Drystone retaining walls: condition appraisal and remedial treatment

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Outline of presentation

- Who is CIRIA
- Definition
- Background
- Why do we have them?
- Where are they found?
- Research
- Construction
- Failure
- Inspection
- Maintenance
- Conclusions

Who is CIRIA?

- A not-for-profit company
- Member owned
- Concerned with best practice and near-market innovation
- Independent
- Long established (1960)

What does CIRIA do?

- Research
- Publications
- Training
- Networks
- Industry initiatives

Research

- Working with the industry to identify and codify emerging better and new practice.

- Scope: Market sector view
  - **Buildings & Facilities**
  - **Transport Infrastructure**
  - **Water & Utilities**

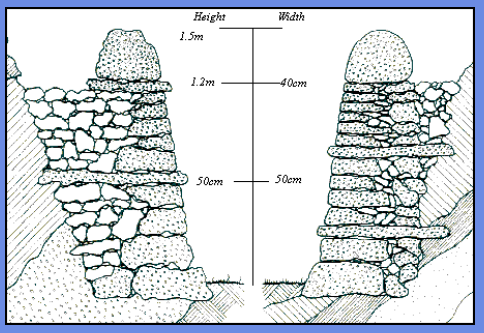
- Scope: Theme & technology view
  - **e.g. Sustainability, Health & Safety, Flooding, etc.**

- Approach: Collaborative projects & activities

For further details on CIRIA's activities, please visit:

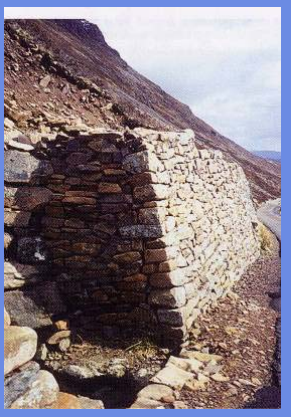
www.ciria.org

Drystone retaining walls



Definition

A masonry wall without mortar constructed against a soil or rock face using blocks of various sizes



Background

- Very nature of being resistant and resilient these structures have stood the test of time
- Increasing industrialisation and urbanisation lead to further construction
- Key point is that they are NOT engineered structures
- Primary use is as facing structures
- Examples seen of up to 10m in height
- Protecting critical structures including railway lines

Why do we have them?

- During time of infrastructure corridor construction the contours of the land were followed
- Often along side long ground (slope) both above and below
- Give protection to the slope to maintain the stability of the corridor

Where are they found?

- Occur in parts of the country that have a readily available supply of suitable near surface rock types
- Where these rocks are of sufficient quality and quantity
- To construct wall the mason identify a source of stone, cut and shape blocks accordingly

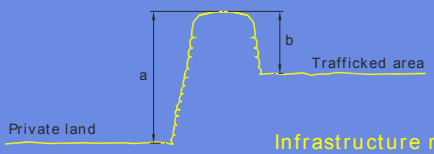
Construction locations

- Southwest England
- Derbyshire
- Lancashire
- Scotland
- Northern Ireland

Construction settings

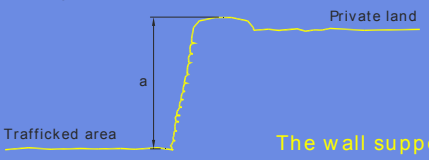
- Highways
- Railways
- Canals
- Ports and harbours

Drystone wall settings



Infrastructure retained by the wall

Note:
a = height retaining wall
b = height parapet wall

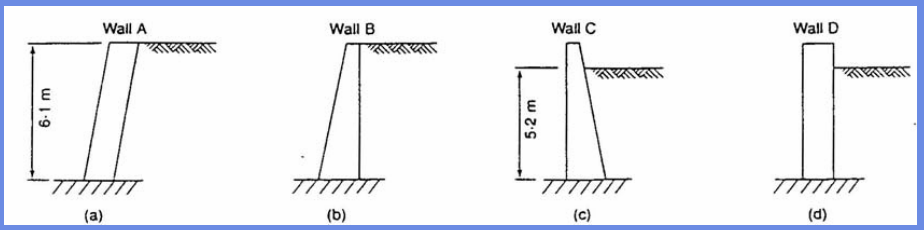


The wall supports adjacent land above the infrastructure

Research – 19th Century

- Assessment of stability was the first attempt to look at engineering of structures
- Full scale trials carried out at Kingstown
- 4 walls of 6.1m height were constructed in different configurations
- Each wall was backfilled until they showed signs of distress or collapsed

