**Singapore National Annex to Eurocode 7: Geotechnical design – Part 1: General rules**

# AMENDMENT NO. 1

January 2018

**1.** *Replace* the "SS EN 1997:2010" with "SS EN 1997:2010 +A1:2018"

**2. Page 8, NA.1 Scope, Paragraph 1 of (a)**

*Delete* the following subclauses: 2.4.7.1(4), 2.4.7.1(5), 2.4.7.1(6), 8.5.2(3), 8.6(4) and 10.2(3).

*Add* the following subclauses: 8.4(6)P, 8.4(7)P, 8.5.1(1)P, 8.5.1(2)P, 8.5.2(1)P, 8.5.2(3)P, 8.5.2(5)P, 8.5.3(1)P, 8.5.3(2)P, 8.5.3(3)P, 8.5.3(4)P, 8.6.2(2)P and 8.6.2(3)P.

**3. Page 8, NA.1 Scope, Paragraph 2 of (a)**

*Replace* "A.2" with "A.2.1 and A.2.2".

*Add* "A.6".

**4. Page 9, Table NA.1**

a) *Replace* "(STRI GEO)" with "(STRI/GEO)" in clause 2.4.6.2(2)P

b) *Replace* 2.4.7.1(3) with the following:

| Subclause | Feature | Provisions of this National Annex |
|---|---|---|
| 2.4.7.1(3) | The value of partial factors to be used in accidental situations. | Take as equal to 1.0. |
| 2.4.7.1(3) | The values of partial factors for ground material strengths and resistances to be used in accidental situations. | Use the square root of values given for persistent and transient design situations in Annex A of this National Annex. |
| 2.4.7.1(3) | The values of partial factors for structural material strengths and resistances to be used in accidental situations. | Use the values given in SS EN 1992 to SS EN 1996 and SS EN 1999. |

**5. Page 10, Table NA.1**

*Replace* the provisions of 2.4.7.1(6), "See A.6.1 to A.6.6 of Annex A of this National Annex" with "See A.7.1 to A.7.6 of Annex A of this National Annex".

*Replace* the provisions of 2.4.7.3.3(2)P, "Use the values given in A.3.3.1, A.3.3.2, A.3.3.4, A.3.3.5 and A.3.3.6 in Annex A of this National Annex" with "Use the values given in A.3.3.1, A.3.3.2, A.3.3.4, A.3.3.5, A.3.3.6 and A.6 in Annex A of this National Annex."

**6. Page 11, Table NA.1**

*Delete* the following subclauses:

| Subclause | Feature | Provisions of this National Annex |
|---|---|---|
| 8.5.2(2)P | The value of factor $\gamma_S$ | Use the values given in A.3.3.4 of Annex A of this National Annex |
| 8.5.2(3) | The value of correlation factor $\xi_a$ for anchorages that are not individually checked by acceptance tests. | A value should be agreed, where appropriate, with the client and the relevant authorities. |
| 8.6(4) | The value of the model factor to be applied to an anchorage force at SLS. | See A.6.6 of Annex A of this National Annex. |
| 10.2(3) | Resistance to uplift by friction or anchor forces may also be treated as a stabilising permanent vertical action (Gstb;d). | Resistance to uplift by friction and anchor forces using tension piles and diaphragm walls, but not ground anchors, may also be treated as a stabilising permanent vertical action (Gstb;d). |

**7. Page 11, Table NA.1**

*Add* the following subclauses:

| Subclause | Feature | Provisions of this National Annex |
|---|---|---|
| 8.4(6) | The method of determining the necessary free length. | The necessary free length may be determined by the methods given in BS 8081 or by numerical analysis or other methods that examine the overall stability and displacement of the supported structure and surrounding ground. |
| 8.4(7) | The criteria for the necessity to check the group effects. | Group effects should be checked when the centre to centre spacing between the fixed lengths of the anchors is less than 1.5m or 4 diameters, whichever is greater, following the test procedures of Test Method 2 of EN 22477-5 or, in its absence, the test procedures of BS 8081:2015. |
| 8.5.1(1) | The value of factor $\gamma_{Serv}$ | Use the values given in A.6 (1) of Annex A of this National Annex. |
| 8.5.1(2) | Whether a separate evaluation of the serviceability limit state of the anchor is required and whether the verifications for ultimate limit state and serviceability limit state are to be carried out separately or in a combined procedure. | Verifications for ultimate limit state and serviceability limit state are to be carried out, as further detailed in relation to 8.6.2(2) below. |
| 8.5.2(2) | The value of creep rate ($\alpha_{ULS}$) or load loss ($K_{I;ULS}$) | Use the values given in A.6(4) of Annex A of this National Annex. |

