be lapped, a lap of least 0.5m is required. Note: geosynthetic should not be lapped in the strength direction, unless this has been specifically allowed for in the design. Generally, geosynthetics should only be lapped in the lateral direction.*

CONSTRUCTION SEQUENCE: STEP 4

GEOSYNTHETIC REINFORCEMENT INSTALLATION

a. Placement of geosynthetic reinforcement:

1. Ensure infill is level with, or slightly above, the top of the CRB unit.
2. Clean debris off top of unit.
3. Cut geosynthetic reinforcement to design length (L) as shown on plans (see Figure 11) and install with strength direction perpendicular to wall face.
4. The geosynthetic is to be secured to the block in a manner as recommended by the block manufacturer or the geosynthetic supplier. Generally, this is achieved by simply ensuring that the geosynthetic is "pinched" hard between the blocks.
5. Place CRB unit on top of geosynthetic.
6. Move CRB unit to engage shear connectors (where applicable) and establish proper setback.

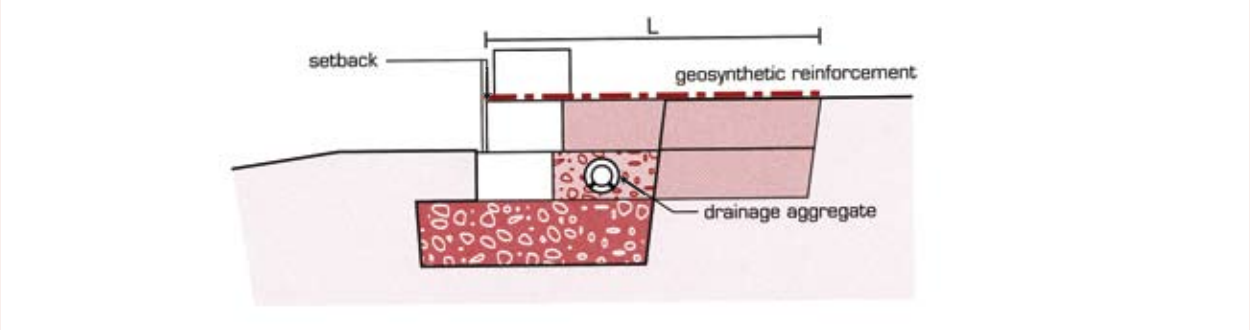

Figure 10: Placement of geosynthetic reinforcement.

b. Backfilling over geosynthetic reinforcement:

1. Lay geosynthetic flat, without creases or folds, using earth windrow to maintain tension throughout fill placement process.
2. Fill infill soil in and between CRB units as required.
3. Compact fill soil.
4. Compact drainage aggregate.
5. Place remainder of fill soil.