Drystone wall configurations at Kingstown



Research – 20th Century

- Incidences of failure although rare were often dramatic and of great concern
- Concern via county organisations resulted in research studies
- One of the first tasks was to establish the extent of the structures
- Identified the replacement cost if required rebuilding to co-defied standard
- Most proactive areas to increase understanding is Derbyshire and Gwynedd
- Stability could rarely be proved when numerical checks undertaken
- Analysis would indicate an unacceptable factor of safety

Spot the drystone wall!!

Construction

- Made up of big and small blocks
- Rock fragments used to lock larger blocks together
- Constructed by an experienced stone mason
- Waste material generated utilised behind the wall to assist with drainage
- Number reasons why structure successful

Failure

- Sometimes built to a poor standard
- Natural drainage gradually reduces as water movement transports fines and clogs pore spaces
- Vegetation encourages the development of fines and root development causes instability
- Over a period of time water pressures have led to local instabilities through a number of processes

Upside wall: top

- Progressive development of upside slope of wall
- Vegetation
- Structures
- Infrastructures (roads, services)
- Landscaping

Upside wall: bottom

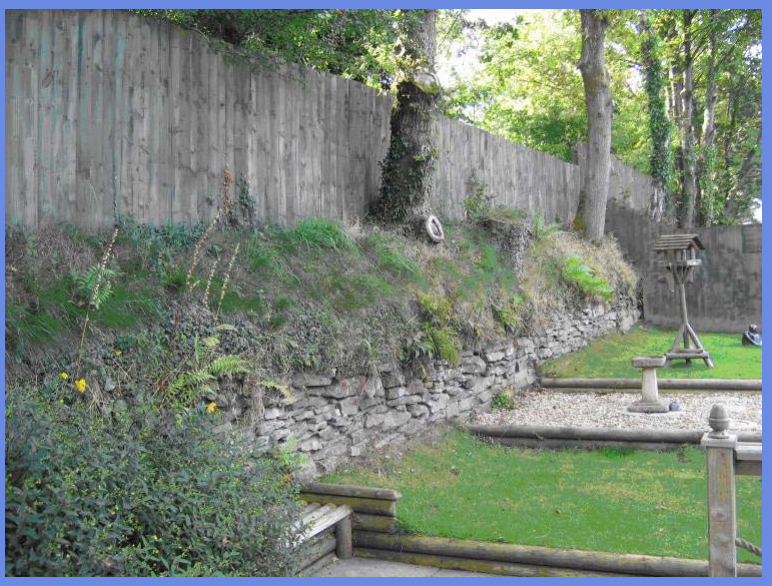
- Infrastructures (roads, services)
- Possibly vegetation
- Landscaping
- Provide disturbance leading to instability of the toe of the wall

Downside wall: top

- Utilities and services
- Traffic loading
- Vehicle striking
- Parapet wall
- Big H&S issues concerning vehicles and people
- Housing, farms, urbanisation

Downside wall: bottom

- Question of who is responsible for the wall?
- Most out of sight of typical configurations that follow land contours
- Issue over who inspects
- Area of most repair
- Risk of removal of blocks for other uses!

