

Geoguide 6 – Guide to Reinforced Fill Structure and Slope Design

First Edition

AMENDMENT NO.: GG6/01/2017

BACKGROUND

This amendment sheet incorporates the recommendations given in the following GEO Technical Guidance Notes:

- (i) GEO Technical Guidance Note No. 40 (TGN 40) – Guidelines on Temporary Drainage Provisions and Precautionary Measures against Severe Rainfall during Site Formation Works and Construction of Reinforced Fill Structures;
- (ii) GEO Technical Guidance Note No. 41 (TGN 41) – Amendments to British Standards References in Technical Guidance Documents for Migration to Eurocodes.

The amendments are given below.

AMENDMENTS

SECTION 4

CONSTRUCTION MATERIALS

- (a) Section 4.1.2 **In line 3, delete ‘BS EN 10025 (BSI, 1993)’ and substitute ‘BS EN 10025-1 (BSI, 2004b), BS EN 10025-2 (BSI, 2004c)’.**

In line 3, delete ‘BS 4449 (BSI, 1997)’ and substitute ‘BS 4449 (BSI, 2009c)’.

In line 5, delete ‘BS EN 10002-1 (BSI, 2001)’ and substitute ‘BS EN ISO 6892-1 (BSI, 2009b)’.
- (b) Section 4.1.3 **In paragraph 1, line 6, delete ‘BS EN 10319 (BSI, 1996)’ and substitute ‘BS EN ISO 10319 (BSI, 2008a)’.**
- (c) Section 4.1.9 **In paragraph 2, line 10, delete ‘BS 8006 (BSI, 1995)’ and substitute ‘BS 8006-1 (BSI, 2010)’.**
- (d) Section 4.1.10 **In paragraph 1, lines 1 and 2, delete ‘BS EN ISO 10321 (BSI, 1996)’ and substitute ‘BS EN ISO 10321 (BSI, 2008b)’.**

In paragraph 1, line 2, delete ‘BS EN ISO 10002-1 (BSI, 2001)’ and substitute ‘BS EN ISO 6892-1 (BSI, 2009b)’.
- (e) Section 4.2.1 **In paragraph 2, lines 2 and 3, delete ‘BS 5400: Part 4 (BSI, 1990), BS 8110: Part 1 (BSI, 1997)’ and substitute ‘BS EN 206-1 (BSI, 2000), BS EN 1992-1-1 (BSI, 2004a)’.**

In paragraph 2, line 3, delete ‘Buildings and Lands Department (1987a)’ and substitute ‘BD (2013)’

In paragraph 2, line 4, delete ‘BS 449: Part 2 (BSI, 1969), BS 5950: Part 1

(BSI, 2000)’ and substitute ‘BS EN 14475 (BSI, 2006b)’.

In paragraph 2, lines 4 and 5, delete ‘Buildings and Lands Department (1987b)’ and substitute ‘BD (2011)’.

(f) Section 4.2.2, (1)
Reinforced concrete

In paragraph 1, line 3, delete ‘BS 8110: Part 1 (BSI, 1997)’ and substitute ‘BS EN 206-1 (BSI, 2000), BS 8500-1 (BSI, 2012a), and BS 8500-2 (BSI, 2012b)’.

SECTION 6

DESIGN CONSIDERATIONS

(a) Section 6.12

Add the following after paragraph 2:

Upon completion of construction of a reinforced fill structure, its associated drainage layers are generally sealed off. However, under special circumstances, such as excavation works in the vicinity of a reinforced fill structure, the associated drainage layers may be exposed giving rise to the possibility of excessive ingress of surface water. The maintenance manual of the reinforced fill structure should draw the attention of the maintenance agent to the need for ensuring adequate temporary drainage provisions and implementation of necessary precautionary and mitigation measures, to keep the water away from the structure and guard against excessive ingress of water into the drainage layers under the circumstances.

(b) Section 6.12

In paragraph 3, line 2, delete ‘(GEO, 1998)’ and substitute ‘(GEO, 2003)’.

SECTION 7

DESIGN OF REINFORCED FILL STRUCTURES

(a) Section 7.9.2

In second bullet point, line 2, delete ‘(BS 8006)’ and add ‘(BS 8006-1 (BSI, 2010))’ in the last line after ‘connection’.

(b) Section 7.11.2(2)

Add the following after paragraph 4:

The adequacy of the subsurface drainage capacity of a reinforced fill structure should be assessed and regularly reviewed during construction, taking account of the changing site topography and temporary drainage provisions. The design and detailing of the subsurface drainage system of the reinforced fill structure should be robust enough against the build-up of water pressure from unintended ingress of water, which may cause hydraulic (piping) failure, internal or external instability, or distress.