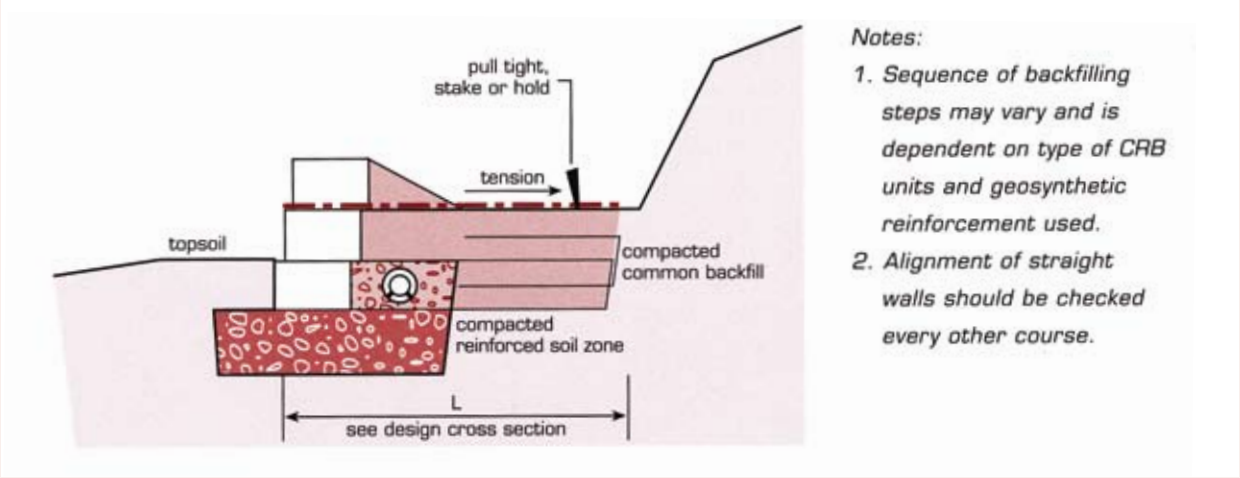

Figure 11: Section through backfilling procedure with geosynthetics.

CONSTRUCTION SEQUENCE: STEP 5

COMPLETION OF WALL

Steps a and b:

1. Continue wall to full height using steps 3 and 4.
2. Place and compact final backfill.
3. Finish grade for positive drainage away from wall face. (Drainage swale is optional). If needed, install a surface drain (with sufficient fall) behind the top of the wall.
4. Place topsoil and vegetate slopes above and around wall terminations.
5. Where applicable vegetate pockets in CRB units.

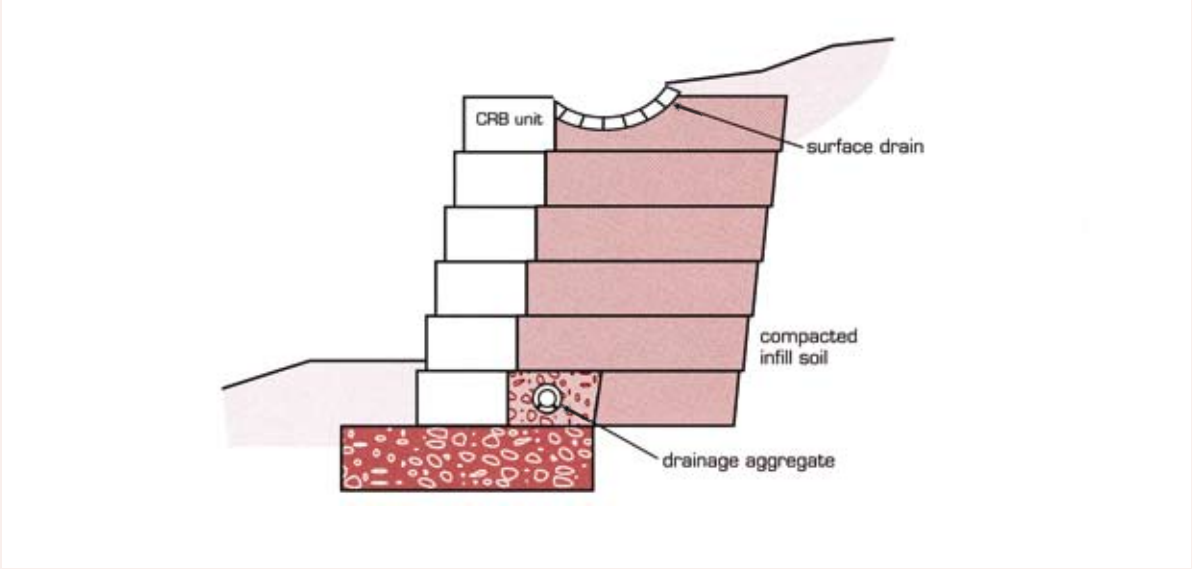

Figure 12: Section through completed gravity CRB walls.