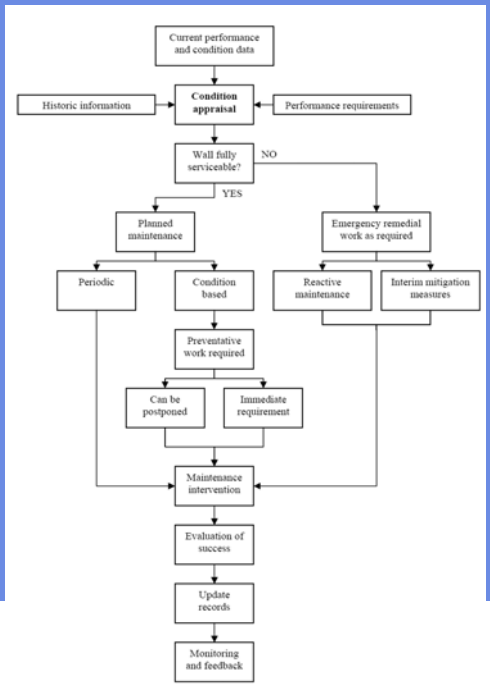


Past inspection regime

- Often did not occur for decades (sometimes over 100 yrs)
- Approach was very reactive – waited until a failure was reported
- Only last 5 to 10 yrs have local authorities been able to understand the extent and nature of their stock

Current inspection regime

- Location recorded with accuracy
- Assessment of alignment
- Logging of surface features
- Assessment needed as no supporting drawings to assist
- Take the structure at face value



Past maintenance regime

- Issue over why have maintained and repaired structures caused more problems and greater expenditure
- Most early repairs did not recognise why the structure had been STABLE for so many years
- Key point was their free draining nature was not recognised
- Used cement mortar and grouting (pumped in)
- Issue was that works made structure IMPERMEABLE and RIGID

Pointing

- Simple means by hand for small localised repairs
- Larger scale repairs use pressure pointing giving improved penetration
- HOWEVER can impede drainage of groundwater increasing disturbing pressures
- To reduce this risk usually insert weep holes at the foot of the wall

Grouting

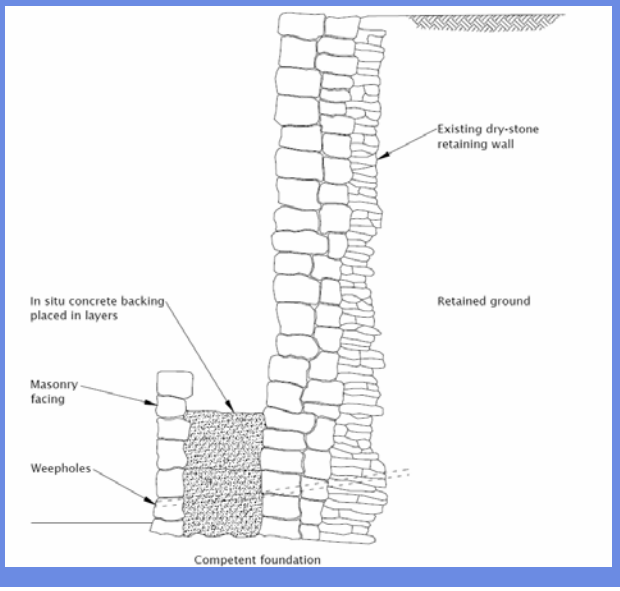
- Not widely used due to specialised nature of the process and equipment need to carry out the work
- Uncertainty regarding penetration of the grout
- Use makes the structure RIGID
- Again giving rise to impeded drainage

Soil nailing

- Inserted into grouted holes at inclination of 10 to 20 degrees
- Length of the nail needs to be sufficient to allow pull-out resistance required to develop
- Used for slope stabilisation
- Issue concerning degradation of nail
- Should not impede drainage of the wall or backfill

Thickening

- Places masonry facing or primary faced precast panels a distance in front of the existing wall with the space between being backfilled
- By constructing to 1/6 height of existing wall will increase factor of safety by 60%
- Used when foundations are sound and shallow



Buttressing

- Can be both temporary and permanent
- Used successfully on trunk roads
- Need sufficient land surrounding wall to install
- Gabions long been used to provide temporary buttressing or effect emergency repairs