| Subclause | Feature | Provisions of this National Annex |
|---|---|---|
| 8.5.2(3) | The value of correlation factor $\xi_{ULS}$ | Use the values given in A.6(3) of Annex A of this National Annex |
| 8.5.2(3) | The minimum number of investigation and suitability tests *n* | Use the values given in A.6(3) of Annex A of this National Annex. |
| 8.5.2(5) | The value of factor $\gamma_{a,ULS}$ | Use the values given in A.6(2) of Annex A of this National Annex. |
| 8.5.3(1) | The test method to be used to determine the measured resistance | Use Test Method 2 as given in EN 22477-5 or, in its absence, the methods of BS 8081. |
| 8.5.3 (1) | The number of investigation and/or suitability tests (*n*) required to determine the measured geotechnical serviceability limit state resistance | See Table A.NA.20 |
| 8.5.3(2) | The limit value of the creep rate ($\alpha_{SLS}$) and load loss ($K_{l;SLS}$) or $P_C$ | Use the values given in A.6(4) of Annex A of this National Annex |
| 8.5.3(3) | The minimum number of investigation and suitability tests *n* to be carried to determine $(R_{SLS;m})_{min}$ | Use the values given in A.6(3) of Annex A of this National Annex. |
| 8.5.3(4) | The value of factor $\gamma_{a;SLS}$ | Use the values given in A.6(3) of Annex A of this National Annex |
| 8.6.2(2) | The value of factors $\gamma_{a;acc;ULS}$ and $\gamma_{a;acc;SLS}$ | Use the values given in A.6(3) of Annex A of this National Annex |
| 8.6.2(2) | Whether the proof load in an acceptance test is to be related to the ultimate limit state design force (8.13) or to $F_{serv;k}$ (8.14). | The acceptance test is to be related to ultimate and serviceability limit states using both equations 8.13 and 8.14, with factors provided in Table A.NA.20 and the criteria provided in Table A.NA.21. However, if the criteria required for SLS are met when the ULS proof load is applied, the SLS stage of the test may be omitted. |
| 8.6.2(3) | Limiting values for creep rate/load loss at proof load in an acceptance test | Use the values given in A.6(4) of Annex A of this National Annex |
| 8.6.2(3) | Requirements to check creep rate/load loss at other specified loads, less than the proof load. | A check on creep rate or load loss at a load equivalent to $F_{serv;k}$ is required. Use the values of criteria given in A.6(4) of Annex A of this National Annex. |

**8. Page 13, NA.4**

*Replace* “BS 5930” with “BS 5930:2015”.

*Replace* “BS 8002” with “BS 8002:2015”.

*Replace* “BS 8081” with “BS 8081:2015”.

*Replace* “TR 26” with “BS 6031 and PD 6694-1”.

*Replace* “CP 4” with “BS 8004:2015”.

*Replace* “CIRIA C580 [1]” with “CIRIA C760”.

*Replace* “prEN 14490:2010[1)]” with “BS EN 14490:2010”.

*Delete* footnote “[1)] In preparation”

**9. Page 14, Bibliography, Standards publications**

a) *Replace* all the publications with:

BS 1377 (all parts) Methods of test for soils for civil engineering purposes

BS 5930:2015 Code of practice for site investigations

BS 8002:2015 Code of practice for earth retaining structures

BS 8006:2011 Code of practice for strengthened/reinforced soils and other fills

BS 8008 Safety precautions and procedures for the construction and descent of machine-bored shafts for piling and other purposes

BS 8081:2015 Code of practice for ground anchorages

BS8004:2015 Code of practice for foundations

BS EN 14475 Execution of special geotechnical work – Reinforced fill

BS EN 14490:2010 Execution of special geotechnical works –Soil nailing

BS EN 1536:2010+A1:2015 Execution of special geotechnical works – bored piles

BS EN 1537:2013 Execution of special geotechnical works – ground anchors

BS EN 1538: 2010+A1:2015 Execution of special geotechnical works – diaphragm walls

BS EN ISO 22477-1 Geotechnical investigation and testing – Testing of geotechnical structures -- Part 1: Pile load test by static axially loaded compression

prEN ISO 22477-5 Geotechnical investigation and testing – Testing of geotechnical structures. Testing of ground anchor

BS EN ISO 22477-10 Geotechnical investigation and testing – Testing of geotechnical structures- Testing of piles: rapid load testing

SS EN 1990: 2008 Eurocode: Basis of structural design

SS EN 1997-1:2017 Eurocode 7: Geotechnical design – Part 1– General rules

b) *Replace* [1] with “Gaba A. R. et al.C760 Guidance on retaining wall design.[1)] ”.

c) *Delete* footnote "[2)] In preparation".