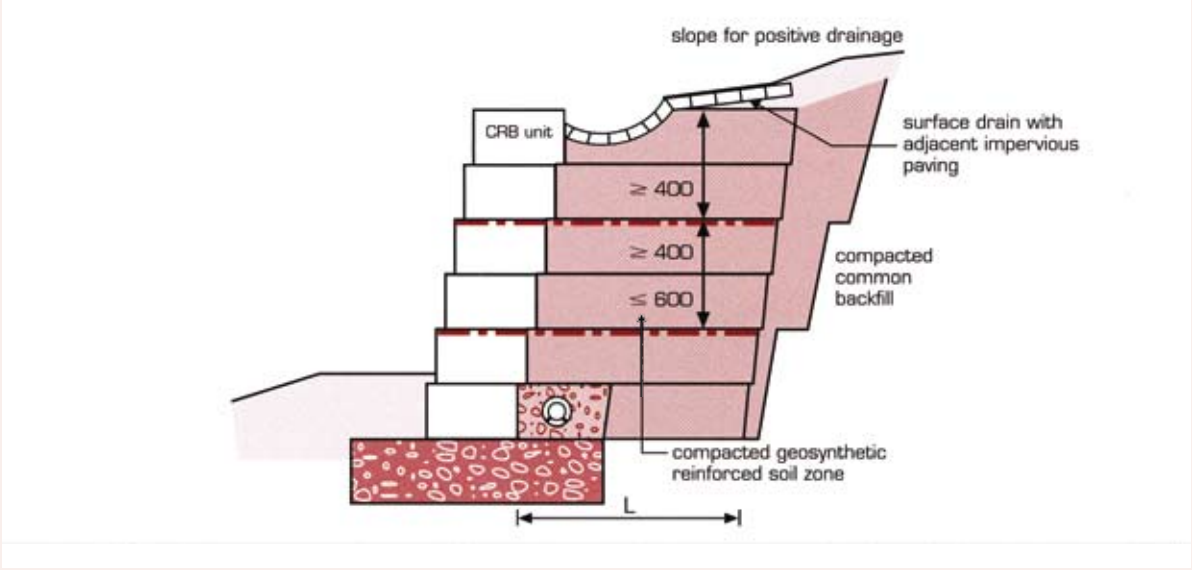

Figure 13: Completed reinforced CRB wall.

DRAINAGE

In many cases, drainage will be required behind the wall. The purpose of the drainage is to drain excess ground water from the soil mass behind the wall. In doing so, the stability of the wall is increased.

A drainage system comprises the following:

Pipe: The purpose of the pipe is to convey the water collected behind the wall to a point of discharge. It is important that the pipe has slots or perforations, a minimum gradient and clear outlet.

Filter: The filter comprises natural aggregate and geotextile geosynthetic composite subsurface drain. It is placed around the pipe to prevent the infiltration of soil into the pipe. Infiltration of soil into the pipe causes two major problems, namely it leads to the clogging of the pipe and further leads to the undermining of the soil behind the wall which can cause failure of the wall.
A composite subsurface drain may also be used in lieu of natural aggregates.

Drainage blanket: A horizontal layer (typically 100-150mm thick) of single sized natural aggregate constructed behind the retaining wall and extending under the infill soil, connected to the subsoil drainage system. A geotextile should be placed around the drainage blanket to prevent contamination of the drainage blanket.

Face wall drain: A vertical drainage layer constructed of single sized natural aggregate immediately behind the retaining wall. Geotextiles should be placed to separate the natural aggregate from the fill soil.

The contractor must ensure that the filter used (whether composite or natural) is compatible with the backfill material to be used. This means that filter should not lead to piping (loss of fins through the filter) or clogging (reduced capacity of through-flow). In cases where a natural filter is used, the capability between the particle size of the filter and the hole size of the pipe should be checked. The following rule of thumb can be used:

D85f > hole size
D85f > 1,2 x sloth width
D85f = Sieve size at which 85% of filter will pass

The filter may extend up the entire height of the wall or extend a certain length horizontally behind the wall. This will be as directed by the engineer. See figure 14.