Embankments

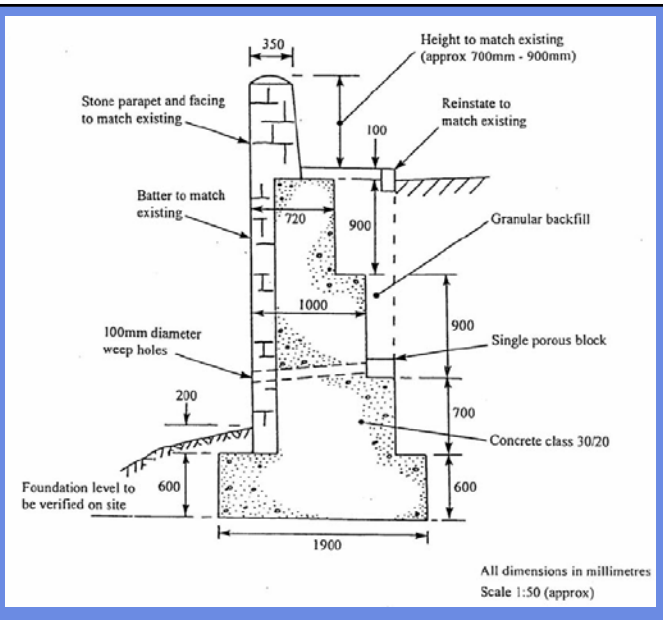
- Simplest and most straightforward method
- Difficult to find locations where sufficient land to allow installation
- Care is needed concerning water pressures behind the wall are relieved and suitable drainage remains

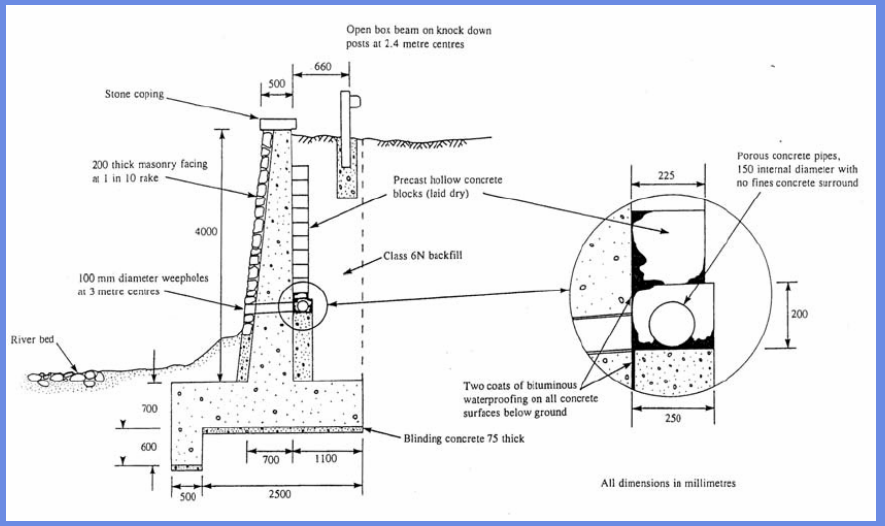
Rebuilding

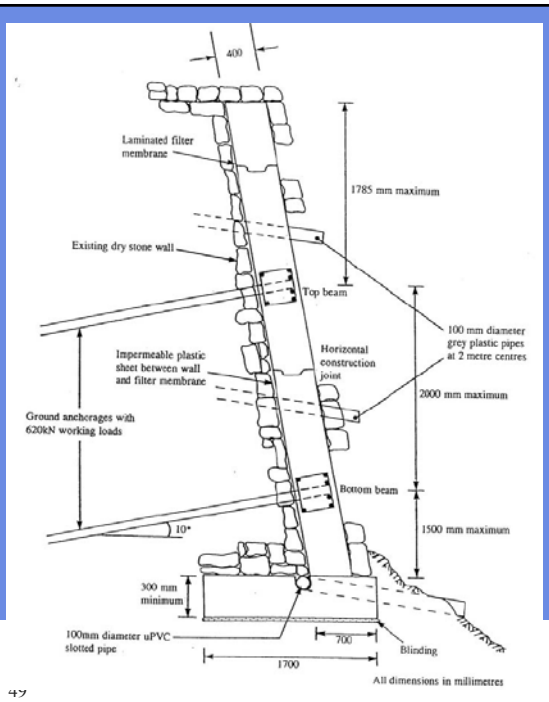
- Like for like
- Issues concerning whether structure would fulfil requirements of modern design codes and standards