(c) Section 7.11

Add the following after sub-section 7.11.2:

Section 7.11.3 Temporary Drainage

Due attention should also be given to ensuring adequate temporary drainage provisions and precautionary and mitigation measures to discharge the surface water and subsurface water safely during construction. Details are further elaborated in Section 11.2.5.

SECTION 8

DESIGN OF REINFORCED FILL SLOPES

(a) Section 8.8.2

In line 2, add ‘, Section 11.2.5 and’ after ‘see Section 7.11’

SECTION 9**AESTHETICS AND LANDSCAPING**

- (a) Section 9.1 **In paragraph 1, line 6, delete ‘GEO Publication No. 1/2000 (GEO, 2000)’ and substitute ‘GEO Publication No. 1/2011 (GEO, 2011)’**
- (b) Section 9.4 **In paragraph 1, line 3, delete ‘(GEO, 1998)’ and substitute ‘(GEO, 2003)’**

SECTION 11**CONSTRUCTION CONTROL**

- (a) Section 11.2.1 **Add the following after paragraph 3:**

A risk assessment should be carried out for projects involving site formation which may be vulnerable to severe rainfall events causing adverse landslide impacts on the public in case of uncontrolled overflow of surface water towards slopes, retaining walls and other features. This should include an assessment of the drainage-related hazards on slope safety when the site is affected by rainfall which exceeds the design event. If necessary, a risk management plan incorporating measures to manage the landslide risk, including any necessary precautionary and mitigation measures at different stages of construction, should be put in place to prevent adverse effects of overflow of surface water on slope safety when the capacity of the temporary drainage provisions is overwhelmed. The plan should contain, inter alia, the location of standby plant and equipment, the persons who will monitor the weather conditions and implement the measures when required (including outside working hours), and the emergency contact details of key personnel.

- (b) Section 11.2.5 **Replace paragraph 1 with the following.**

Drainage is an important consideration for reinforced fill features. A reinforced fill feature should not be allowed to become water-logged since this will adversely affect its stability. In Hong Kong, there have been cases where inadequate temporary surface water drainage has led to failure of reinforced fill structures during construction, resulting in expensive remedial works (Raybould et al, 1996; Lam et al, 2001b; FSWJV, 2013). In these cases, constructions were carried out on sloping terrain during the wet season and due to inadequate temporary surface water drainage provisions, the filling areas were severely flooded. The rapid rise in water levels led to heavy seepage through the facing panels and the washing out of the backfill of the partially completed structures. Dislodgment of the panels caused escalation of the process and major displacements of the facing panels occurred when the toe supports of the structures were undermined by further erosion. It is also noted that the internal detailing of the distressed reinforced fill structure is vulnerable to piping in the event of significant water ingress into its drainage layers which were not sealed off during construction (FSWJV, 2013).

- (c) Section 11.2.5 **Add the following after paragraph 2:**

Temporary drainage plans should be updated in a timely manner to suit the site conditions during construction. Adequate drainage provisions shall be maintained on site at all times, including during the period when the temporary drainage works are being re-routed or re-constructed in accordance with any updated temporary drainage plans to suit various stages of construction.

Specifically the integrity and stability of a reinforced fill structure during construction are particularly vulnerable to excessive water ingress. Adequate temporary drainage provisions and precautionary and mitigation measures should be implemented to prevent excessive water ingress into the reinforced fill structure not allowed for in the design and thereby overwhelming its drainage capacity, causing distress or structure instability.

TABLES

- (a) Table 2 **In Note (1), delete ‘BS 8006 (BSI, 1995)’ and substitute ‘BS 8006-1 (BSI, 2010)’.**
- (a) Table 9 **In Note (1), delete ‘BS 8006 (BSI, 1995)’ and substitute ‘BS 8006-1 (BSI, 2010)’.**
- (a) Table 10 **In Note, delete ‘BS 8006 (BSI, 1995)’ and substitute ‘BS 8006-1 (BSI, 2010)’.**

FIGURES

- (a) Figure 26 **In Note, delete ‘BS 8006 (BSI, 1995)’ and substitute ‘BS 8006-1 (BSI, 2010)’.**