*Re-number* footnote [3)] to [1)].

**10. Page 16, Table A.NA.2**

*Add* the following to Table A.NA.2 after "Unconfined strength"

| | | |
|---|---|---|
| Weight density | $\gamma_\gamma$ | 1.0 |

*Add* "For the verification of the EQU limit state, the values of partial factors on geotechnical resistances, such as the capacities of piles and anchors, may be taken as the square roots of the values for STR and GEO given below in tables A.NA.6, A.NA.7, A.NA.8 and A.NA.19" after Table A.NA.2.

**11. Page 17, A.3.1, Paragraph 2, last line**

*Replace* "A.6.3" with "A.7.3".

**12. Page 18, A.3.3.2, Paragraph 3, last sentence**

*Replace* "1.4" and "1.2" with "1.55" and "1.35" respectively.

**13. Pages 18 and 19, Tables A.NA.6, A.NA.7 and A.NA.8**

*Replace* "settlement" with "settlement (or heave)" for items (b) and (c) in the last row of the tables.

**14. Page 20, A.3.3.4**

*Replace* A.3.3.4 with following:

See A.6.

Table A.NA.12 – This table is not used.

**15. Page 22, Table A.NA.16**

*Replace* footnote B) "Larger values of $\gamma_R$ should be used for non-prestressed anchorages, to make their designs consistent with those of tension piles (A.3.3.2 and A.3.3.3) or retaining structures (A.3.3.5), as appropriate" with "See Table A.NA.19 "

**16. Page 22, Table A.NA.17**

*Replace "*1.335" with "1.35"

*Add* "Hence, the hydrostatic component of the destabilizing total pore water pressure can usually be eliminated from the inequality and has no effect on the safety requirement" to NOTE after SS EN 1997-1:2010.

**17. Page 23**

*Insert* new clause A.6

**A.6 Partial resistance factors, correlation factors, limiting criteria for ultimate and serviceability limit states, and number of investigation/suitability tests for anchors**

(1)P For the derivation of design values of actions and action effects for persistent and transient design situations at the ultimate limit state the values of partial factors ($\gamma_{Serv}$) should be as given in Table A.NA.18.

**Table A.NA.18 – Partial factors on actions and action effects for persistent and transient design situations at the ultimate limit state**

| Limit state | Symbol | Value |
|---|---|---|
| Ultimate (eq. 8.3) | $\gamma_{Serv}$ | 1,35 |
| NOTE – The recommended value of $\gamma_{Serv}$ applies to all Design Approaches | | |

(2)P For the verification of anchors in ultimate limit state for persistent and transient design situations the values of partial factors ($\gamma_{a;ULS}$) should be as given in Table A.NA.19.

**Table A.NA.19 – Partial resistance factors ($\gamma_{a;ULS}$) for anchors in ultimate limit state for persistent and transient design situations**

| Symbol | STR/GEO | | | | UPL |
|---|---|---|---|---|---|
| | R1 | | | R4 | |
| $\gamma_{a;ULS}$ | 1,1 | | | 1,1 | 1,1 |

(3)P For the verification of anchor test methods for persistent and transient design situations at the ultimate limit state and for serviceability limit states the values of partial factors ($\xi_{ULS}$, $\gamma_{a;SLS}$, $\gamma_{a;acc;ULS}$, $\gamma_{a;acc;SLS}$) should be as given in Table A.NA.20.

**Table A.NA.20 – Values depending on anchor test method for persistent and transient design situations at the ultimate limit state and for serviceability limit states**

| Symbol | Equation | Test method [a] | | |
|---|---|---|---|---|
| | | | 2 | |
| $\xi_{ULS}$ | 8.6, 8.12 | | b | |
| $\gamma_{a;SLS}$ | 8.10 | | 1,0 | |
| $n$ | | | d | |
| $\gamma_{a;acc;ULS}$ | 8.13 | | c | |
| $\gamma_{a;acc;SLS}$ | 8.14 | | 1,0 | |

[a] For a description of the test methods see EN ISO 22477-5. In Singapore, only Test Method 2 is proposed. In the absence of EN ISO 22477-5 refer to BS 8081:2015.