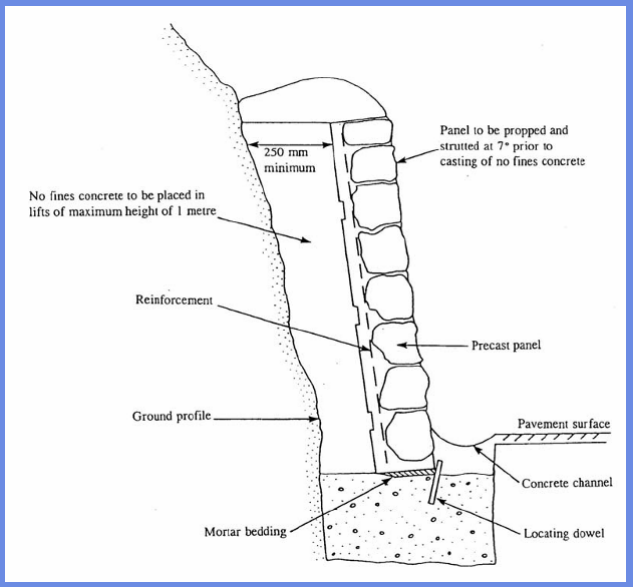
Replacement

- Stone-faced mass concrete retaining walls
- Stone-faced reinforced concrete retaining walls
- Stone-faced retaining walls employing ground anchors
- Precast stone-faced gravity retaining walls
- Reinforced and anchored soil retaining walls


350
Height to match existing
(approx 700mm - 900mm)
Stone parapet and facing
to match existing
Reinstate to
match existing
100
Batter to match
existing
720
900
Granular backfill
1000
900
100mm diameter
weep holes
Single porous block
200
700
Concrete class 30/20
Foundation level to
be verified on site
600
600
1900
All dimensions in millimetres
Scale 1:50 (approx)


Open box beam on knock down
posts at 2.4 metre centres
660
500
Stone coping
200 thick masonry facing
at 1 in 10 rake
Precast hollow concrete
blocks (laid dry)
225
Porous concrete pipes,
150 internal diameter with
no fines concrete surround
4000
Class 6N backfill
100 mm diameter weepholes
at 3 metre centres
River bed
200
Two coats of bituminous
waterproofing on all concrete
surfaces below ground
250
700
600
Blinding concrete 75 thick
700
1100
500
2500
All dimensions in millimetres


400
Laminated filter membrane
1785 mm maximum
Existing dry stone wall
Top beam
100 mm diameter grey plastic pipes at 2 metre centres
Impermeable plastic sheet between wall and filter membrane
Horizontal construction joint
2000 mm maximum
Ground anchorages with 620kN working loads
Bottom beam
1500 mm maximum
10°
300 mm minimum
100mm diameter uPVC slotted pipe
700
Blinding
1700
All dimensions in millimetres


250 mm minimum
Panel to be propped and strutted at 7° prior to casting of no fines concrete
No fines concrete to be placed in lifts of maximum height of 1 metre
Reinforcement
Precast panel
Ground profile
Pavement surface
Concrete channel
Mortar bedding
Locating dowel

Conclusions

- Many repairs ultimately result in replacement of original structure
- This has importance because of the progressive realisation that these are heritage structures
- Particularly important for asset owners because they have responsibility for ensuring and maintaining stability of these structures

Further details

Current CIRIA project
www.ciria.org/rp723.htm

CIRIA infrastructure guidance showcase
www.ciria.org/workshop_050308.html

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Thank you for listening

Any questions?