APPENDIX A

- (a) Clause A.12(1)(a) **Delete ‘BS 8110: 1997’ and substitute ‘BS EN 206-1: 2000, BS 8500-1: 2006+A1: 2012 and BS 8500-2: 2006+A1: 2012’.**
- (a) Clause A.12(1)(b) **In lines 2 to 3, delete ‘BS 4482: 1995, BS 4483: 1998, BS EN 10025: 1993 or BS EN 10130: 1999’ and substitute ‘BS 4482: 2005, BS 4483: 2005, BS EN 10025-1: 2004, BS EN 10025-2: 2004 or BS EN 10130: 2006’.**
- (a) Clause A.12(1)(c) **In lines 1 to 2, delete ‘BS EN 10025: 1993’ and substitute ‘BS EN 10025-1: 2004 and BS EN 10025-2: 2004’.**
- (a) Clause A.13(1)(a) **In lines 2 to 4, delete ‘BS 4482: 1995, BS 4483: 1998, BS EN 10025: 1993 or BS EN 10130: 1999’ and substitute ‘BS 4482: 2005, BS 4483: 2005, BS EN 10025-1: 2004, BS EN 10025-2: 2004 or BS EN 10130: 2006’.**
- (a) Clause A.13(2)(d) **In line 2, delete ‘BS 4449:1997’ and substitute ‘CS2:2012’.**
- In line 3, delete ‘BS 4482: 1985 or BS EN 10025: 1993’ and substitute ‘BS 4482: 2005, BS EN 10025-1:2004 or BS EN 10025-2:2004’.**
- (a) Clause A.13(2)(e) **In lines 2 and 3, delete ‘BS 4482: 1985, BS EN 10025: 1993, or BS EN 10130:1999’ and substitute ‘BS 4482:2005, BS EN 10025-1:2004, BS EN 10025-2:2004, or BS EN 10130:2006’.**
- (a) Clause A.14 **In line 1, delete ‘BS EN ISO 1461: 1999’ and substitute ‘BS EN ISO 1461:2009’.**
- (a) Table A.1 **In Note, insert ‘(1)’ before ‘No dispersant’.**

Add the following as Note (2).

‘(2) BS Sieve Sizes are in accordance with BS 410-1:2000, ISO 3310-1:2000.’

(a) Table A.2 **Note (3), delete ‘either’ and ‘or microbial activity index’.**

Add the following as Note (4).

‘(4) BS Sieve Sizes are in accordance with BS 410-1:2000, ISO 3310-1:2000.’

(a) Clause A.40(1) **In line 3, delete ‘BS EN 10002-1: 2001’ and substitute ‘BS EN ISO 6892-1: 2009’.**

(a) Clause A.40(2) **In line 2, delete ‘BS EN ISO 10319:1996’ and substitute ‘BS EN ISO 10319:2008’.**

In line 4, delete ‘BS EN ISO 10321:1996’ and substitute ‘BS EN ISO 10321:2008’.

(a) Clause A.42 **In line 2, delete ‘BS EN ISO 1461:1999’ and substitute ‘BS EN ISO 1461:2009’.**

(a) Clause A.53 **In line 2, delete ‘BS 1377: Part 3: 1990, test 3’ and substitute ‘Geospec 3, Clause 9’.**

(a) Clause A.55 **Delete lines 1 and 2, and substitute ‘Not used.’**

REFERENCES

(a) **Add the following new references:**

BD (2011). *Code of Practice for the Structural Use of Steel*. Buildings Department, Hong Kong, 366 p.

BD (2013). *Code of Practice for Structural Use of Concrete*. Buildings Department, Hong Kong, 191 p.

BSI (2000). *Concrete - Part 1: Specification, Performance, Production and Conformity (BS EN 206-1:2000)*. British Standards Institution, London, 74 p.

BSI (2004a). *Eurocode 2: Design of Concrete Structures - Part 1-1: General Rules and Rules for Buildings (BS EN 1992-1-1:2004)*. British Standards Institution, London, 230 p.

BSI (2004b). *Hot Rolled Products of Structural Steels - Part 1: General Technical Delivery Conditions (BS EN 10025-1:2004)*. British Standards Institution, London, 36 p.

BSI (2004c). *Hot Rolled Products of Structural Steels - Part 2: Technical Delivery Conditions for Non-alloy Structural Steels (BS EN 10025-2:2004)*. British Standards Institution, London, 38 p.

BSI (2005a). *Steel Fabric for the Reinforcement of Concrete - Specification (BS 4483:2005)*. British Standards Institution, London, 18 p.

BSI (2005b). *Steel Wire for the Reinforcement of Concrete Products - Specification (BS 4482:2005)*. British Standards Institution, London, 30 p.

BSI (2006a). *Cold Rolled Low Carbon Steel Flat Products for Cold Forming – Technical Delivery Conditions (BS EN 10130:2006)*. British Standards Institution, London, 16 p.

BSI (2006b). *Execution of Special Geotechnical Works - Reinforced Fill (BS EN 14475:2006)*. British Standards Institution, London, 60 p.