[b] For investigation tests, $\xi_{ULS} \geq 1.0$ should be used. $\xi_{ULS} > 1.0$ may be adopted in order to justify use of values of $\xi_{ULS}$ and $\gamma_{a;acc;ULS} < 1.0$ in suitability and acceptance tests, as detailed below.

For suitability tests, in order to provide consistency with previous Singapore practice, the formula $\xi_{ULS}$ = 1.35 $F_{serv;k}/E_{ULS;d}$ may be used (which will give values of $\xi_{ULS}$ <1 if $E_{ULS;d}$ >1.35$F_{Serv;k}$). This leads to a proof load equivalent to "1.5$T_w$" required by BS 8081:1989 and is only valid if $\gamma_{Serv}$ =1.35 and $\gamma_{a;ULS}$ =1.1. Use of this approach is acceptable provided the designer is satisfied, on the basis of investigation tests, calculation or other experience, that every anchor will have sufficient ultimate resistance to satisfy Equation 8.1. In cases where this is uncertain, $\xi_{ULS}$ ≥1.0 should be used.

[c] For acceptance tests, in order to provide consistency with previous Singapore practice, the formula $\gamma_{a;acc;ULS}$ = 1.5 $F_{serv;k}/E_{ULS;d}$ may be used (which will give values of $\gamma_{a;acc;ULS}$ <1 if $E_{ULS;d}$ >1.5 $F_{serv;k}$). This leads to a proof load equivalent to "1.5$T_w$" required by BS 8081:1989. Use of this approach is acceptable provided the designer is satisfied, on the basis of investigation tests, calculation or other experience that every anchor will have sufficient ultimate resistance to satisfy Equation 8.1. In cases where this is uncertain, $\gamma_{a;acc;ULS}$ =1.1 should be used.

[d] The minimum value of n shall be 1 for investigation tests and 3 for suitability tests, although verification by comparable experience (as defined in 1.5.2.2) may be considered in lieu of investigation and suitability tests.

(4)P For the verification of investigation, suitability and acceptance tests for persistent and transient design situations at the ultimate limit state and for serviceability limit states, the values of limiting criteria ($k_t$ and $\alpha_2$) should be as given in Table A.NA.21. Test methods requiring the criteria $\alpha_1$, $\alpha_3$ and $P_c$ are not used in this national annex.

**Table A.NA.21 Limiting criteria for investigation, suitability and acceptance tests for persistent and transient design situations at the ultimate and serviceability limit states**

| Test Method [a] | Limiting criterion | Investigation and suitability tests | | Acceptance tests | |
|---|---|---|---|---|---|
| | | ULS (Eq.8.5) | SLS (Eq. 8.8) | ULS (Eq. 8.13) | SLS (Eq. 8.14) |
| 2 | $K_I$ | 5% per log cycle of time | 2% per log cycle of time [e] | 5% per log cycle of time | 2% per log cycle of time [e] |
| | $\alpha_2$[b] | 5% $\Delta_{eULS}$[c] per log cycle of time | 2% $\Delta_{eSLS}$[d] per log cycle of time | 5% $\Delta_{eULS}$ per log cycle of time | 2% $\Delta_{eSLS}$ per log cycle of time |

[a] For a description of the test methods see EN ISO22477-5, or EN 1537:2013. Pending the publication of EN ISO 22477-5, the procedures of BS 8081 may be substituted for Test Method 2, adopting the limiting criteria shown in this table.

[b] $\alpha_2$ is the creep rate determined by Test Method 2, from the displacement per log cycle of time at constant anchor load (as defined in EN ISO 22477-5).

[c] $\Delta_{eULS}$= ($P_p$ x tendon free length)/ (area of tendon x elastic modulus of tendon)

[d] $\Delta_{eSLS}$= ($F_{serv;k}$ x tendon free length)/ (area of tendon x elastic modulus of tendon)

[e] Tighter criteria should be considered in cases where serviceability is exceptionally critical.

**18. Page 23, A.6**

*Replace* “A.6” with “A.7”.