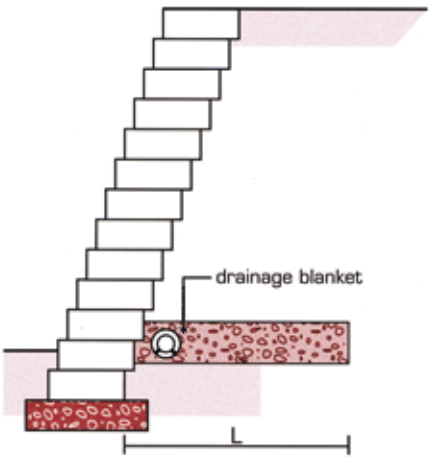

Figure 14a: Drainage blanket

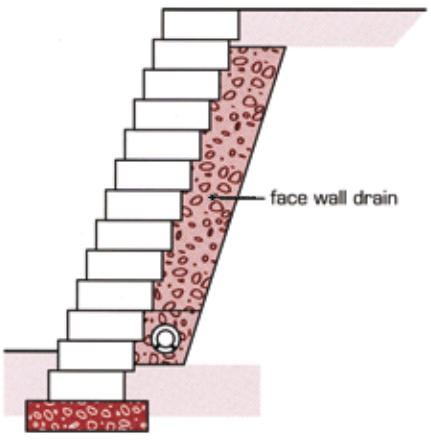

Figure 14b: Face wall drain

TOPPING OFF

The top of the wall is to be finished off as specified. The top blocks will be either filled with topsoil for planting or with concrete.

CONSTRUCTION TOLERANCES

Construction tolerances should be established prior to the start of construction so that both the owner and the contractor will have the same understanding of what is an acceptable standard of work. These tolerances, normally outlined in the construction specifications, should provide a controllable construction margin for the contractor. Following are some typical tolerance guidelines:

DIMENSIONAL TOLERANCES FOR CRB WALLS

As with any constructed works, some deviation from construction drawing alignments will occur. Variability in construction of CRB walls is approximately equal to that of cast-in-place concrete retaining walls. As opposed to cast-in-place concrete walls, alignment of CRB walls can be simply corrected or modified during construction. Based upon examination of numerous completed CRB walls, the following recommended maximum tolerances appear to be achievable with good construction techniques:

- Vertical control
  - +- 30mm over a 3m height
- Horizontal location control
  - straight lines: +- 30mm over a 3m distance
  - straight and radius corner locations: +- 300mm
  - curves and serpentine radius: +- 600mm
- Rotation
  - from established plan wall batter: +1,0º to -2,0º
  - from total established horizontal setback: +- 10,0%
- Bulging
  - -30mm over a 3m distance

Horizontal and vertical control can be maintained by surveying the wall during construction. Control of wall rotation and building during construction can be influenced by CRB unit dimension tolerances, type of soil fill utilised, soil compaction techniques and the uniformity in geosynthetic tension applied during backfilling. Non-uniformity in manual pretensioning of the reinforcement may result in localized bulging. Consistent construction techniques should be used throughout wall erection.

Careful planning and attention should be paid to the compaction equipment and procedures used during construction. Compaction within one metre of the front of wall face should be limited to hand-operated equipment, preferably a vibrating plate or tamper. The remainder of the reinforced soil zone can be compacted with walk-behind or riding self-propelled compaction equipment, depending upon soil type and available operating area. Non-uniform compaction procedures can result in vertical and horizontal alignment control problems. Upon completion of the wall, landscaping equipment and other vehicles should be kept at least one and a half metres behind the wall face.

SITE HANDOVER

Installer to Client:

a) Wall must be clean and all site debris cleared, blocks brushed and pockets cleared to accept planting.

b) All variation orders or extras must be confirmed and signed for by client and copies signed. Forms handed to client for his records. Book copy retained to confirm agreed quantities for invoicing of V.O.'s.

c) Consultant must be present at handover to confirm acceptability and completion and to present stability certificate to client.

d) Installation is complete and can be signed off.

CRB DIVISION MEMBERS (FEBRUARY 2009)

PRODUCER MEMBERS

ARW Concrete	*011 704 2557*
Cape Brick	*021 511 2006*
Columbia DBL	*021 905 1665*
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