BSI (2008a). *Geosynthetics - Wide-width Tensile Test (ISO 10319:2008) (BS EN ISO 10319:2008)*. British Standards Institution, London, 18 p.

BSI (2008b). *Geosynthetics - Tensile Test for Joints/Seams by Wide-width Strip Method (ISO 10321:2008) (BS EN ISO 10321:2008)*. British Standards Institution, London, 20 p.

BSI (2009a). *Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles - Specifications and Test Methods (ISO 1461:2009) (BS EN ISO 1461:2009)*. British Standards Institution, London, 24 p.

BSI (2009b). *Metallic Materials - Tensile Testing, Part 1: Method of Test at Ambient Temperature (BS EN ISO 6892-1:2009)*. British Standards Institution, London, 76 p.

BSI (2009c). *Steel for the Reinforcement of Concrete - Weldable Reinforcing Steel - Bar, Coil and Decoiled product - Specification (BS 4449:2005+A2:2009)*. British Standards Institution, London, 34 p.

BSI (2010). *Code of Practice for Strengthened/Reinforced Soils and Other Fills (BS 8006-1:2010)*. British Standards Institution, London, 260 p.

BSI (2012a). *Concrete - Complementary British Standard to BS EN 206-1 - Part 1: Method of Specifying and Guidance for the Specifier (BS 8500-1:2006+A1:2012)*. British Standards Institution, London, 66 p.

BSI (2012b). *Concrete - Complementary British Standard to BS EN 206-1 - Part 2: Specification for Constituent Materials and Concrete (BS 8500-2:2006+A1:2012)*. British Standards Institution, London, 52 p.

FSWJV (2013). *Report on the 22 May 2013 Distress at a Reinforced Earth Wall at a Construction Site above Shun On Road, Sau Mau Ping*. Fugro Scott Wilson Joint Venture, 86 p.

GEO (2001). *Model Specification for Soil Testing (Geospec 3)*. Geotechnical Engineering Office, Hong Kong, 340 p.

GEO (2003). *Guide to Slope Maintenance (Geoguide 5) (Third edition)*. Geotechnical Engineering Office, Hong Kong, 132 p.

GEO (2011). *Technical Guidelines on Landscape Treatment for Slopes (GEO Publication No. 1/2011)*. Geotechnical Engineering Office, Hong Kong, 217 p.

HKSARG (2012). *Construction Standard, Steel Reinforcing Bars for the*

Reinforcement of Concrete (CS2:2012). The Government of the Hong Kong Special Administrative Region, Hong Kong, 50 p.

(b) **Delete the following references:**

BSI (1969). *Specification for the use of structural steel in building. Metric units (BS 449 : Part 2 : 1969)*. British Standards Institution, London.

BSI (1990). *Steel, concrete and composite bridges. Code of practice for design of concrete bridges (BS 5400: Part 4 : 1990)*. British Standards Institution, London.

BSI (1993). *Hot rolled products of non-alloy structural steels. Technical delivery conditions (BS EN 10025 : 1993)*. British Standards Institution, London.

BSI (1995). *Code of Practice for strengthened/reinforced soil and other fills (BS 8006 : 1995)*. British Standards Institution, London.

BSI (1996). *Geotextiles. Wide-width tensile test (BS EN ISO 10319 : 1996)*. British Standards Institution, London.

BSI (1996). *Geotextiles. Tensile test for joints/seams by wide-width method (BS EN ISO 10321 : 1996)*. British Standards Institution, London.

BSI (1997). *Specification for carbon steel bars for the reinforcement of concrete (BS 4449 : 1997)*. British Standards Institution, London.

BSI (1997). *Structural use of concrete. Part 1 – Code of practice for design and construction (BS 8110 : 1997)*. British Standards Institution, London.

BSI (2000). *Structural use of steelwork in building. Code of practice for design. Rolled and welded sections (BS 5950-1 : 2000)*. British Standards Institution, London.

BSI (2001). *Tensile testing of metallic materials. Method of test at ambient temperature (BS EN 10002-1 : 2001)*. British Standards Institution, London.

Building and Lands Department (1987a). *Code of Practice for the Structural Use of Concrete 1987*. Hong Kong SAR Government.

Building and Lands Department (1987b). *Code of Practice for the Structural Use of Steel 1987*. Hong Kong SAR Government.

GEO (1998). *Guide to Slope Maintenance (Geoguide 5). (Second edition). English version (reprinted 1999), 91 p.* Geotechnical Engineering Office, Hong Kong.

GEO (2000). *Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (GEO Publication No. 1/2000)*. Geotechnical Engineering Office, Hong Kong.